ALIBABA CLOUD

Alibaba Cloud

Apsara Stack Enterprise

User Guide - Analytics and Artificial Intelligence

Product Version: 1911, Internal: V3.10.0

Document Version: 20201112

Alibaba Cloud

Legal disclaimer

Alibaba Cloud reminds you to carefully read and fully understand the terms and conditions of this legal disclaimer before you read or use this document. If you have read or used this document, it shall be deemed as your total acceptance of this legal disclaimer.

1. You shall download and obtain this document from the Alibaba Cloud website or other Alibaba Cloud-authorized channels, and use this document for your own legal business activities only. The content of this document is considered confidential information of Alibaba Cloud. You shall strictly abide by the confidentiality obligations. No part of this document shall be disclosed or provided to any third party for use without the prior written consent of Alibaba Cloud.

2. No part of this document shall be excerpted, translated, reproduced, transmitted, or disseminated by any organization, company or individual in any form or by any means without the prior written consent of Alibaba Cloud.

3. The content of this document may be changed because of product version upgrade, adjustment, or other reasons. Alibaba Cloud reserves the right to modify the content of this document without notice and an updated version of this document will be released through Alibaba Cloud-authorized channels from time to time. You should pay attention to the version changes of this document as they occur and download and obtain the most up-to-date version of this document from Alibaba Cloud-authorized channels.

4. This document serves only as a reference guide for your use of Alibaba Cloud products and services. Alibaba Cloud provides this document based on the "status quo", "being defective", and "existing functions" of its products and services. Alibaba Cloud makes every effort to provide relevant operational guidance based on existing technologies. However, Alibaba Cloud hereby makes a clear statement that it in no way guarantees the accuracy, integrity, applicability, and reliability of the content of this document, either explicitly or implicitly. Alibaba Cloud shall not take legal responsibility for any errors or lost profits incurred by any organization, company, or individual arising from download, use, or trust in this document. Alibaba Cloud shall not, under any circumstances, take responsibility for any indirect, consequential, punitive, contingent, special, or punitive damages, including lost profits arising from the use or trust in this document (even if Alibaba Cloud has been notified of the possibility of such a loss).

5. By law, all the contents in Alibaba Cloud documents, including but not limited to pictures, architecture design, page layout, and text description, are intellectual property of Alibaba Cloud and/or its affiliates. This intellectual property includes, but is not limited to, trademark rights, patent rights, copyrights, and trade secrets. No part of this document shall be used, modified, reproduced, publicly transmitted, changed, disseminated, distributed, or published without the prior written consent of Alibaba Cloud and/or its affiliates. The names owned by Alibaba Cloud shall not be used, published, or reproduced for marketing, advertising, promotion, or other purposes without the prior written consent of Alibaba Cloud. The names owned by Alibaba Cloud include, but are not limited to, "Alibaba Cloud", "Aliyun", "HiChina", and other brands of Alibaba Cloud and/or its affiliates, which appear separately or in combination, as well as the auxiliary signs and patterns of the preceding brands, or anything similar to the company names, trade names, trademarks, product or service names, domain names, patterns, logos, marks, signs, or special descriptions that third parties identify as Alibaba Cloud and/or its affiliates.

6. Please directly contact Alibaba Cloud for any errors of this document.

Document conventions

Style	Description	Example
Danger	A danger notice indicates a situation that will cause major system changes, faults, physical injuries, and other adverse results.	**Danger:** Resetting will result in the loss of user configuration data.
Warning	A warning notice indicates a situation that may cause major system changes, faults, physical injuries, and other adverse results.	**Warning:** Restarting will cause business interruption. About 10 minutes are required to restart an instance.
Notice	A caution notice indicates warning information, supplementary instructions, and other content that the user must understand.	**Notice:** If the weight is set to 0, the server no longer receives new requests.
Note	A note indicates supplemental instructions, best practices, tips, and other content.	**Note:** You can use Ctrl + A to select all files.
>	Closing angle brackets are used to indicate a multi-level menu cascade.	Click **Settings**> **Network**> **Set network type**.
Bold	Bold formatting is used for buttons , menus, page names, and other UI elements.	Click **OK**.
`Courier font`	Courier font is used for commands	Run the `cd /d C:/window` command to enter the Windows system folder.
Italic	Italic formatting is used for parameters and variables.	`bae log list --instanceid` *Instance_ID*
[] or [a|b]	This format is used for an optional value, where only one item can be selected.	`ipconfig [-all|-t]`
{} or {a|b}	This format is used for a required value, where only one item can be selected.	`switch {active|stand}`

Table of Contents

1.MaxCompute

1.1. What is MaxCompute?

MaxCompute is a data processing platform developed by Alibaba Group to process large volumes of data. MaxCompute provides channels for upload and download, a range of computing and analysis features including SQL and MapReduce, and comprehensive security solutions.

MaxCompute is used to store and compute large volumes of structured data. It provides warehouse solutions for large amounts of data, as well as big data analysis and modeling services.

As data collection techniques are becoming increasingly diverse and comprehensive, industries are amassing larger volumes of data. The scale of data collection has increased from 100 GB to over 1 PB, far exceeding the processing capabilities of traditional software. Analysis tasks for large volumes of data require distributed computing instead of reliance on a single server. However, distributed computing models require skilled data analysts. To use a distributed model, data analysts must understand the business needs and underlying computing model.

MaxCompute is designed to provide an intuitive approach to analyze and process large amounts of data without the need for distributed computing knowledge. MaxCompute is widely implemented within Alibaba's businesses for scenarios such as data warehousing and BI analysis for large Internet enterprises, website log analysis, e-commerce transaction analysis, and exploration of user characteristics and interests.

MaxCompute provides the following features:

- Data channel
  - Tunnel: provides highly-concurrent offline data upload and download services. MaxCompute Tunnel enables you to upload or download a large volume of data to or from MaxCompute. You must use a Java programming API to access MaxCompute Tunnel.
  - DataHub: provides real-time upload and download services. Data uploaded through DataHub is available immediately, while data uploaded through MaxCompute Tunnel is not.
- Computing and analysis
  - SQL: MaxCompute stores data in tables and provides SQL query capabilities. MaxCompute can be used as traditional database software, but it is far more powerful and is capable of processing petabytes of data. MaxCompute SQL does not support transactions, indexes, or operations such as UPDATE and DELETE. The SQL syntax used in MaxCompute is different from that in Oracle and MySQL. SQL statements from other database engines cannot be migrated seamlessly to MaxCompute. MaxCompute SQL responds to queries within a few minutes or seconds, instead of milliseconds. MaxCompute SQL is easy to learn. You can get started with MaxCompute SQL based on your prior experience of database operations, without having a deep understanding of distributed computing.
  - MapReduce: First proposed by Google, MapReduce is a distributed data processing model that has gained extensive attention and been used in a wide range of business scenarios. This document briefly describes the MapReduce model. You must have a basic knowledge of distributed computing and relevant programming experience before using MapReduce. MapReduce provides a Java programming interface.

  - Graph: an iterative graph computing framework provided in MaxCompute. Graph computing jobs use graphs to build models. A graph is a collection of vertices and edges that have values. You can edit and evolve a graph through iteration to obtain the final result. Typical applications include PageRank, single source shortest path (SSSP) algorithm, and K-means clustering algorithm.
  - Unstructured data access and processing (integrated computing scenarios): MaxCompute SQL cannot directly process external data (such as unstructured data from OSS). Data must be imported to MaxCompute tables by using relevant tools before computation. The MaxCompute team introduces the unstructured data processing framework to the MaxCompute system architecture to resolve this problem.

    MaxCompute can process the following data sources by creating external tables:

    - Internal data sources: OSS, Table Store, AnalyticDB, ApsaraDB for RDS, HDFS (Alibaba Cloud), and TDDL.
    - External data sources: HDFS (open source), MongoDB, and Hbase.
  - Unstructured data access and processing (inside MaxCompute): By reading and writing volumes, MaxCompute can store unstructured data, which otherwise must be stored in an external storage system.
- Spark on MaxCompute: a big data analytics engine designed by Alibaba Cloud to provide big data processing capabilities for Alibaba, government agencies, and enterprises. For more information, see Spark on MaxCompute.
- Elasticsearch on MaxCompute: an enterprise-class full-text retrieval system developed by Alibaba Cloud to retrieve large volumes of data. It provides near-real-time (NRT) search performance for government agencies and enterprises. For more information, see Elasticsearch on MaxCompute.
- SDK: a toolkit provided for developers. For more information, see Java SDK.
- Security solution: MaxCompute provides powerful security services to guarantee user data security.

1.2. Usage notes

You can selectively read topics in this document based on your requirements. This topic provides reading suggestions in the document based on user skill level.

Beginners

If you are a beginner, we recommend that you read the following topics:

- What is MaxCompute: The topic provides a general introduction of MaxCompute and its core features. You can obtain general knowledge about MaxCompute.
- Quick start: The topic provides step-by-step examples and instructions on how to perform basic MaxCompute operations, such as installing and configuring the client, creating tables, granting permissions, importing and exporting data, running SQL tasks, running user-defined functions (UDFs), and running MapReduce.
- Basic concepts and common commands: The topic introduces the basic concepts of MaxCompute and common MaxCompute commands. This topic helps familiarize yourself with MaxCompute operations.
- Tools: The topic describes how to download, configure, and use common MaxCompute tools to perform data analysis.

Data analysts

If you are a data analyst, we recommend that you read the following topics:

MaxCompute SQL: The topic describes how to query and analyze large amounts of data stored in MaxCompute. This topic covers the following operations:

- Execute DDL statements CREATE, DROP, and ALERT to manage tables and partitions.
- Execute SELECT statements to select records in a table, and execute WHERE clauses to view the records that meet a specified filtering condition.
- Associate two tables through an EQUIJOIN operation.
- Execute GROUP BY statements to aggregate columns.
- Execute INSERT OVERVIEW or INSERT INTO statements to insert results into another table.
- Use built-in functions and UDFs to complete a variety of computations.
- Use UDTs to reference classes or objects of third-party languages in SQL statements to obtain data or call methods.
- Use UDJs to implement flexible cross-table and multi-table custom operations, and reduce the operations on the underlying details of the distributed system through MapReduce.
- Use the Select Transform feature to simplify the reference of script code.
- Collect table statistics and configure table lifecycles.
- Use regular expressions.

Developers

If you are an experienced developer with basic understanding of distributed computing and need to perform data analysis that cannot be implemented with SQL, we recommend that you read the following topics on advanced MaxCompute functional modules:

- MapReduce is a Java programming model provided by MaxCompute. You can use the API to write MapReduce programs and process MaxCompute data.
- MaxCompute Graph is a processing framework designed that iteratively computes and models graphs. A graph consists of vertices and edges, both of which contain values. MaxCompute Graph iteratively edits and evolves graphs to obtain analysis results.
- Eclipse plugin provides an IDE to help you complete development of MapReduce, UDFs, and Graph.
- Java SDK is a toolkit provided to developers.
- MaxCompute Tunnel allows you to perform batch upload and download operations on offline data to and from MaxCompute.

Project owners or administrators

If you are a project owner or administrator, we recommend that you read the following topics:

Security solution: This topic describes how to authorize users, enable cross-project resource sharing, configure project data protection, and configure authorization policies.

1.3. Preparations

1.3.1. Log on to the ASCM console

This topic describes how to log on to the Apsara Stack Cloud Management (ASCM) console.

Prerequisites

- Before logging on to the ASCM console, make sure that you have obtained the IP address or domain name of the ASCM console from the deployment personnel. The URL used to access the ASCM console is in the following format: https://[IP address or domain name of the ASCM console].
- We recommend that you use the Google Chrome browser.

Procedure

1. In the address bar, enter the URL of the ASCM console. Press Enter.
2. Enter your username and password.

   Obtain the username and password for logging on to the console from the operations administrator.

   > **Note** When you log on to the ASCM console for the first time, you must change the password of your username as instructed. For security concerns, your password must meet the minimum complexity requirements: The password must be 8 to 20 characters in length and must contain at least two types of the following characters: letters, digits, and special characters such as exclamation points (!), at signs (@), number signs (#), dollar signs ($), and percent signs (%).

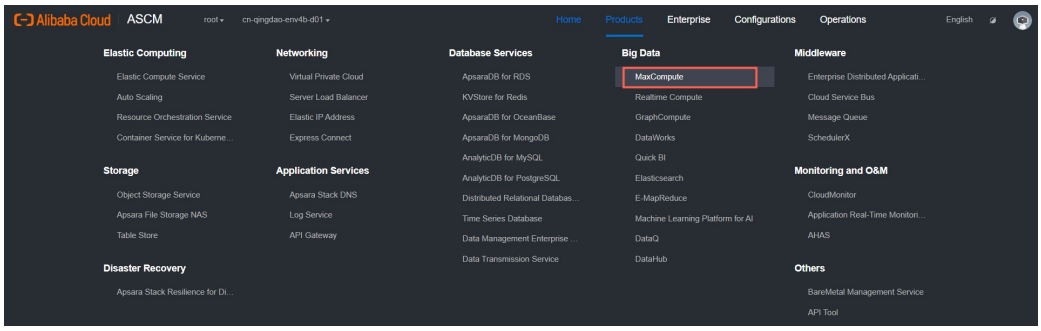
3. Click **Login**.

1.3.2. Prepare an Apsara Stack tenant account

Procedure

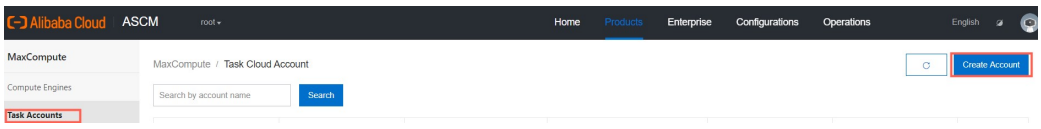
1. Log on to the Apsara Stack Cloud Management (ASCM) console as an administrator.
2. In the top navigation bar, choose **Products > Big Data > MaxCompute** to access the **MaxCompute** page.

   Access the MaxCompute page



3. Click **Task Accounts** in the left-side navigation pane, and click **Create Account** in the upper-right corner.

   Create an account



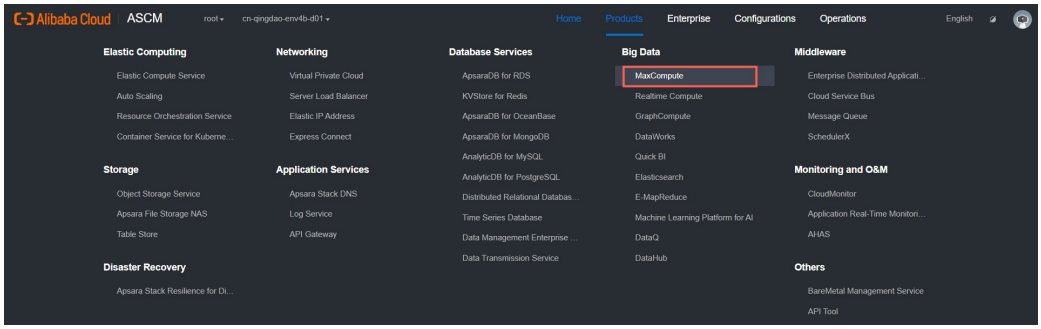
4. In the dialog box that appears, enter account information and click **OK**.

1.3.3. Create a project

Procedure

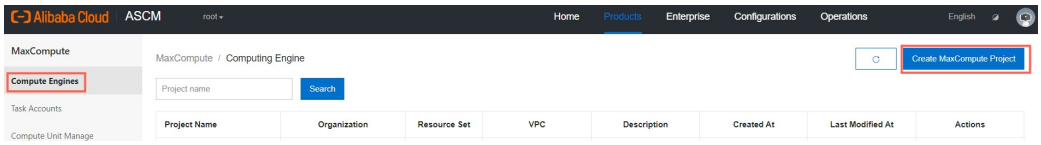
1. Log on to the Apsara Stack Cloud Management (ASCM) console as an administrator.
2. In the top navigation bar, choose **Products > Big Data > MaxCompute** to access the **MaxCompute** page.

   Access the MaxCompute page



3. Click **Compute Engines** in the left-side navigation pane, and click **Create MaxCompute Project** in the upper-right corner.

   Create a project



4. On the page that appears, enter project information and click **Submit**.

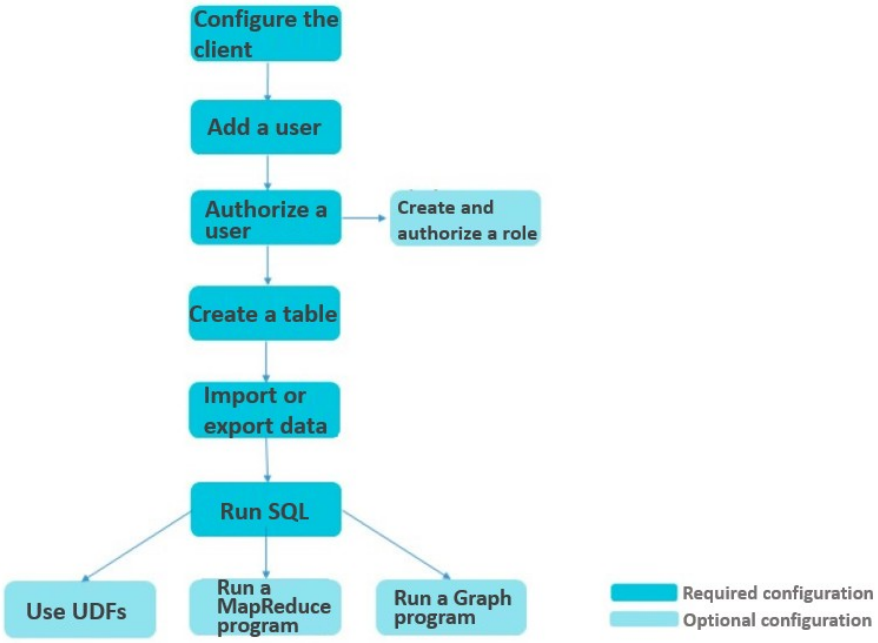
1.4. Quick start

1.4.1. Overview

This topic describes the operation process of MaxCompute. It aims to provide you with step-by-step instructions on basic MaxCompute operations.

MaxCompute operation process shows the procedure.

MaxCompute operation process



1. Configure the client.

   You must install and configure the client to use all the features of MaxCompute.

2. Add a user.

   Except for the project owner, all users must be manually added to a project and granted permissions before they can perform operations on the project.

3. Authorize a user.

   After you add a user, you must authorize the user to perform operations on the project. A user can only perform operations on the project after the user is authorized.

4. (Optional) Create and authorize a role.

   It can be very time-consuming to individually authorize users if a project contains a large number of users. Project administrators can use roles to grant users a specified set of permissions. After you authorize a role, all users assigned this role are granted the same permissions.

5. Create a table.

   After you are added to a project and authorized, you can start to use MaxCompute. Table operations are the most basic operations in MaxCompute.

6. Import or export data.

   You can use the SDK provided by MaxCompute Tunnel to compile your own Java tools and import and export data.

7. Run SQL.

   Only the limits on a few common SQL statements are described here. For more information about how to execute SQL statements, see MaxCompute SQL.

8. Then, you can perform any of the following optional operations:
   - Use UDFs.

After you install the MaxCompute client, you can try to use UDFs. MaxCompute provides three types of UDFs: UDFs, UDAFs, and UDTFs. These functions are collectively known as UDFs.

- Run a MapReduce program.

  After you install the MaxCompute client, you can run a MapReduce program.

- Run a Graph program.

  After you install the MaxCompute client, you can run a Graph program.

1.4.2. Configure the client

You must install and configure the client to use all of the features of MaxCompute.

Context

The client was developed in Java. Make sure that you have JRE 1.8 installed on your local PC. Make sure that you have an Apsara Stack tenant account and have obtained the AccessKey ID and AccessKey secret.

> **Note** Before you configure the client, make sure that you have created a project and obtained the AccessKey ID and AccessKey secret.

Procedure

1. Download the client package to your local PC.
2. Decompress the package to the folder where you want to store the client. The package contains the following four folders:

   ```
   bin/
   conf/
   lib/
   plugins/
   ```

3. Edit the odps_config.ini file in the conf folder as follows:

   ```
   project_name=my_project
   access_id=********************
   access_key=**********************
   end_point= <MaxCompute endpoint>
   ```

> Note
>
> - Set access_id and access_key to the AccessKey ID and AccessKey secret of your Apsara Stack tenant account, respectively.
> - Project_name=my_project specifies the project that you want to access. This is the default project that will be accessed each time you log on to the client. If this parameter is not configured, you must run the `use project_name` command to access the project after you log on to the client.
> - Set end_point to the endpoint of MaxCompute. The endpoint varies depending on the user account.
> - For more information about the client, see MaxCompute client.

4. After the modifications, run the odps file in the bin directory (*./bin/odpscmd* in a Linux system or *./bin/odpscmd.bat* in a Windows system). You are now ready to execute SQL statements. Example:

```
create table tbl1(id bigint);
insert overwrite table tbl1 select count(*) from tbl1;
select 'welcome to MaxCompute!' from tbl1;
```

> Note For information about more SQL statements, see MaxCompute SQL.

1.4.3. Add and delete users

Other than the project owner, all other users must be added to a MaxCompute project and granted the corresponding permissions before they can perform any operations on the project. This topic describes how a project owner can add or delete users in a project.

If you are a project owner, we recommend that you read this topic in full. If you are a common user, we recommend that you submit an application to a project owner to join a project, and read the subsequent topics once you are added to the project.

Add users

Run the following command to add a user:

```
ADD USER <full_username>;
```

Run the following command on the client to add a user (bob@aliyun.com) to a project:

```
add user bob@aliyun.com;
```

If you are not sure whether the user is already in the project, run the following command to view the users in the project:

```
LIST USERS;
```

> Note
>
> - After a user is added to a MaxCompute project, the user must be granted permissions by the project owner. Then, the user can perform operations authorized by the permissions.
> - For more information about authorization, see Grant and view permissions.

Delete users

Run the following command to delete a user:

```
REMOVE USER <full_username>;
```

Run the following command on the client to delete a user from a project:

```
remove user bob@aliyun.com;
```

> Note
>
> - Before you delete a user, make sure that you have revoked all the permissions of the user. If you delete a user without revoking the permissions of the user, the permissions are retained. If the user is added to the project again, the user will have the permissions that were granted previously.
> - For more information about how to add or delete users, see Manage users in a project.

1.4.4. Grant and view permissions

1.4.4.1. Overview

After you add a user, you need to authorize the user. A user can only perform operations on the project after the user is authorized.

Authorization is a process of granting the permission to perform an operation (such as reading, writing, or viewing), on objects (such as tables, tasks, and resources) in MaxCompute.

This topic is intended for project administrators. If you are a regular MaxCompute user, verify that you have obtained the required permissions. You can quickly skim this topic.

MaxCompute provides two authorization mechanisms, ACL authorization and policy authorization.

1.4.4.2. ACL authorization

This topic describes the commands for ACL authorization and provides examples.

ACL authorization in MaxCompute applies to the following objects: project, table, function, resource, instance, and task. Every object has different operation permissions. For more information, see ACL authorization actions.

Command syntax:

```
GRANT privileges ON project_object TO project_subject
REVOKE privileges ON project_object FROM project_subject
privileges ::= action_item1, action_item2, ...
project_object ::= PROJECT project_name | TABLE schema_name |
INSTANCE inst_name | FUNCTION func_name |
RESOURCE res_name | JOB job_name
project_subject ::= USER full_username | ROLE role_name
```

Note You can skip the ROLE clause in the preceding command. It is described in the topics after this.

Example:

```
grant CreateTable on PROJECT $user_project_name to USER ALIYUN$bob@aliyun.com;
-- Grant bob@aliyun.com the permissions to create tables in the project named $user_project_name.
grant Describe on Table $user_table_name to USER ALIYUN$bob@aliyun.com;
-- Grant bob@aliyun.com the permissions to obtain information (Describe permission) in the table named $
$user_table_name.
grant Execute on Function $user_function_name to USER ALIYUN$bob@aliyun.com;
-- Grant bob@aliyun.com the permissions to run the function named $user_function_name.
```

1.4.4.3. Policy authorization

This topic describes the commands for policy authorization and provides an example.

Policy authorization is a principal-based process. For more information, see Authorization policies.

Command syntax:

```
GET POLICY;
PUT POLICY <policyFile>;
GET POLICY ON ROLE <roleName>;
PUT POLICY <policyFile> ON ROLE <roleName>;
```

Example:

```
{
"Version": "1",
"Statement": [
{
"Effect": "Deny",
"Action": [
"odps:*"
],
"Resource": "acs:odps:*:projects/$user_project_name/tables/*",
 "Condition": {
"StringEquals": {
"odps:TaskType": [
"DT"
]
}
}
},
{
"Effect": "allow ",
 "Action": [
"odps:List",
"odps:Read",
"odps:Describe",
"odps:Select"
],
"Resource": [
 "acs:odps:*:projects/$user_project_name/tables/a",
"acs:odps:*:projects/$user_project_name"
],
"Condition": {
 "StringEquals": {
"odps:TaskType": [
          "SQL"
           ]
      }
  }
}
]
}
```

> **Note** The preceding example disables the Tunnel feature of $user_project_name, and grants a user the permissions to perform list, read, describe, and select operations on the project and table a in the project.

1.4.4.4. View permissions

You can run a command to view user permissions in MaxCompute.

Run the following command to view the permissions of a user:

```
show grants for $user_name;
```

> **Note** For more information about how to view user permissions, see View permissions.

1.4.5. Create and authorize a role

If a project has a large number of users, the authorization process is time-consuming. Project administrators can use roles to categorize users with the same permissions. After you authorize a role, all users assigned with this role are granted the same permissions. This topic describes how to create a role and grant permissions to it.

One user can have multiple roles, and multiple users can have the same role.

Create a role

Run the following command to create a role:

```
CREATE ROLE <roleName>;
```

Example:

```
create role player;
```

Add a user to a role

Run the following command to add a user to a role:

```
GRANT <roleName> TO <full_username>;
```

Example:

```
grant player to bob@aliyun.com;
```

Delete a role

Run the following command to delete a role:

```
DROP ROLE <roleName>;
```

Example:

```
drop role player;
```

> **Note** Before you delete a role, make sure that all users have been removed from the role.

Grant permissions to a role

The command for granting permissions to a role is similar to the command for granting permissions to a user. For more information about how to grant permissions to a user, see Grant and view permissions. For more information about role authorization, see Role management.

1.4.6. Create or delete a table

1.4.6.1. Create a table

This topic describes how to create a table.

Run the following command to create a table:

```
CREATE TABLE [IF NOT EXISTS] table_name
[(col_name data_type [COMMENT col_comment], ...)] [COMMENT table_comment]
[PARTITIONED BY (col_name data_type [COMMENT col_comment], ...)] [LIFECYCLE days]
[AS select_statement]
CREATE TABLE [IF NOT EXISTS] table_name
LIKE existing_table_name
```

Example:

```
create table test1 (key string);
-- Create a non-partitioned table.
create table test2 (key bigint) partitioned by (pt string, ds string);
-- Create a partitioned table.
create table test3 (key boolean) partitioned by (pt string, ds string) lifecycle 100;
-- Create a table with a lifecycle.
create table test4 like test3;
-- Table test3 has the same attributes (such as the field type and partition type) as those of test4, except for l
ifecycle.
create table test5 as select * from test2;
-- Create table test5 without replicating the partition and lifecycle information of test2 to it. Only data of tes
t2 is copied to test5.
```

You can set partitions or lifecycles for MaxCompute tables. For more information about how to create a table, see Create a table. For more information about how to modify partitions, see Add a partition and Delete a partition. For more information about how to modify the lifecycle, see Modify the lifecycle of a table.

1.4.6.2. Obtain table information

This topic describes how to obtain the table information.

Command syntax:

```
desc <table_name>;
```

Example:

```
desc test3;
-- Obtain the information about test3.
desc test4;
-- Obtain the information about test4.
```

1.4.6.3. Delete a table

This topic describes how to delete a table.

Run the following command to delete a table:

```
DROP TABLE [IF EXISTS] table_name;
```

Example:

```
drop table test2;
```

> **Note** For more information, see Delete a table.

1.4.7. Import or export data

You can compile your own Java tools by using the SDK provided by MaxCompute Tunnel to import or export data. For the sample code, see Tunnel SDK examples.

1.4.8. Run SQL

1.4.8.1. Overview

This topic describes the limits to a few common SQL statements only. For more information about how to run SQL statements, see MaxCompute SQL.

Note the following issues when using MaxCompute SQL:

- MaxCompute SQL does not support transactions, indexes, or operations such as UPDATE and DELETE.
- The SQL syntax of MaxCompute is different from that of Oracle or MySQL. You cannot seamlessly migrate SQL statements from other database engines to MaxCompute.
- MaxCompute SQL does not respond to queries in real time. It requires a few minutes to return query results, instead of seconds or milliseconds.

1.4.8.2. SELECT statement

This topic describes limits of the SELECT statement.

The following limits apply to the SELECT statement:

- The key of the GROUP BY statement can be the name of a column in the input table, or the expression composed of input table columns. However, it cannot be the output column of the SELECT statement.

```
select substr(col2, 2) from tbl group by substr(col2, 2);
- Allowed: The key of the GROUP BY statement is an expression of columns in the input table.
select col2 from tbl group by substr(col2, 2);
-- Not allowed: The key of the GROUP BY statement is not included in columns of the SELECT statement.
select substr(col2, 2) as c from tbl group by c;
-- Not allowed: The key of the GROUP BY statement is the alias of a column, or output column of the SELECT statement.
```

> **Note** For SQL parsing, the GROUP BY operation is conducted before the SELECT operation, which means the GROUP BY statement can only use the column or expression of the input table as the key.

- DISTRIBUTE BY must be added in front of SORT BY.
- The key of ORDER BY/SORT BY/DISTRIBUTE BY must be the output column of SELECT statement, or the column alias.

```
select col2 as c from tbl order by col2 limit 100
-- Not allowed: The key of the ORDER BY statement is not the output column of the SELECT statement, or the column alias.
select col2 from tbl order by col2 limit 100;
-- Allowed: If an output column of the SELECT statement does not have an alias, the column name is used as the alias.
```

> **Note** For SQL parsing, the ORDER BY, SORT BY, and DISTRIBUTE BY operations come after the SELECT operation. Therefore, they can only accept the output columns of the SELECT statement as the key.

For more information about the SELECT statement, see SELECT statement.

1.4.8.3. INSERT statement

This topic describes the limits of the INSERT statement.

The following limits apply to INSERT statements:

- When an INSERT statement is used to insert data into a partition, the partition column cannot be included in the select list.

```
insert overwrite table sale_detail_insert partition (sale_date='2017', region='china') select shop_name, customer_id, total_price, sale_date, region from sale_detail;
-- An error is returned. The sale_date and region columns are partition columns and are not allowed in a INSERT statement for a static partition.
```

- When an INSERT statement is used to insert a dynamic partition, the dynamic partition column must be included in the select list.

```
insert overwrite table sale_detail_dypart partition (sale_date='2017', region) select shop_name,customer_id,total_price from sale_detail;
-- An error is returned. When a dynamic partition is specified for the insert, the dynamic partition columns must be included among the selected columns.
```

For more information about the INSERT statement, see INSERT statement.

1.4.8.4. JOIN statement

This topic describes the limits of JOIN statements.

The following limits apply to JOIN operations:

- MaxCompute SQL supports the following JOIN operations: {LEFT OUTER|RIGHT OUTER|FULL > OUTER|INNER} JOIN.
- MaxCompute SQL supports a maximum of 128 parallel JOIN operations.

For more information about JOIN operations, see JOIN statement.

1.4.8.5. Other limits

This topic describes the other application limits of MaxCompute SQL.

- MaxCompute SQL supports a maximum of 256 concurrent UNION operations.
- MaxCompute SQL supports a maximum of 256 concurrent INSERT OVERWRITE/INTO operations.

1.4.9. Compile and use UDFs

1.4.9.1. Overview

This topic provides examples on how to compile and use MaxCompute UDFs.

MaxCompute provides three types of UDFs: UDFs, UDAFs, and UDTFs. These functions are collectively known as UDFs.

> Note
>
> - UDFs only support Java APIs. To compile a UDF program, you can upload UDF code to your project by adding resources, and run the CREATE FUNCTION statement to create a UDF.
> - This topic provides examples of UDF, UDAF, and UDTF code.

1.4.9.2. UDF example

This topic uses the convert-to-lowercase function as an example to demonstrate the process of creating a UDF. Specifically, follow these steps:

Procedure

1. Write code. To archive function, write a program and compile in terms of MaxCompute UDF frame.

   ```
   package org.alidata.odps.udf.examples; import com.aliyun.odps.udf.UDF;
   public final class Lower extends UDF { public String evaluate(String s) {
   if (s == null) { return null; } return s.toLowerCase();
   }
   }
   ```

   Name the preceding JAR package *my_lower.jar*.

2. Add resources. Specify the referenced UDF code before running UDF. User code must be added to MaxCompute by adding resources. Java UDFs must be compiled into the JAR package and added in MaxCompute as a JAR resource. The UDF framework loads the JAR package automatically and runs UDF.

   Example of the command to add JAR resources:

   ```
   add jar my_lower.jar;
   ```

   > Note If multiple resources have the same name, rename the JAR package and modify the name of relevant JAR packages in the example command below. You can also use the "f" option to override the existing JAR resources.

3. Register the UDF. When your JAR package is uploaded, MaxCompute does not have any information about this UDF. Therefore, you must register a unique function name in MaxCompute, and specify to which function and under which JAR resources this function name corresponding.

   An example of using commands to register the UDF is as follows:

   ```
   CREATE FUNCTION test_lower AS org.alidata.odps.udf.examples.Lower USING my_lower.jar;
   ```

   Example of the function used in SQL:

   ```
   select test_lower('A') from my_test_table;
   ```

1.4.9.3. UDAF example

This topic provides an example of UDAF code for your reference.

UDAFs are registered in the same way as UDFs and are used in the same way as built-in aggregate functions.

The following UDAF code is for reference only:

```
package org.alidata.odps.udf.examples;
import com.aliyun.odps.io.LongWritable; import com.aliyun.odps.io.Text;
import com.aliyun.odps.io.Writable; import com.aliyun.odps.udf.Aggregator;
import com.aliyun.odps.udf.UDFException;
/**
project: example_project
table: wc_in2
partitions: p2=1,p1=2
columns: colc,colb,cola
*/
public class UDAFExample extends Aggregator {
@Override
public void iterate(Writable arg0, Writable[] arg1) throws UDFException { LongWritable result = (LongWritabl
e) arg0;
for (Writable item : arg1) { Text txt = (Text) item;
result.set(result.get() + txt.getLength());
}
}
@Override
public void merge(Writable arg0, Writable arg1) throws UDFException { LongWritable result = (LongWritable)
arg0;
LongWritable partial = (LongWritable) arg1; result.set(result.get() + partial.get());
}
@Override
public Writable newBuffer() { return new LongWritable(0L);
}
@Override
public Writable terminate(Writable arg0) throws UDFException { return arg0;
}
}
```

1.4.9.4. UDTF example

This topic provides an example of UDTF code for your reference.

UDTFs are registered and used in the similar way to UDFs.

UDTF code example:

```
package org.alidata.odps.udtf.examples;
import com.aliyun.odps.udf.UDTF;
import com.aliyun.odps.udf.UDTFCollector; import com.aliyun.odps.udf.annotation.Resolve; import com.al
iyun.odps.udf.UDFException;
// TODO define input and output types, e.g., "string,string->string,bigint".
@Resolve({"string,bigint->string,bigint"}) public class MyUDTF extends UDTF {
@Override
public void process(Object[] args) throws UDFException { String a = (String) args[0];
Long b = (Long) args[1];
for (String t: a.split("\\s+")) { forward(t, b);
}
}
}
```

1.4.10. Compile and run a MapReduce job

This topic describes how to quickly run a MapReduce program after the MaxCompute client is installed.

Context

A WordCount program is used as an example in this topic.

Before you compile and run a MapReduce program, make sure that the following requirements are met:

- JDK 1.8 has been installed on your host.
- The MaxCompute client has been configured. For more information, see Configure the client.

Procedure

1. Create input and output tables. Example:

   ```
   create table wc_in (key string, value string);
   create table wc_out (key string, cnt bigint);
   ```

   > **Note** For more information about the table creation statement, see Create a table.

2. Use the data transfer tool to upload data. Example:

   ```
   odpscmd -e "tunnel upload kv.txt wc_in"
   ```

3. Compile a MaxCompute program and debug it.
   - MaxCompute provides the Eclipse plug-in to help you quickly develop MapReduce programs and debug them on your local machine.
   - You need to create a MaxCompute project in Eclipse, and then compile a MapReduce program in this project. After successful local debugging, upload the compiled program to MaxCompute for

base testing.

> **Note** If the Java program requires the use of resources, you must use the -resources parameter to specify the resources.

1.4.11. Compile and run a Graph job

You can submit a Graph job in the same way that you would submit a MapReduce job. This topic provides an example of how to submit a Graph job.

Context

This example uses the SSSP algorithm. The operation procedure is as follows:

Procedure

1. Create input and output tables. Example:

```
create table sssp_in (v bigint, es string);
create table sssp_out (v bigint, l bigint);
```

> **Note** For more information about the table creation statement, see Create a table.

2. Use the data transfer tool to upload data. Example:

```
tunnel u -fd " " sssp.txt sssp_in;
```

3. Compile an SSSP.

> **Note** During the Graph development process, you can locally compile and debug SSSP algorithm examples. You only need to package the SSSP code. You do not need to package the SDK into *odps-graph-example-sssp.jar*.

4. Add JAR resources. Example:

```
add jar $LOCAL_JAR_PATH/odps-graph-example-sssp.jar odps-graph-example-sssp.jar
```

> **Note** For more information about how to add resources, see Add resources.

5. Run the SSSP. Example:

```
jar -libjars odps-graph-example-sssp.jar -classpath $LOCAL_JAR_PATH/odps-graph-example-sssp.jar co
m.aliyun.odps.graph.examples.SSSP 1 sssp_in sssp_out;
```

> **Note**
>
> The MaxCompute client provides a jar command to run MaxCompute Graph jobs. This command is used in the same way as you would use the jar command in MapReduce. The Graph job execution command outputs the job instance ID, execution progress, and result summary. The command output is as follows:
>
> ID = 20170730160742915gl205u3 2017-07-31 00:18:36 SUCCESS
>
> Summary:

```
Graph Input/Output Total input bytes=211 Total input records=5 Total output bytes=161
Total output records=5 graph_input_[bsp.sssp_in]_bytes=211 graph_input_[bsp.sssp_in]_records
=5 graph_output_[bsp.sssp_out]_bytes=161 graph_output_[bsp.sssp_out]_records=5 Graph Stati
stics
Total edges=14
Total halted vertices=5 Total sent messages=28 Total supersteps=4 Total vertices=5
Total workers=1 Graph Timers
Average superstep time (milliseconds)=7 Load time (milliseconds)=8
Max superstep time (milliseconds) =14 Max time superstep=0
Min superstep time (milliseconds)=5 Min time superstep=2
Setup time (milliseconds)=277 Shutdown time (milliseconds)=20
Total superstep time (milliseconds)=30 Total time (milliseconds)=344
OK
```

1.4.12. View job running information

This topic describes how to use the LogView tool to query job running information.

LogView is a tool used to view and debug tasks after a job is submitted to MaxCompute. You can use LogView to view the following content of a job:

- Running status of tasks
- Running results of tasks
- Details of each task and the progress of each step

After a job is submitted to MaxCompute, a link to LogView is generated. You can open the link in a browser to view the job running information.

```
odps@ test_workshop001>select * from result_test;

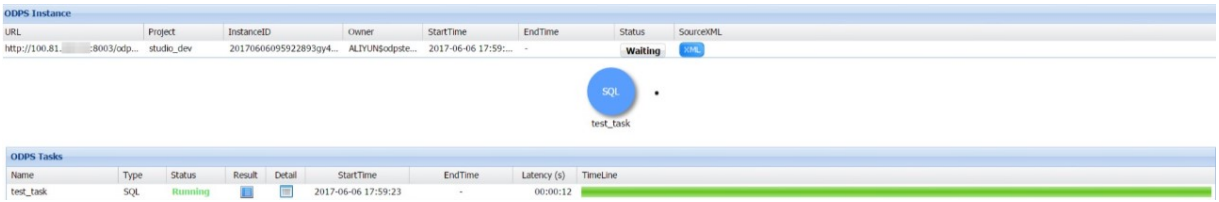
ID = 20190917055240226ga6e5mim
Log view:
http://logview.odps.aliyun.com/logview/?h=http://service.cn.maxcomp
m/api&p=test_workshop001&i=20190917055240226ga6e5mim&token=YkxhUzJQ
1NIamRWNDBBU3VJPSxPRFBTX09CTzoxMDc5OTI2ODk2OTk5NDIxLDE1NjkzMDQzNjAs
nQiOlt7IkFjdGlvbiI6WyJvZHBzOlJ1YWQiXSwiRWZmZWN0IjoiQWxsb3ciLCJSZXNv
3M6b2RwczoqOnByb2plY3RzL3R1c3Rfd29ya3Nob3AwMDEvaW5zdGFuY2UzLzIwMTkw
jI2Z2E2ZTUtaW0iXX1dLCJWZXJzaW9uIjoiMSJ9
Job Queueing...
Summary:

+------------+------------+
| education  | num        |
+------------+------------+
```

Note The LogView page of each job is valid for seven days.

Features

This section describes components on the LogView Web UI.



The LogView page is composed of two parts:

- Instance information
- Task information

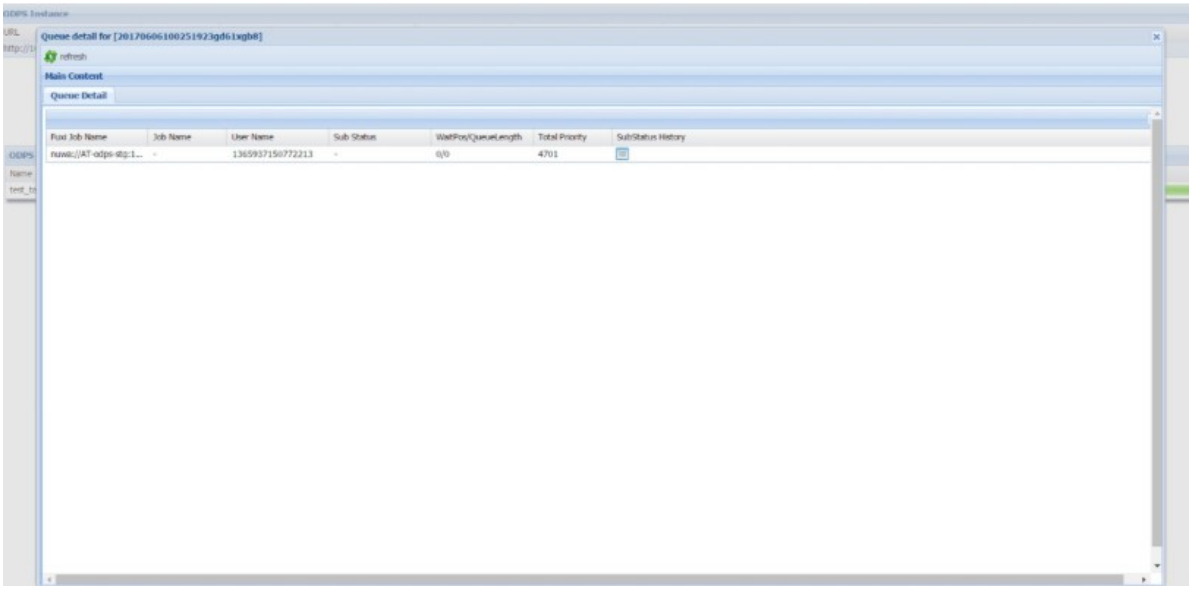
Instance information

The upper pane of the LogView page displays information about the MaxCompute instance corresponding to the SQL tasks that you submit, such as URL, Project, InstanceID, Owner, StartTime, EndTime, and Status.

- If the value of Status is one of the following states, you can click the value to view the queue information:
  - **Waiting**: The job is being processed in MaxCompute and has not been submitted to Job Scheduler.
  - **Waiting List: n**: The job has been submitted to Job Scheduler and is waiting to run in the queue with n-1 other jobs ahead of it.
  - **Running**: The job is running in Job Scheduler.

Note If the value of Status is Terminated, the job has been terminated and has no queue information.

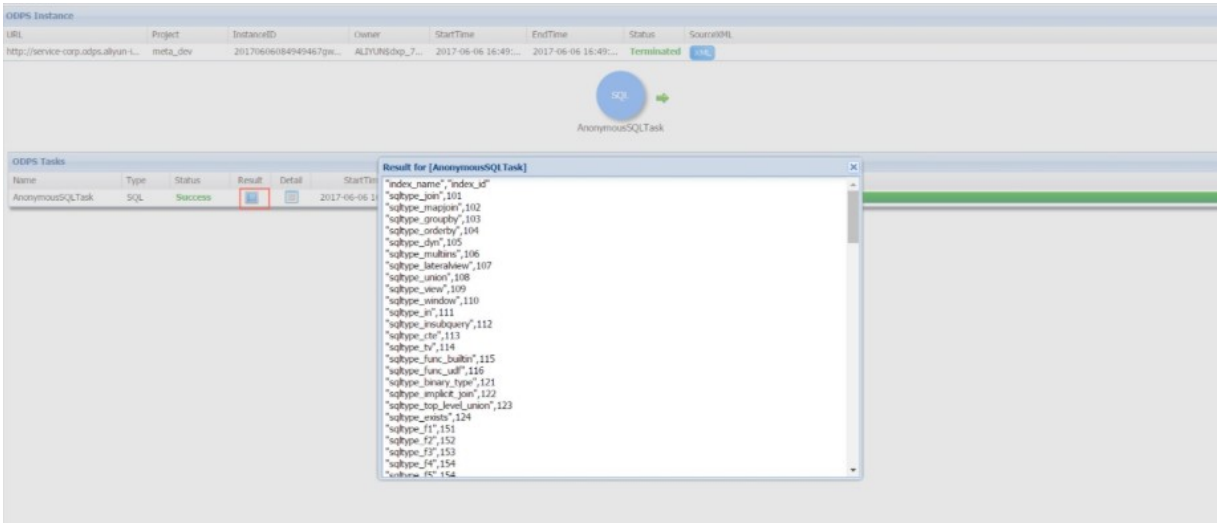
- After you click the value of Status, the following queue information is displayed:
  - **Sub Status**: the current sub-status information.
  - **WaitPos**: the position in the queue. If the value is 0, the job is running. If the value is -, the job has not been submitted to Job Scheduler.
  - **QueueLength**: the total queue length in Job Scheduler.
  - **Total Priority**: the running priority assigned by the system.
  - **SubStatus History**: You can click the icon in this column to view a detailed status history, such as the status code, status description, start time, and duration of a state. This information is unavailable in some versions.



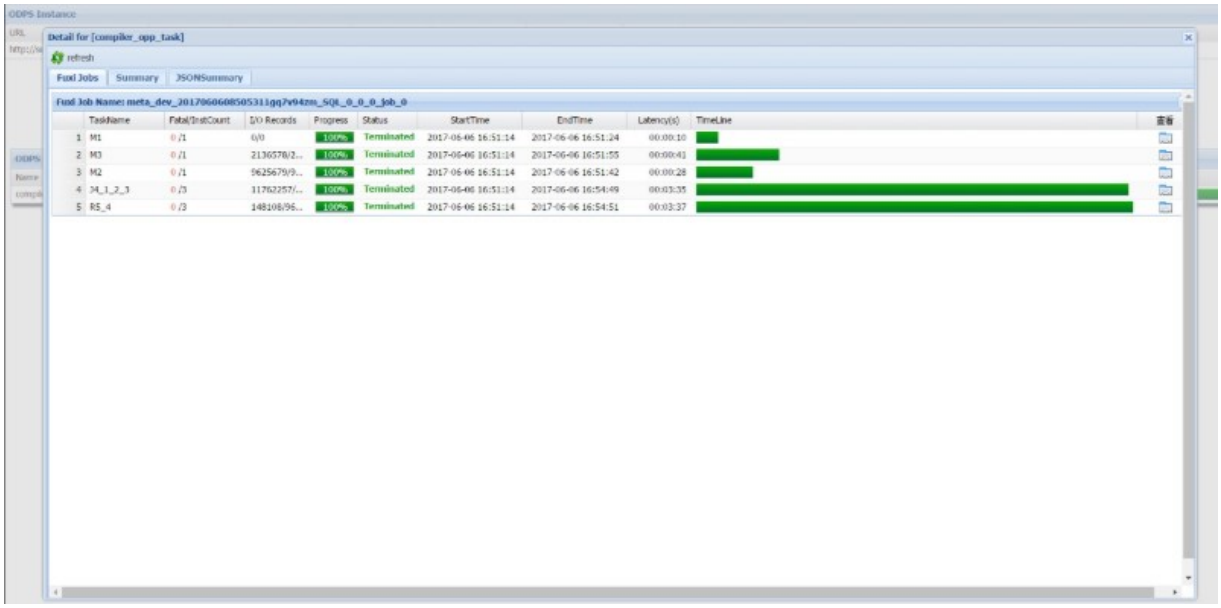
Task information

The lower pane of the LogView page displays the task information corresponding to the instance, such as Name, Type, Status, Result, Detail, StartTime, EndTime, Latency (s), and TimeLine. Like on other pages, latency indicates the total running duration.

Result: You can click the icon in this column to view the task running results after the job is finished. The following figure shows the execution results of a SELECT statement.



Detail: You can click the icon in the **Detail** column to view the task running details regardless of whether the job is running or finished.

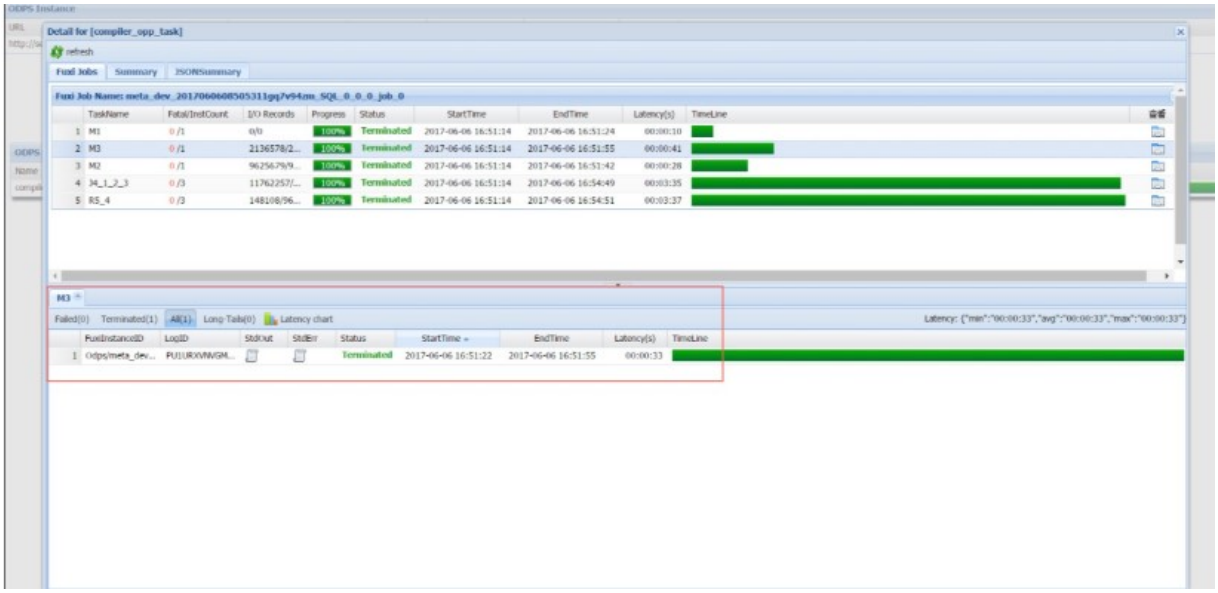


The details about a MaxCompute task are displayed in the detail dialog box. Pay attention to the following points:

- A MaxCompute task consists of one or more Fuxi jobs. For example, if an SQL task that you submit is complex, MaxCompute automatically submits multiple Fuxi jobs to Job Scheduler.
- Each Fuxi job consists of one or more Fuxi tasks. For example, a simple MapReduce task generates two Fuxi tasks: Map Task (M1) and Reduce Task (R2). A complex SQL task may also generate multiple Fuxi tasks.
- The name of a Fuxi task is composed of a letter that indicates the task type and one or more numbers that indicate the task number and its dependencies. For example, in the preceding figure, M1, M2, and M3 are Map tasks, J4_1_2_3 is a Join task that is started after M1, M2, and M3 are finished, and R5_4 is a Reduce task that is started after J4_1_2_3 is finished.
- I/O Records indicates the numbers of input and output records of a Fuxi task.

To view the information about the corresponding instances, you can click the icon in the Show Detail column corresponding to a Fuxi task or double-click the Fuxi task.

> **Note** Each Fuxi task consists of one or more Fuxi instances. As the number of input records of a Fuxi task increases, MaxCompute automatically starts more nodes to help the task process data. Each node corresponds to a Fuxi instance.



In the lower pane of the dialog box, information about the Fuxi instances is displayed in groups. For example, you can click the Failed tab to view the nodes where errors occurred. You can click the icon in the StdOut column to view the standard output information, or click the icon in the StdErr column to view the standard error information.

> **Note** Printed information written in the submitted MaxCompute task is also displayed in the standard output information and standard error information.

Use LogView for troubleshooting

- **Tasks with errors**

  If an error occurs during a task, you can click the icon in the Result column corresponding to the task in the lower pane of the LogView page to view the error information. Alternatively, you can click the icon in the StdErr column corresponding to a Fuxi instance in the detail dialog box to view the error information about the instance.

- **Data skew**

  The long tail of one or more Fuxi instances may slow down the corresponding Fuxi task. The long tail is caused by uneven data distribution in the task. After the task is completed, you can view the running results on the Summary tab of the detail dialog box. The following output provides an example of the running results.

  ```
  output records:
  R2_1_Stg1: 199998999 (min: 22552459, max: 177446540, avg: 99999499)
  ```

  If the difference between the min and max values is large, data skew occurs. For example, if a specific value appears more often than other values in a column, data skew occurs when you execute a JOIN operation based on this field.

1.5. Basic concepts and common commands

1.5.1. Terms

This topic describes the basic terms of MaxCompute.

Project

A basic organizational unit of MaxCompute. Like a database or schema in a traditional database system, a project is the basic unit of multi-user isolation and access control. A user can have permissions on multiple projects. After security authorization, you can access objects such as tables, resources, functions, and instances in a project from another project.

You can run the Use Project command to access a project. Example:

```
use my_project
-- Access a project named my_project.
```

> **Note** After you run the preceding command, you are navigated to a project named my_project and gain permissions to manage objects in this project. You are then able to manage objects that belong to this project, regardless of which project you are currently in. The Use Project command is provided by the MaxCompute client. For more information, see Common commands.

Table

A data storage unit of MaxCompute. Logically, a table is a two-dimensional structure consisting of rows and columns, in which each row represents a record and each column represents a field of the same data type. One record can contain one or more columns. The column names and types constitute the schema of this table. All data in MaxCompute is stored in tables. Data in table columns can be any of the data types supported by MaxCompute. Tables are the input and output objects of all MaxCompute computing tasks. You can create and delete tables, or import data to tables.

Partitions of a table can be defined to process data more efficiently. You can specify some fields in the table as partition columns. Partitions within a table are similar to directories within a file system. Each value of a partition column is called a partition in MaxCompute. You can group multiple fields of a table to a single partition to create a multi-level partition. Multi-level partitions are similar to multi-level directories. If you specify the name of the partition that you want to access, MaxCompute only scans the specified partition. This improves processing efficiency and reduces cost. For more information, see Column and partition operations.

Data type

Columns of a MaxCompute table must be of a certain data type. MaxCompute supports the following data types:

Basic data types

Type	New in MaxCompute 2.0?	Constant	Description	Value range
TINYINT	Yes	1Y,-127Y	The 8-bit signed integer type.	-128 to 127

Type	New in MaxCompute 2.0?	Constant	Description	Value range
SMALLINT	Yes	32767S,-100S	The 16-bit signed integer type.	-32768 to 32767
INT	Yes	1000,-15645787	The 32-bit signed integer type.	-2^{31} to $2^{31}-1$
BIGINT	No	100000000000L,-1L	The 64-bit signed integer type.	$-2^{63}+1$ to $2^{63}-1$
STRING	No	abc, bcd, alibaba, inc	The UTF-8 coded string. The character behaviors of other codes are not defined.	The size of all values in a string column cannot exceed 8 MB.
FLOAT	Yes	None	The 32-bit binary floating point type.	/
BOOLEAN	No	True,False	The Boolean type.	True or False
DOUBLE	No	3.1415926 1E+7	The 64-bit binary floating point type.	$-1.0\ 10^{308}$ to $1.0\ 10^{308}$
DATETIME	No	Datetime '2017-11-11 00:00:00'	The date and time type. The standard system time is UTC+8.	0001-01-01 00:00:00 000 to 9999-12-31 23:59:59 999
DECIMAL	No	3.5BD, 99999999999.9999999BD	The precise numeric type based on the decimal system.	Integer: $-10^{36}+1$ to $10^{36}-1$ Fractional: round to 10^{-18}
VARCHAR	Yes	None	The variable-length type. n specifies the length.	1 to 65535
BINARY	Yes	None	The binary data type.	A single binary column cannot exceed 8 MB.

Type	New in MaxCompute 2.0?	Constant	Description	Value range
TIMESTAMP	Yes	Timestamp '2017-11-11 00:00:00.123456789'	The timestamp type. This type is not time zone specific.	0001-01-01 00:00:00 000000000 to 9999-12-31 23:59:59 999999999

Note that if you want to use the new data types in MaxCompute 2.0, you must first execute the following statement to enable the new data type flag: `set odps.sql.type.system.odps2=true;` (at the session level) or `setproject odps.sql.type.system.odps2=true;` (at the project level). Otherwise, the following error may occur: `xxxx type is not enabled in current mode`. The data types listed in the preceding table can be NULL.

Note Only lowercase letters can be used in the preceding statements.

Notice

Note the following points when you use the new data types in MaxCompute 2.0:

- After you execute the `set odps.sql.type.system.odps2=true;` statement, it results in the following major impacts:
  - The semantics of the INT keyword change. INT in an SQL statement indicates a 32-bit integer.
  - The semantics of an integer constant change. Take the `SELECT 1 + a;` statement as an example.
    - If the new data type flag is not enabled, the integer constant is processed as BIGINT. If the length of the constant exceeds the range for a BIGINT value, the integer constant is processed as DOUBLE.
    - If the new data type flag is enabled, the integer constant is 1 of the 32-bit INT type.
    - Possible compatibility issues: The INT type may lead to inconsistencies in function prototypes during subsequent operations. For example, the actions of peripheral tools and subsequent operations might be changed by new type tables generated after data is written to a disk.
  - Implicit type conversion rules change.

    If the new data type flag is enabled, some implicit types may not be converted. For example, errors may occur or precision may be reduced when the data type is converted from STRING to BIGINT, from STRING to DATETIME, from DOUBLE to BIGINT, from DECIMAL to DOUBLE, or from DECIMAL to BIGINT. In these cases you can use the CAST function to convert the data type.

    Implicit type conversion greatly affects functions and INSERT statements. For example, an INSERT statement can be executed when the new data type flag is disabled, but returns an error when the flag is enabled.

- When the new data type flag is disabled, some operations and built-in functions that use new data types as parameters and response values are ignored. When the new data type flag is enabled, they become valid.
  - Some built-in functions can only be used after the new data type flag is enabled. This includes most functions that use INT type parameters and subsequently suffer from BIGINT overload, such as YEAR, QUARTER, MONTH, DAY, HOUR, MINUTE, SECOND, MILLISECOND, NANOSECOND, DAYOFMONTH, and WEEKOFYEAR. These functions can be implemented by using the DATEPART function.
  - UDF resolution changes.
- The resolution of the BIGINT keyword changes.
- The partition column types change.
  - If the new data type flag is disabled, the partition column type can only be STRING.
  - If the new data type flag is enabled, the partition column type can be STRING, VARCHAR, CHAR, TINYINT, SMALLINT, INT, or BIGINT.
  - If the new data type flag is disabled, partition fields in INSERT operations are processed as STRING.
- The behavior of the LIMIT statement changes.

  Take the `SELECT * FROM t1 UNION ALL SELECT * FROM t2 limit 10;` statement as an example.
  - If the new data type flag is disabled, it is `SELECT * FROM t1 UNION ALL SELECT * FROM ( SELECT * FROM t2 limit 10) t2;` .
  - If the new data type flag is enabled, it is `SELECT * FROM (SELECT * FROM t1 UNION ALL SELECT * FROM t2 ) t limit 10;` .

  Actions of the UNION, INTERSECT, EXCEPT, LIMIT, ORDER BY, DISTRIBUTE BY, SORT BY, and CLUSTER BY statements also change if the new data type flag is enabled.
- The resolution of the IN expression changes.

  Take the a in (1, 2, 3) expression as an example.
  - If the new data type flag is disabled, all the values in the parentheses () must be of the same type.
  - If the new data type flag is enabled, all the values in the parentheses () are implicitly converted to the same type.

- If the value of a constant is greater than the maximum value of INT but less than the maximum value of BIGINT, it is converted to BIGINT. If the constant is greater than the maximum value of BIGINT, it is converted to DOUBLE. If odps.sql.type.system.odps2 is not set to true, MaxCompute retains the conversion and notifies you that the INT data is being processed as the BIGINT type. If odps.sql.type.system.odps2 is not set to true, we recommend that you change these types to BIGINT to prevent confusion.
- VARCHAR constants can be expressed through implicitly converted STRING constants.
- STRING constants can be combined. For example, abc and xyz can be combined as abcxyz. Different parts can be written in different rows.

- Time values in milliseconds cannot be displayed. You can add `-dfp` in the Tunnel command to specify the time display format in milliseconds.

MaxCompute supports complex data types. The following table lists their definitions and constructors.

Complex data types

Type	Definition	Constructor
Array	array< int >; array< struct< a:int, b:string >>	array(1, 2, 3); array(array(1, 2); array(3, 4))
Map	map< string, string >; map< smallint, array< string>>	map("k1", "v1","k2", "v2"); map(1S, array('a', 'b'), 2S, array('x', 'y'))
Struct	struct< x:int, y:int>; struct< field1:bigint, field2:array< int>, field3:map< int, int>>	named_struct('x', 1, 'y', 2); named_struct('field1', 100L, 'field2', array(1, 2), 'field3', map(1, 100, 2, 200)

If PyODPS is used, you can use the following methods to enable the new data type flag:

- You can execute `o.execute_ SQL ('set ODPS. SQL .type.system.odps2=true;query_ SQL ', hints={" ODPS. SQL .submit.mode": "script"})` to enable the new data type flag.
- You can enable the new data type flag by using DataFrame. For example, use an immediately executed action, such as persist, execute, or to_pandas, by setting the hints parameter. The setting in the following figure is valid only for a single job.

```
from odps.df import DataFrame
users = DataFrame(o.get_table('odps2_test'))
users.persist('copy_test',hints={'odps.sql.type.system.odps2':'true'})
```

- To enable the new data type flag by using DataFrame and have the setting take effect globally, you need to execute `options.sql.use_odps2_extension = True`.

Resource

A concept used in MaxCompute. To accomplish tasks by using user-defined functions (UDFs) or MapReduce, you must use resources.

- MaxCompute SQL UDF: After you write a UDF, you must compile it as a JAR package and upload the package to MaxCompute as a resource. When you run the UDF, MaxCompute automatically downloads the JAR package and obtains the code to run this UDF. JAR packages are a type of MaxCompute resource. When you upload a JAR package, a resource is created in MaxCompute.
- MaxCompute MapReduce: After you write a MapReduce program, you must compile it as a JAR

package and upload the package to MaxCompute as a resource. When you run a MapReduce job, the MapReduce framework automatically downloads the JAR package and obtains the code to run this MapReduce job.

> Note
> - There are some limits on how MaxCompute UDFs and MapReduce access resources. For more information, see Limits.
> - You can also upload tables or text files to MaxCompute as different types of resources. You can read or use these resources when you run UDFs or MapReduce jobs. MaxCompute provides APIs for you to read and use resources. For more information, see the examples for resource use and UDTF instructions.

MaxCompute supports the following resource types:

- File
- Table: tables in MaxCompute.
- JAR: compiled JAR packages.
- Archive: compressed files identified by the resource name extension. Supported file types include .zip, .tgz, .tar.gz, .tar, and .jar.
- Py: Python scripts used by Python UDFs.

> Note For more information about resource operations, see Resource operations.

UDF

MaxCompute provides SQL computing capabilities. You can use the built-in functions in MaxCompute SQL statements to implement certain computing or counting functions. If these built-in functions do not meet your requirements, you can use the Java APIs provided by MaxCompute to develop UDFs. UDFs are classified into user-defined scalar functions (UDSFs), user-defined aggregate functions (UDAFs), and user-defined table-valued functions (UDTFs).

After you write the UDF code, you need to compile the code into a JAR package, upload it to MaxCompute as a resource, and register this UDF in MaxCompute. To use a UDF in MaxCompute, you only need to specify its name and parameters in an SQL statement as you do when you use the built-in functions of MaxCompute.

> Note For more information about UDF operations, see Function operations.

Task

A basic computing unit of MaxCompute. Both SQL and MapReduce features are implemented as tasks. MaxCompute parses most of the tasks that you submit, such as SQL DML statements and MapReduce tasks. MaxCompute generates a task execution plan based on the parsing results.

An execution plan consists of several mutually dependent stages. An execution plan can be logically defined as a directed graph. Vertices of the graph represent stages, and edges of the graph represent dependencies between stages. MaxCompute executes stages based on the dependencies in the graph (execution plan). A stage has multiple processes, also known as workers. The workers in each stage cooperate to complete computations for the stage. Different workers in a stage process different data, but they all use the same execution logic.

A computing task converts to an instance when it is executed. You can perform operations on this instance, such as obtaining status information and killing the instance.

Some MaxCompute tasks, such as SQL DDL statements, are not computing tasks. These tasks only need to read and modify metadata in MaxCompute. MaxCompute does not generate execution plans for these tasks.

> **Notice** MaxCompute does not convert all requests to tasks. For example, project, resource, UDF, and instance operations are not executed as tasks.

Task instance

Some MaxCompute tasks are converted to instances during the execution process. An instance has two stages: Running and Terminated. Instances that are in the Running stage are also in the Running state, while instances that are in the Terminated stage can be in the Success, Failed, or Canceled state. You can query or modify the status of a running task by using the instance ID provided by MaxCompute. Example:

```
status <instance_id>;
-- Query the status of an instance.
kill <instance_id>;
-- Terminate an instance and change its status to Canceled.
```

Resource quota

There are two types of resource quota: storage and computing. The storage quota is the upper limit of storage space configured for a project. If the storage usage approaches the storage quota, an alert is triggered. The computing quota limits the use of memory and CPU resources. The memory and CPUs used to run processes in a project cannot exceed the computing quota.

1.5.2. Common commands

1.5.2.1. Introduction

MaxCompute allows you to perform operations on objects, such as projects, tables, resources, and instances. You can use client commands or the SDK to perform operations on these objects.

This topic describes how to run these commands in the MaxCompute client.

> **Note**
> - For more information about how to install and configure the client, see Configure the client.
> - For more information about the SDK, see SDK introduction.

1.5.2.2. Project operations

This topic describes common project commands.

Create or delete a project

MaxCompute does not provide commands for creating or deleting projects. You can configure or operate your projects on the console.

Access a project

Command syntax:

```
use <project_name>;
```

Purpose: It is used to access the specified project. After you enter a project, you can directly operate all objects in the project.

> **Note** If the specified project does not exist or you have not been added to the project, the system returns an exception and exits.

Example:

```
odps@ myproject> use my_project;
-- my_project is a project that you have permission to access.
```

> **Note**
>
> - The preceding command runs in the client.
> - All command keywords, project names, table names, and column names in MaxCompute are case-insensitive.
> - After you run the command, you can directly access objects in this project. Example:
>
>   Run the following command to access the test_src table in the my_project project (assume test_src exists in my_project):
>
>   ```
>   odps@ myproject>select * from test_src;
>   ```
>
>   MaxCompute automatically searches for the table from my_project. If this table exists, its data is returned. Otherwise, the system returns an exception and exits.
>
>   If you are in my_project and want to access the test_src table in my_project2, you must specify the project name. Run the following command to access test_src in my_project2:
>
>   ```
>   odps@ myproject>select * from my_project2.test_src;
>   ```
>
>   Data of test_src in my_project2, not my_project, is returned.

View projects

Command syntax:

```
list projects;
```

Purpose: It is used to display all projects in MaxCompute.

Clear objects from a project

Run the following command to view objects in the recycle bin:

```
show recyclebin;
```

Purpose: It is used to list all objects in the project recycle bin.

> **Note** Only the project owner can run this command.

Run the following command to clear all objects from the project recycle bin:

```
purge all;
```

Purpose: It is used to clear all objects from the project recycle bin to release storage space.

> **Note** Only the project owner can run this command.

Run the following command to clear a table:

```
purge table tblname;
```

Purpose: It is used to clear all objects in a specified table from the recycle bin to release the storage space.

> **Note**
> - If the specified table exists, the project owner and users who have write permissions on the table can run this command.
> - If the table has been deleted using a DROP command, only the project owner can run this command.

1.5.2.3. Table operations

This topic describes common commands for table operations.

Create a table (CREATE TABLE)

Syntax

```
CREATE TABLE [IF NOT EXISTS] table_name
[(col_name data_type [COMMENT col_comment], ...)] [COMMENT table_comment]
[PARTITIONED BY (col_name data_type [COMMENT col_comment], ...)] [LIFECYCLE days]
[AS select_statement];
CREATE TABLE [IF NOT EXISTS] table_name
LIKE existing_table_name;
```

Description: Creates a table.

Example

```
CREATE TABLE IF NOT EXISTS sale_detail( shop_name STRING,
customer_id STRING, total_price DOUBLE)
PARTITIONED BY (sale_date STRING,region STRING);
-- If a table named sale_detail does not exist, a partitioned table with this name is created.
```

> **Note**
> - Table names and column names are not case-sensitive.
> - A table name or column name can contain only letters, digits, and underscores (_) and must start with a letter. It cannot exceed 128 bytes in length.
> - A comment must be a valid string within 1,024 bytes. Otherwise, an error is returned.
> - For more information about the command, see Create a table.

Change the owner of a table (CHANGEOWNER)

Syntax

```
ALTER TABLE table_name CHANGEOWNER to new_owner;
```

Description: Changes the owner of a table.

Example

```
ALTER TABLE test1 CHANGEOWNER to 'ALIYUN$xxx@aliyun.com';
-- Change the owner of table test1 to ALIYUN$xxx@aliyun.com.
```

Delete a table (DROP TABLE)

Syntax

```
DROP TABLE [IF EXISTS] table_name;
```

Description: Deletes a table.

> **Note** If a command without the IF EXISTS option is executed and the table does not exist, an exception is returned. If a command with this option is executed, a success is returned regardless of whether the table exists.

Parameters

table_name: the name of the table you want to delete.

Example

```
DROP TABLE sale_detail;
-- If the sale_detail table exists, a success is returned.
DROP TABLE IF EXISTS sale_detail;
-- A success is returned regardless of whether the sale_detail table exists.
```

View table information (DESC)

Syntax

```
DESC <table_name>;
-- View information about a table or view.
DESC extended <table_name>;
-- View information about an external table.
```

Description: Returns the information about a specified table. The returned information includes Owner, Project, CreateTime, LastDDLTime, LastModifiedTime, InternalTable (indicates that the object is a table. The value is always YES), Size (table size in bytes), Native Columns (information about non-partition columns, including field, type, and comment), Partition Columns (information about partition columns, including partition name, type, and comment), and Extended Info (information about the external table, such as StorageHandler and Location).

Parameters

table_name: In the first command, it indicates the name of a table or view. In the second command, it indicates the name of an external table.

Example

```
odps@ project_name>DESC sale_detail;
-- Describe a partitioned table.
+------------------------------------------------------------------------------------+
| Owner: ALIYUN$odpsuser@aliyun.com | Project: test_project |
|TableComment: |
+------------------------------------------------------------------------------------+
|CreateTime: 2017-01-01 17:32:13 |
|LastDDLTime: 2017-01-01 17:57:38 |
|LastModifiedTime: 2017-01-01 18:00:00 |
+------------------------------------------------------------------------------------+
|InternalTable: YES | Size: 0 |
+------------------------------------------------------------------------------------+
|Native Columns: |
+------------------------------------------------------------------------------------+
|Field | Type | Comment |
+------------------------------------------------------------------------------------+
|shop_name | string | |
|customer_id | string | |
|total_price | double | |
+------------------------------------------------------------------------------------+
|Partition Columns: |
+------------------------------------------------------------------------------------+
|sale_date | string | |
|region | string | |
+------------------------------------------------------------------------------------+
```

Note

- The preceding command is executed in the MaxCompute client.
- If the described object is a non-partitioned table, the Partition Columns field is not displayed.
- If the described object is a view, the InternalTable field is replaced with VirtualView whose value is always YES, and the Size field is replaced with ViewText, which defines View, such as select * > from src. For more information about views, see Create a view.

View partition information (DESC)

Syntax

```
desc table_name partition(pt_spec);
```

Description: Views the partition information of a partitioned table.

Example

```
odps@ project_name>desc meta.m_security_users partition (ds='20151010');
+------------------------------------------------------------------------------------+
| PartitionSize: 2109112                                                             |
+------------------------------------------------------------------------------------+
| CreateTime:          2015-10-10 08:48:48                                           |
| LastDDLTime:         2015-10-10 08:48:48                                           |
| LastModifiedTime:    2015-10-11 01:33:35                                           |
+------------------------------------------------------------------------------------+
OK
```

Show tables (SHOW TABLES/SHOW TABLES LIKE)

Syntax

```
SHOW TABLES;
SHOW TABLES like 'chart'
```

Description

- **SHOW TABLES**: shows all tables in the current project.
- **SHOW TABLES like 'chart'**: shows the tables whose name matches chart in the current project. You can use regular expressions in the command to filter tables.

Example

```
odps@ project_name>show tables;
odps@ project_name>show tables like 'ods_brand*';
ALIYUN$odps_user@aliyun.com:table_name
.....
```

> **Note**
>
> - The preceding commands are executed in the MaxCompute client.
> - odps_user@aliyun.com indicates the name of the user who creates the table.
> - table_name indicates the table name.

Show partitions (SHOW PARTITIONS)

Syntax

```
SHOW PARTITIONS <table_name>;
```

Description: Lists all partitions of a table.

Parameters

table_name: the name of the table that you query. An error is returned if the table does not exist or is a non-partitioned table.

Example

```
SHOW PARTITIONS table_name;
partition_col1=col1_value1/partition_col2=col2_value1
partition_col1=col1_value2/partition_col2=col2_value2
```

> **Note**
> - The preceding command is executed in the MaxCompute client.
> - partition_col1 and partition_col2 indicate the partition columns of the table.
> - col1_value1, col2_value1, col1_value2, and col2_value2 indicate the values in the matching columns.

1.5.2.4. Instance operations

This topic describes common commands for instance operations.

Show instances (SHOW INSTANCES/SHOW P)

Syntax

```
SHOW INSTANCES [FROM startdate TO enddate] [number];
SHOW P [FROM startdate TO enddate] [number];
SHOW INSTANCES [-all];
SHOW P [-all];
SHOW P -p <project name>;
```

Description: Shows information about instances that you have created.

Parameters

- **startdate To enddate**: a period of time. Information about the instances created within the specified period is returned. The dates must be in the format of yyyy-mm-dd. This parameter is optional. If it is not specified, information about instances that you have created in the last three days is returned.
- **number**: the number of instances to be returned. Information about the specified number of instances submitted at the time nearest to the current time is returned in chronological order. If this parameter is not specified, information about all instances that meet the requirements is returned.
- **-all**: Information about instances executed in the current project is returned. By default, a maximum of 50 instances can be returned. You can run the command only when you have the LIST permission on the current project. To return more than 50 instances, you must use the -limit number option. For example, you can run the show p -all -limit 100 command to return information about 100 instances executed in the current project.

- **project name**: the project name. The account that you use must be a member of the project.

Output fields include StartTime (in seconds), RunTime (in seconds), Status (instance status), instanceID, and the SQL statement corresponding to the instance. The following code provides an example of the command output:

```
odps@ $project_name>show p;
StartTime        RunTime  Status  InstanceID            Owner     Query
2015-04-28 13:57:55  1s     Success  20150428xxxxxxxxxxxxxxxxx  ALIYUN$xxxxx@aliyun-inner.com     select *
from tab_pack_priv limit 20;
...  ...  ...  ...  ...  ...
...  ...  ...  ...  ...  ...
```

An instance can be in any of the following states:

- **Running**
- **Success**
- **Waiting**
- **Failed**: The job failed, but data in the target table is not modified.
- **Suspended**
- **Cancelled**

View the status of an instance (STATUS)

Syntax

```
STATUS <instance_id>;
```

Description: Views the status of a specified instance, which can be Success, Failed, Running, or Canceled.

> **Note** If the instance was not created by you, an exception is returned.

Parameters

instance_id: the unique identifier of an instance. It specifies the instance whose status is queried.

Example

```
odps@ $project_name>status 20131225123xxxxxxxxxxxxxxx;
Success
-- Query the status of the instance whose ID is 20131225123xxxxxxxxxxxxxxx. The query result is Success.
```

> **Note** The preceding command is run in the MaxCompute client.

Show running jobs (TOP INSTANCE)

Syntax

```
top instance;
top instance -all;
```

> **Note** Only the project owner and administrator can use the command.

Description

- **top instance**: obtains information about running jobs that you submit in the current project. The output fields include InstanceID, Owner, Type, StartTime, Progress, Status, Priority, RuntimeUsage (CPU/MEM), TotalUsage (CPU/MEM), and QueueingInfo (POS/LEN).
- **top instance -all**: obtains information about all running jobs in the current project. By default, a maximum of 50 jobs are returned. To return more records, use the -limit number option.

Example

```
odps@ $project_name>top instance;
```

> **Note** The preceding command is run in the MaxCompute client.

Stop an instance (KILL)

Syntax

```
kill <instance_id>;
```

Description: Stops an instance. You can only stop an instance in the Running state. Note that this is an abnormal process. A return from the command only means that the system has received the request. It does not mean that the job has been stopped. Therefore, you must run the STATUS command to view the instance status.

Parameters

instance_id: the unique identifier of an instance. It must be the ID of a running instance. Otherwise, an error is returned.

Example

```
odps@ $project_name>kill 20131225123xxxxxxxxxxxxxx;
-- Stop the instance whose ID is 20131225123xxxxxxxxxxxxxx.
```

> **Note** The preceding command is run in the MaxCompute client.

Describe an instance (DESC INSTANCE)

Syntax

```
desc instance <instance_id>;
```

Description: Obtains information about the job corresponding to an instance. The obtained information includes the SQL statement, owner, start time, end time, and status.

Parameters

instance_id: the unique identifier of an instance.

Example

```
odps@ $project_name> desc instance 20150715xxxxxxxxxxxxxxx;
ID                  20150715xxxxxxxxxxxxxxx
Owner               ALIYUN$XXXXXX@alibaba-inc.com
StartTime           2015-07-15 18:34:41
EndTime             2015-07-15 18:34:42
Status              Terminated
console_select_query_task_1436956481295 Success
Query               select * from mj_test;
-- Query information about the job corresponding to the instance whose ID is 20150715xxxxxxxxxxxxxxx.
```

> **Note** The preceding command is run in the MaxCompute client.

Obtain task operation log information (WAIT)

Syntax

```
wait instance_id;
```

Description: Obtains task operation log information based on an instance ID. The returned information includes a link to LogView. You can view log details by using the link.

Parameters

instance_id: the unique identifier of an instance.

Example

```
wait 20170925161122379gxxxxxx;
ID = 20170925161122379g3xxxxxx
Log view:
http://logview.odps.aliyun.com/logview/?h=http://service.odps.aliyun.com/api&p=alian&i=20170925161122
3xxxxxxdqp&token=XXXXXXvbiI6IjEifQ==
Job Queueing...
Summary:
resource cost: cpu 0.05 Core * Min, memory 0.05 GB * Min
inputs:
    alian.bank_data: 41187 (588232 bytes)
outputs:
    alian.result_table: 8 (640 bytes)
Job run time: 2.000
Job run mode: service job
Job run engine: execution engine
M1:
    instance count: 1
    run time: 1.000
    instance time:
        min: 1.000, max: 1.000, avg: 1.000
    input records:
        TableScan_REL5213301: 41187  (min: 41187, max: 41187, avg: 41187
)
    output records:
        StreamLineWrite_REL5213305: 8  (min: 8, max: 8, avg: 8)
R2_1:
    instance count: 1
    run time: 2.000
    instance time:
        min: 2.000, max: 2.000, avg: 2.000
    input records:
        StreamLineRead_REL5213306: 8  (min: 8, max: 8, avg: 8)
    output records:
        TableSink_REL5213309: 8  (min: 8, max: 8, avg: 8)
-- Query the task operation logs of the instance whose ID is 20170925161122379gxxxxxx.
```

> **Note** The preceding command is run in the MaxCompute client.

1.5.2.5. Resource operations

This topic describes common commands for resource operations.

Add a resource (ADD FILE/ARCHIVE/TABLE/JAR/PY)

Syntax

```
add file <local_file> [as alias] [comment 'cmt'][-f];
add archive <local_file> [as alias] [comment 'cmt'][-f];
add table <table_name> [partition <(spec)>] [as alias] [comment 'cmt'][-f];
add jar <local_file.jar> [comment 'cmt'][-f];
add py <local_file.py> [comment 'cmt'][-f];
```

Description: Adds resources to MaxCompute.

The following table lists parameters in this command.

Parameters

Parameter	Description
file/archive/table/jar/py	Indicates the resource type. For more information about resource types, see Resource in Terms.
local_file	Indicates the path of a local file. The file name is used as the resource name, which uniquely identifies the resource.
table_name	Indicates the name of a table in MaxCompute.
[PARTITION (spec)]	If the resource that is added is a partitioned table, MaxCompute only takes a partition as a resource, as opposed to the whole partitioned table.
alias	Indicates the resource name. If this parameter is not specified, the file name is used as the resource name. JAR and Py resources do not support this parameter.
[comment 'cmt']	Indicates a comment on the resource.
[-f]	If a resource with the same name exists, this operation overwrites the existing resource. If this option is not specified and a resource with the same name exists, the operation fails.

Example

```
odps@ odps_public_dev>add table sale_detail partition (ds='20170602') as sale.res comment 'sale detail on 201706 02' -f;
OK: Resource 'sale.res' have been updated.
-- Add a table resource with alias sale.res to MaxCompute.
```

> **Note** The size of each resource file cannot exceed 500 MB. The total size of resources referenced by a single SQL or MapReduce task cannot exceed 2,048 MB.

Delete a resource (DROP RESOURCE)

Syntax

```
DROP RESOURCE <resource_name>;
```

Description: Deletes an existing resource.

Parameters

resource_name: the name of the resource to be deleted. It is specified when the resource is created.

View the resource list (LIST RESOURCES)

Syntax

```
LIST RESOURCES;
```

Description: Lists all resources in the current project.

Example

```
odps@ $project_name>list resources;
Resource Name    Comment    Last Modified Time     Type
1234.txt              2014-02-27 07:07:56    file
mapred.jar            2014-02-27 07:07:57    jar
```

Download a resource (GET RESOURCE)

Syntax

```
GET RESOURCE <resource_name> <path>;
```

Description: Downloads a resource from MaxCompute to a local device. You can download file, JAR, archive, and Py resources, but not table resources.

Parameters

- **resource_name**: the name of the resource to be downloaded.
- **path**: the local path to save the resource.

Example

```
odps@ $project_name>get resource odps-udf-examples.jar d:\;
OK
```

1.5.2.6. Function operations

This topic describes common commands for function operations.

Register a function (CREATE FUNCTION)

Syntax

```
CREATE FUNCTION <function_name> AS <package_to_class> USING<resource_list>;
```

The following table lists parameters in this command.

Parameters

Parameter	Description
function_name	Indicates the UDF name. This name is used in SQL statements to reference this function.
package_to_class	For a Java UDF, package_to_class indicates a fully qualified class name. It consists of names from the top-level package name all the way to the UDF implementation class name, which are separated with periods (.). For a Python UDF, package_to_class indicates the Python script name and class name, which are separated with periods (.). This name must be enclosed in a pair of single quotation marks (').
resource_list	Indicates the list of resources that the UDF uses. The list must include the resource where the UDF code is located. Ensure that the resource is uploaded to MaxCompute before you register the function. If the user code reads resource files by using the distributed cache API, this list must also include all resource files that are read by the UDF. If the resource list contains multiple resources, separate them with commas (,). The resource list must be enclosed in a pair of single quotation marks ('). If you need to specify the project where the resource is located, use the <project_name>/resources/<resource_name> format.

Example

- Assume that Java UDF class org.alidata.odps.udf.examples.Lower is in my_lower.jar. Execute the following statement to create the my_lower function:

  ```
  CREATE FUNCTION my_lower AS 'org.alidata.odps.udf.examples.Lower'
  USING 'my_lower.jar';
  ```

- Assume that Python UDF class MyLower is in the pyudf_test.py script of the test_project project. Execute the following statement to create the my_lower function:

  ```
  create function my_lower as 'pyudf_test.MyLower'
  using 'pyudf_test.py';
  ```

- Assume that Java UDF class com.aliyun.odps.examples.udf.UDTFResource is in udtfexample1.jar and

the function depends on file resource file_resource.txt, table resource table_resource1, and archive resource test_archive.zip. Execute the following statement to create the test_udtf function:

```
create function test_udtf as 'com.aliyun.odps.examples.udf.UDTFResource'
using 'udtfexample1.jar, file_resource.txt, table_resource1,test_archive.zip';
```

Note

- Similar to resource file names, function names must be unique.
- Only the project owner has the permission to use UDFs to overwrite built-in functions. If you use a UDF that overwrites a built-in function, warning information is included in Summary after the SQL statement is executed.

Delete a function (DROP FUNCTION)

Syntax

```
DROP FUNCTION <function_name>;
```

Parameters

function_name: the name of the function you want to delete.

Example

```
DROP FUNCTION test_lower;
```

View the function list (LIST FUNCTIONS)

Syntax

```
LIST FUNCTIONS;
-- View all UDFs in the current project.
LIST FUNCTIONS -p project_name;
-- View all UDFs in a specified project.
```

1.5.2.7. Time zone configuration operations

This topic describes how to use a SET command to configure the time zone of a MaxCompute project.

Time zone configurations

By default, the time zone of a MaxCompute project is UTC+8. The DATETIME, TIMESTAMP, and DATE fields and the related built-in time functions are all calculated based on UTC+8. You can use one of the following methods to configure the time zone:

- **Session level**: Submit the set odps.sql.timezone=<timezoneid>; statement along with a computing statement for execution. Example:

```
set odps.sql.timezone=Asia/Tokyo;
-- Set the time zone to Asia/Tokyo.
select getdate();
-- Query the current time zone.
output:
+------------+
| _c0      |
+------------+
| 2018-10-30 23:49:50 |
+------------+
```

- **Project level**: Execute the setProject odps.sql.timezone=<timezoneid>; statement. Only the project owner has the permission to execute this statement.

> **Notice** After the time zone is set at the project level, it is used in all computing tasks that are time related. The data of existing tasks are also affected. Therefore, set the time zone only when it is absolutely necessary. We recommend that you only set time zones for new projects.

Limits and precautions

- SQL built-in date functions, UDFs, UDTs, UDJs, and the SELECT TRANSFORM statement all support time zone configuration at the project level.
- A time zone must be configured in the format such as Asia/Shanghai, which supports daylight saving time. Do not configure it in the GMT+9 format.
- If the time zone of the SDK differs from that of the project, you must configure the GMT time zone to convert the data type from DATETIME to STRING.
- After you configure the time zone, the output time may be different from the real time when you run the related SQL statements by using DataWorks. For data that is between the years 1900 and 1928, the time difference is 352 seconds. For data that is before the year 1900, the time difference is 9 seconds.
- New versions of MaxCompute, Java SDK, and the related console are provided to ensure that the DATETIME data stored in MaxCompute is correct in multiple time zones. The target Java SDK and console versions have the -oversea suffix. The upgrade may affect the display of the DATETIME data that is before January 1, 1928 in MaxCompute.
- If the local time zone is not UTC+8, we recommend that you upgrade the Java SDK and console to ensure that the SQL-based computing results and data transferred using Tunnel after January 1, 1900 are accurate and consistent. After the upgrade, for the DATETIME data before January 1, 1900, the SQL-based computing results and data transferred using Tunnel may still have a difference of 343 seconds. For the DATETIME data between January 1, 1900 and January 1, 1928 uploaded before the upgrade, the time in the new version is 352 seconds earlier.
- If you do not upgrade the Java SDK and console to the version with the -oversea suffix, the SQL-based computing results and data transferred using Tunnel will have differences. For data before January 1, 1900, the time difference is 9 seconds. For data between January 1, 1900 and January 1, 1928, the time difference is 352 seconds.

> **Note** The time zone of the upgraded Java SDK or console version does not affect the time zone configuration in DataWorks. Therefore, the time zones may vary. You must evaluate the impact on scheduled tasks in DataWorks.

- If you use a third-party client that is connected to MaxCompute by using JDBC, you must set the time zone on the client to ensure the time consistency between the client and the server.
- MapReduce supports time zone configuration.
- Spark supports time zone configuration.
  - If tasks are submitted to the MaxCompute computing cluster, the time zone of the project can be automatically obtained.
  - If tasks are submitted from spark-shell, spark-sql, or pyspark in yarn-client mode, you must configure the spark-defaults.conf parameter of the driver and add the spark.driver.extraJavaOptions -Duser.timezone=America/Los_Angeles statement. The timezone parameter in the preceding statement indicates the time zone to be used.
- PAI supports time zone configuration.
- Graph supports time zone configuration.

1.5.2.8. Tunnel operations

This topic describes common commands for Tunnel operations.

Features

- **UPLOAD**: uploads files or directories (level-1 directories). Data can be uploaded only to a table or a partition of a table. For a partitioned table, you must specify the partition where data is upload.

```
tunnel upload log.txt test_project.test_table/p1="b1",p2="b2";
tunnel upload log.txt test_table --scan=only;
```

- **DOWNLOAD**: downloads a table or partition to a single file. For a partitioned table, specify the partition to be downloaded.

```
tunnel download test_project.test_table/p1="b1",p2="b2" log.txt;
```

- **RESUME**: resumes the transfer of files or directories after a network or Tunnel service error occurs. Dship supports resumable data transfer.

```
tunnel resume;
```

- **SHOW**: displays historical task information.

```
tunnel show history -n 5
tunnel show log
```

- **PURGE**: clears the session directory. Sessions within the past three days are purged by default.

```
tunnel purge 5
```

Use of Tunnel commands

Tunnel commands allows you to obtain help information by using the Help subcommand on the client. Each command and option support short command format:

```
odps@ project_name>tunnel help;
Usage: tunnel <subcommand> [options] [args]
Type 'tunnel help <subcommand>' for help on a specific subcommand.
Available subcommands:
  upload (u)
  download (d)
  resume (r)
  show (s)
  purge (p)
  help (h)
tunnel is a command for uploading data to / downloading data from ODPS.
```

The following table describes parameters in this command.

Parameters

Parameter	Description
upload	Uploads data to MaxCompute tables.
download	Downloads data from MaxCompute tables.
resume	Resumes data upload if a failure occurs. Currently, data download cannot be resumed. Each data upload or download operation is called a session. To resume a session, you must specify the session ID in the RESUME command.
show	Displays historical running information.
purge	Clears the session directory.
help	Provides Tunnel help information.

UPLOAD

Imports data from a local file to a MaxCompute table in append mode. Subcommand syntax:

```
usage: tunnel upload [options] <path> <[project.]table[/partition]>
        upload data from local file
-bs,-block-size <ARG>         block size in MiB, default 100
-c,-charset <ARG>             specify file charset, default ignore.
                              set ignore to download raw data
-cp,-compress <ARG>           compress, default true
-dbr,-discard-bad-records <ARG>  specify discard bad records
                              action(true|false), default false
-dfp,-date-format-pattern <ARG>  specify date format pattern, default
                              yyyy-MM-dd HH:mm:ss
-fd,-field-delimiter <ARG>      specify field delimiter, support
                              unicode, eg \u0001. default ","
-h,-header <ARG>              if local file should have table header,
                              default false
-mbr,-max-bad-records <ARG>     max bad records, default 1000
-ni,-null-indicator <ARG>       specify null indicator string, default
                              ""(empty string)
-rd,-record-delimiter <ARG>     specify record delimiter, support
                              unicode, eg \u0001. default "\n"
-s,-scan <ARG>                specify scan file
                              action(true|false|only), default true
-sd,-session-dir <ARG>        set session dir, default /D:/console/plugins/dship/
-te,-tunnel_endpoint <ARG>      tunnel endpoint
 -threads <ARG>               number of threads, default 1
-tz,-time-zone <ARG>          time zone, default local timezone:
                              Asia/Shanghai
Example:
  tunnel upload log.txt test_project.test_table/p1="b1",p2="b2"
```

The following table describes parameters in this command.

Parameters

Parameter	Description
-bs,-block-size	Specifies the size of each data block uploaded using Tunnel. Default value: 100 MiB (1 MiB = 1,024 × 1,024 bytes).
-c,-charset	Specifies the encoding format of local data files. The default value is UTF-8 without timing. The source data is downloaded by default.
-cp,-compress	Specifies whether to compress the local file before uploading it to reduce traffic. Compression is enabled by default.

Parameter	Description
-dbr	Specifies whether to ignore dirty data, such as additional columns, missing columns, and unmatched types of column data. If the value is true, all data that does not comply with table definitions is ignored. If the value is false, an error is returned when dirty data is found, and raw data in the destination table is not contaminated.
-dfp	Specifies the format of DATETIME data. The default format is yyyy-MM-dd HH:mm:ss.
-fd	Specifies the column delimiter used in the local data file. The default delimiter is comma (,).
-h	Specifies whether the data file has a table header. If the value is true, Dship skips the table header and starts uploading data from the second row.
-mbr,-max-bad-records	If more than 1,000 rows of dirty data are uploaded, the upload operation is terminated by default. This parameter allows you to adjust the maximum allowable volume of dirty data.
-ni	Specifies the NULL data identifier. The default value is an empty string ("").
-rd	Specifies the row delimiter in the local data file. The default value is \n in a Linux system or \r\n in a Windows system.
-s	Specifies whether to scan the local data file. The default value is false. If the value is true, data is scanned first, and is imported if the format is correct. If the value is false, data is imported without scanning. If the value is only, data is scanned but not imported.
-sd,-session-dir	Specifies the path of the session directory. The default value is */D:/console/plugins/dship/lib/...*
-te	Specifies the endpoint of Tunnel.
-tz	Specifies the time zone. The default value is Asia/Shanghai.

Example

Create a table:

```
CREATE TABLE IF NOT EXISTS sale_detail(
  shop_name STRING,
  customer_id STRING,
  total_price DOUBLE)
PARTITIONED BY (sale_date STRING,region STRING);
```

Add a partition:

```
alter table sale_detail add partition (sale_date='201705', region='hangzhou');
```

Prepare the data file data.txt with the following content:

```
shop9,97,100
shop10,10,200
shop11,11
```

The third row of this file does not comply with the definitions of the sale_detail table. sale_detail defines three columns, but the third row of this file contains only two columns. Run the following command to import the data:

```
odps@ project_name>tunnel u d:\data.txt    sale_detail/sale_date=201705,region=hangzhou -s false Upload
session:    20170610163922488 0870a002ec60c
Start upload:d:\data.txt
Total bytes:41 Split input to 1 blocks
2017-06-10 16:39:22 upload block: '1'
ERROR: column mismatch -,expected 3 columns, 2 columns found, please check    data or delimiter
```

The data import fails because of the dirty data in data.txt. The session ID and error message are displayed. You can run the following command to verify the upload result:

```
odps@ odpstest_ay52c_ay52> select * from sale_detail where sale_date='201705'; ID = 20170610084135370g
yvc61z5
+-----------+-------------+-------------+-----------+--------+
shop_name | customer_id | total_price | sale_date | region |
+-----------+-------------+-------------+-----------+--------+
+-----------+-------------+-------------+-----------+--------+
```

DOWNLOAD

Subcommand syntax

```
odps@ project_name>tunnel help download
usage: tunnel download [options] <[project.]table[/partition]> <path>
        download data to local file
 -c,-charset <ARG>            specify file charset, default ignore.
                              set ignore to download raw data
 -cp,-compress <ARG>          compress, default true
 -dfp,-date-format-pattern <ARG>  specify date format pattern, default
                              yyyy-MM-dd HH:mm:ss
 -e,-exponential <ARG>        When download double values, use
                              exponential express if necessary.
                              Otherwise at most 20 digits will be
                              reserved. Default false
 -fd,-field-delimiter <ARG>     specify field delimiter, support
                              unicode, eg \u0001. default ","
 -h,-header <ARG>             if local file should have table header,
                              default false
   -limit <ARG>               specify the number of records to
                              download
 -ni,-null-indicator <ARG>      specify null indicator string, default
                              ""(empty string)
 -rd,-record-delimiter <ARG>    specify record delimiter, support
                              unicode, eg \u0001. default "\n"
 -sd,-session-dir <ARG>       set session dir, defa        /D:/console/plugins/dship/
-te,-tunnel_endpoint <ARG>     tunnel endpoint
   -threads <ARG>             number of threads, default 1
 -tz,-time-zone <ARG>         time zone, default local timezone:Asia/Shanghai
Example:
  tunnel download test_project.test_table/p1="b1",p2="b2" log.txt
```

The following table describes parameters in this command.

Parameters

Parameter	Description
-fd	Specifies the column delimiter used in the local data file. The default delimiter is a comma (,).
-rd	Specifies the row delimiter used in the local data file. The default delimiter is \r\n.
-dfp	Specifies the format of DATETIME data. The default format is yyyy-MM-dd HH:mm:ss.

Parameter	Description
-ni	Specifies the NULL data identifier. The default value is an empty string ("").
-c	Specifies the encoding format of local data files. The default value is UTF-8.

Example

Download data to result.txt:

```
$ ./tunnel download sale_detail/sale_date=201705,region=hangzhou result.txt; Download session: 20170610
1658245283870a002ed0b9
Total records: 2
2017-06-10 16:58:24 download records: 2
2017-06-10 16:58:24 file size: 30 bytes
OK
```

Open the result.txt file and verify that its content is as follows:

```
shop9,97,100.0
shop10,10,200.0
```

RESUME

Resumes the execution of historical operations. Only data upload can be resumed. Subcommand syntax:

```
usage: tunnel resume [session_id] [--force]
        resume an upload session
 -f,-force   force resume
Example:
  tunnel resume
```

Example

Change the content of the data.txt file to the following items:

```
shop9,97,100
shop10,10,200
```

Resume the data upload:

```
odps@ project_name>tunnel resume 20170610163922488 0870a002ec60c --      force;
start resume
20170610163922488 0870a002ec60c
Upload session: 20170610163922488 0870a002ec60c
Start upload:d:\data.txt
Resume 1 blocks
2017-06-10 16:46:42 upload block: '1'
2017-06-10 16:46:42 upload block complete, blockid=1
upload complete, average > speed is 0 KB/s
OK
```

20170610163922488 0870a002ec60c is the ID of the session that failed to be uploaded. You can run the following command to verify the upload result:

```
odps@ project_name>select * from sale_detail where sale_date='201705';
ID = 20170610084801405g0a741z5
+-----------+-------------+-------------+-----------+--------+
shop_name | customer_id | total_price | sale_date | region |
+-----------+-------------+-------------+-----------+--------+
+-----------+-------------+-------------+-----------+--------+
```

SHOW

Displays historical records. Subcommand syntax:

```
usage: tunnel show history [options]
```

Example

```
odps@ project_name>tunnel show history;
  usage: tunnel show history [options]
        show session information
 -n,-number <ARG>   lines
Example:
  tunnel show history -n 5
  tunnel show log
```

PURGE

Clears the session directory. Sessions within the last three days are purged by default. Subcommand syntax:

```
usage: tunnel purge [n]
        force session history to be purged.([n] days before, default
        3 days)
Example:
  tunnel purge 5
```

1.5.2.9. Other operations

This topic describes common commands for other operations.

ALIAS

The ALIAS command is used to create an alias for a resource. You can read different resources from the MaxCompute MapReduce reference manual or UDF code by creating the same alias for these resources.

Syntax

```
ALIAS <alias>=<real>;
```

Description: Creates an alias for a resource.

Parameters

- **alias**: the alias of a resource.
- **real**: the original name of a resource.

Example

```
ADD TABLE src_part PARTITION (ds='20171208') AS res_20171208;
ADD TABLE src_part PARTITION (ds='20171209') AS res_20171209;
-- Add resources res_20171208 and res_20171209.
ALIAS resName=res_20171208;
jar -resources resName -libjars work.jar -classpath ./work.jar com.company.MainClass args ...;
-- Set the alias of resource res_20171208 to resName and call this resource.
ALIAS resName=res_20171209;
jar -resources resName -libjars work.jar -classpath ./work.jar com.company.MainClass args ...;
-- Set the alias of resource res_20171209 to resName and call this resource.
```

> **Note** In the preceding example, different resource tables are referenced by the same resource alias resName in two jobs. Different data is read with the same code.

SET

Syntax

```
set <KEY>=<VALUE>
```

Description: Configures built-in or user-defined system variables of MaxCompute to affect MaxCompute behavior.

Parameters

- **KEY**: the name of the attribute to be set.
- **VALUE**: the value of the attribute.

MaxCompute SQL and the latest MapReduce version support the following SET commands:

```
set odps.stage.mapper.mem=
-- Set the memory size of each map worker. Unit: MB. Default value: 1024.
set odps.stage.reducer.mem=
-- Set the memory size of each reduce worker. Unit: MB. Default value: 1024.
set odps.stage.joiner.mem=
-- Set the memory size of each join worker. Unit: MB. Default value: 1024.
set odps.stage.mem =
-- Set the memory size of all workers of a specified MaxCompute task. This command has a lower priority tha
n the preceding commands. Unit: MB. This parameter is not specified by default.
set odps.stage.mapper.split.size=
-- Set the input data volume of each map worker (size of each slice in the input file) to indirectly control the
number of workers in each map stage. Unit: MB. Default value: 256.
set odps.stage.reducer.num=
-- Set the number of workers in each reduce stage. This parameter is not specified by default.
set odps.stage.joiner.num=
-- Set the number of workers in each join stage. This parameter is not specified by default.
set odps.stage.num=
-- Set the number of concurrent workers in all stages of a specified MaxCompute task. This command has a l
ower priority than the preceding three commands. This parameter is not specified by default.
```

The earlier MapReduce versions of MaxCompute support the following SET commands:

```
set odps.mapred.map.memory=
-- Set the memory size of each map worker. Unit: MB. Default value: 1024.
set odps.mapred.reduce.memory=
-- Set the memory size of each reduce worker. Unit: MB. Default value: 1024.
setodps.mapred.map.split.size=
-- Set the input data volume of each map worker (size of each slice in the input file) to indirectly control the
number of workers in each map stage. Unit: MB. Default value: 256.
set odps.mapred.reduce.tasks=
-- Set the number of workers in each reduce stage. This parameter is not specified by default.
```

Example

- Adjust the cache size pre-defined for a complex column when data is written to MaxCompute tables

to improve write performance.

```
set odps.sql.executionengine.coldata.deep.buffer.size.max=1048576;
```

- Set the input data volume of each map worker to 256 MB.

```
set odps.stage.mapper.split.size=256
```

SETPROJECT

Syntax

```
setproject ["<KEY>=<VALUE>"];
```

Description: Sets project attributes. If < KEY >=< VALUE > is not specified, the current attribute configurations of the project are displayed.

The following table describes project attributes.

Project attributes

Attribute	Permission owner	Description	Value range
odps.table.drop.ignorenonexistent	All users	Indicates whether to report an error when you try to delete a table that does not exist. If the value is true, no error is reported.	true and false
odps.instance.priority.autoadjust	Project owner	Indicates whether to automatically prioritize smaller tasks. If the value is true, this function is enabled.	true and false
odps.instance.priority.level	Project owner	Indicates the priority of a task in a project.	1 to 3 **Note** The value 1 indicates the highest priority.
odps.security.ip.whitelist	Project owner	Indicates an IP address whitelist for the project.	List of IP addresses separated with commas (,).

Attribute	Permission owner	Description	Value range
odps.table.lifecycle	Project owner	**optional**: The lifecycle clause is optional in a table creation statement. If no lifecycle is set for a table, the table does not expire. **mandatory**: The lifecycle clause is mandatory. **inherit**: If no lifecycle is set for a table, the value of odps.table.lifecycle.value is the lifecycle of this table.	optional, mandatory, inherit
odps.table.lifecycle.value	Project owner	Indicates the default lifecycle.	1 to 37231 **Note** The default value is 37231.
odps.instance.remain.days	Project owner	Indicates how long the information about an instance is retained. Unit: days.	3 to 30
odps.task.sql.outerjoin.ppd	Project owner	Indicates whether the filter conditions in FULL OUTER JOIN are pushed down.	true and false
odps.function.strictmode	Project owner	Indicates whether to return NULL (false) or report an error (true) when built-in functions have dirty data.	true and false
odps.task.sql.write.str2null	Project owner	Indicates whether to consider empty strings as NULL (true).	true and false

EXPORT project meta

Syntax

```
export <projectname> <local_path>;
```

Description: Exports the meta of a project to a local file. Meta is represented by statements acceptable by odpscmd. The exported meta file can be used to recreate a project.

SHOW FLAGS

Syntax

```
show flags;
```

Description: Displays parameters configured by using the SET command.

> **Note** This command takes effect only at the project level.

COST SQL

Syntax

```
cost sql <SQL Sentence>;
```

Description: Estimates the measurement information of an SQL statement, including the size of the input data, number of UDFs, and SQL complexity level.

Example

```
odps@ $odps_project >cost sql select distinct project_name, user_name from meta.m_security_users distri
bute by project_name sort by project_name;
ID = 20190715113033121xxxxxxx
Input:65727592 Bytes
UDF:0
Complexity:1.0
```

1.6. MaxCompute SQL

1.6.1. Overview

1.6.1.1. Scenarios

This topic describes the scenarios of MaxCompute SQL.

MaxCompute SQL offline computing is applicable to scenarios where large volumes of data (terabytes) need to be processed, but do not have high real-time requirements. In such scenarios, it takes a relatively long time to prepare and submit each job. MaxCompute SQL is not well-suited for businesses that require to process thousands of transactions per second. MaxCompute SQL online computing provides near real-time (NRT) processing capabilities.

MaxCompute SQL uses the syntax that is similar to SQL syntax. It can be considered as a subset of standard SQL. However, MaxCompute SQL is not equivalent to a database. It does not have common database characteristics, such as transactions, primary key constrains, and indexes. The maximum length of SQL statements currently supported by MaxCompute is 2 MB.

1.6.1.2. Reserved words

Keywords of SQL statements are reserved words in MaxCompute. Do not use reserved words to name tables, columns, or partitions. Otherwise, an error is returned. Reserved words are case-insensitive.

Common reserved words are listed as follows. For a complete list of reserved words, see Reserved words.

```
% & && ( ) * + - . / ; < <= <>
= > >= ? ADD ALL ALTER
AND AS ASC BETWEEN BIGINT BOOLEAN BY
CASE CAST COLUMN COMMENT CREATE DESC DISTINCT
DISTRIBUTE DOUBLE DROP ELSE FALSE FROM FULL
GROUP IF IN INSERT INTO IS JOIN
LEFT LIFECYCLE LIKE LIMIT MAPJOIN NOT NULL
ON OR ORDER OUTER OVERWRITE PARTITION RENAME
REPLACE RIGHT RLIKE SELECT SORT STRING TABLE
THEN TOUCH TRUE UNION VIEW WHEN WHERE
```

1.6.1.3. Partitioned table

Partition columns provide many benefits, such as higher SQL operating efficiency and lower costs. However, too many partitions can cause problems. Using partition columns as filtering conditions in WHERE clauses of SELECT statements can bring greater benefits. Some SQL partition statements run inefficiently. For example, a statement fails when a large volume of data (more than 2,048 MB) is generated in dynamic partitions in a single MaxCompute instance.

It is easy to underestimate the number of partitions generated when multi-level partitions are used. When a huge number of partitions are generated, you must evaluate the original data to determine if there are excessive partitions.

You can create up to six levels of partitions. For some MaxCompute commands, the syntax differs between partitioned and non-partitioned tables. For more information, see DDL statements and DML statements.

For more information about the table creation statement, see Create a table.

1.6.1.4. Type conversion

1.6.1.4.1. Explicit type conversion

Explicit conversion uses CAST to convert a value type to another one. This topic describes explicit type conversion.

The following table lists explicit type conversions supported by MaxCompute SQL.

Explicit type conversion

From/To	Bigint	Double	String	Datetime	Boolean	Decimal
Bigint	-	Y	Y	N	N	Y
Double	Y	-	Y	N	N	Y
String	Y	Y	-	Y	N	Y
Datetime	N	N	Y	-	N	N
Boolean	N	N	N	N	-	N
Decimal	Y	Y	Y	N	N	-

Y indicates that the type can be converted. N indicates that the type cannot be converted.

Note

- When double type values are converted to bigint, the fractional is truncated. For example, cast(1.6 as bigint) = 1.
- When a string that meets double type requirements is converted to bigint, the string is first converted to the double type before it is converted to the bigint type. Hence, the fractional is truncated. For example, cast("1.6" as bigint) = 1.
- When a string that meets bigint type requirements is converted to the double type, one decimal is retained. For example, cast("1" as double) = 1.0.
- To convert a constant string to the decimal type, enclose the constant string within a pair of quotation marks. If the value is not enclosed in quotation marks, it is treated as a double type value. For example, cast("1.234567890123456789" as decimal).
- Unsupported explicit type conversion operations cause an exception.
- If a conversion fails during execution, the system returns an error and exits.
- The datetime data conversion uses the default format yyyy-mm-dd hh:mi:ss. For more information, see Convert data between string and datetime types.
- Some types cannot be explicitly converted, but can be converted using built-in SQL functions. For example, the to_char function can be used to convert boolean type values to the string type. For more information, see TO_CHAR. The to_date function can be used to convert string type values to the datetime type. For more information, see TO_DATE.
- For more information about CAST, see CAST.
- When the values of the decimal type are out of the value range, the cast string to decimal operation may return an error, such as most significant bit overflow or least significant bit overflow truncation.

1.6.1.4.2. Implicit type conversion and its scope

Implicit type conversion is an automatic type conversion performed by MaxCompute based on the context and a predefined set of rules. This topic describes the rules of implicit type conversion.

The following table lists implicit type conversion rules supported by MaxCompute.

Implicit type conversion 1

From/To	BOOLEAN	TINYINT	SMALLINT	INT	BIGINT	FLOAT
BOOLEAN	T	F	F	F	F	F
TINYINT	F	T	T	T	T	T
SMALLINT	F	F	T	T	T	T
INT	F	F	F	T	T	T
BIGINT	F	F	F	F	T	T
FLOAT	F	F	F	F	F	T
DOUBLE	F	F	F	F	F	F
DECIMAL	F	F	F	F	F	F
STRING	F	F	F	F	F	F
VARCHAR	F	F	F	F	F	F
TIMESTAMP	F	F	F	F	F	F
BINARY	F	F	F	F	F	F

Implicit type conversion 2

From/To	DOUBLE	DECIMAL	STRING	VARCHAR	TIMESTAMP	BINARY
BOOLEAN	F	F	F	F	F	F
TINYINT	T	T	T	T	F	F
SMALLINT	T	T	T	T	F	F
INT	T	T	T	T	F	F
BIGINT	T	T	T	T	F	F
FLOAT	T	T	T	T	F	F
DOUBLE	T	T	T	T	F	F

From/To	DOUBLE	DECIMAL	STRING	VARCHAR	TIMESTAMP	BINARY
DECIMAL	F	T	T	T	F	F
STRING	T	T	T	T	F	F
VARCHAR	T	T	T	T	F	F
TIMESTAMP	F	F	T	T	T	F
BINARY	F	F	F	F	F	T

T indicates that the type conversion can be performed, while F indicates that the type conversion cannot be performed.

> **Note**
>
> - An unsupported implicit type conversion will cause an exception.
> - If the conversion fails, an error is returned.
> - Implicit type conversion is automatically performed by MaxCompute based on context. If the types do not match, we recommend that you perform explicit type conversion using cast.
> - The rules of implicit type conversion are applied to different specific scopes. In certain scenarios, only part of the rules will take effect. For more information, see the scope of implicit type conversions.

Implicit type conversion with relational operators

Relational operators include equal to (=), not equal to (<>), less than (<), less than or equal to (<=), greater than (>), greater than or equal to (>=), IS NULL, IS NOT NULL, LIKE, RLIKE, and IN. The implicit conversion rules of LIKE, RLIKE, and IN are different from those of the other relational operators. These three operators are described in a separate section. The rules described in this section do not apply to these three operators. The following table lists implicit conversion rules when different types of data are involved in relational calculations.

Implicit type conversion with relational operators

From/To	BIGINT	DOUBLE	STRING	DATETIME	BOOLEAN	DECIMAL
BIGINT	-	DOUBLE	DOUBLE	N	N	DECIMAL
DOUBLE	DOUBLE	-	DOUBLE	N	N	DECIMAL
STRING	DOUBLE	DOUBLE	-	DATETIME	N	DECIMAL
DATETIME	N	N	DATETIME	-	N	N
BOOLEAN	N	N	N	N	-	N
DECIMAL	DECIMAL	DECIMAL	DECIMAL	N	N	-

> **Note**
> - If implicit type conversion is not supported between two values to be compared, the relational operation cannot be completed and an error is returned.
> - For more information about relational operators, see Relational operators.

Implicit conversion with special relational operators

Special relational operators are LIKE, RLIKE, and IN.

LIKE and RLIKE are used as follows:

```
source like pattern;
source rlike pattern;
```

Note the following points for the two relational operators in implicit type conversion:

- The source and pattern parameters of LIKE and RLIKE must be of the string type.
- Other types are not supported by this operation and cannot be implicitly converted to the STRING type.
- If the value of source or pattern is NULL, the operation returns NULL.

IN is used as follows:

```
key in (value1, value2,...)
```

The implicit conversion rules of IN are as follows:

- The data types in the value list specified by IN must be consistent.
- If keys and values are compared, the BIGINT, DOUBLE, and STRING types compared are converted to DOUBLE, whereas the DATETIME and STRING types compared are converted to DATETIME. Conversion between other types is not allowed.

Note the following points for the IN operator:

The memory used by the compiler increases with the number of parameters used by the IN operation. An IN operation with 5,000 parameters consumes 17 GB of memory with the GCC compiler. We recommend that you limit the number of parameters to around 1,024. In this case, memory consumption will peak at 1 GB and compilation will only take 39 seconds.

Implicit type conversion with arithmetic operators

Arithmetic operators include plus (+), minus (-), multiplier (*), divider (/), and percent (%). The implicit conversion rules are as follows:

- Only the STRING, BIGINT, DECIMAL, and DOUBLE types can be used in arithmetic operations.
- Before an arithmetic operation, STRING values are implicitly converted to DOUBLE values.
- When an arithmetic operation involves values of both the BIGINT and DOUBLE types, BIGINT values are implicitly converted to DOUBLE values.
- The DATETIME and BOOLEAN types cannot be used in arithmetic operations.

> **Note** For more information about arithmetic operators, see Arithmetic operators.

Implicit conversion with logical operators

Logical operators include AND, OR, and NOT. The implicit conversion rules are as follows:

- Only the BOOLEAN type can be used in logic operations.
- The other types are not supported by logical operations or implicit type conversions.

> **Note** For more information about logical operators, see Logical operators.

1.6.1.4.3. SQL built-in functions

MaxCompute SQL provides a variety of system functions, which can be used to calculate one or more columns of any row and output any type of data.

The implicit conversion rules as follows:

- In a call of a function, if the data type of an input parameter is not consistent with the data type defined in the function, the data type of the input parameter is converted to the function-defined data type.
- The parameters of each built-in SQL function on MaxCompute can have different requirements for implicit type conversion. For more information, see Built-in functions.

1.6.1.4.4. CASE WHEN

This topic describes the implicit conversion rules of CASE WHEN.

The implicit conversion rules of case when are as follows:

- If the returned data types are only bigint and double, they are converted to the double type.
- If data of the string type is also returned, all data types are converted to string. If a data type cannot be converted to string (for example, boolean), an error is returned.
- Conversion between other types is not allowed.

1.6.1.4.5. Partition column

MaxCompute SQL supports partitioned tables. For the definition of partitioned tables, see DDL statements and DML statements. MaxCompute supports partitions of the following types: tinyint, smallint, int, bigint, varchar, and string.

1.6.1.4.6. UNION ALL

The data type, number of column, and column names involved in UNION ALL operation must all be consistent. Otherwise, an error is returned.

1.6.1.4.7. Conversion between string and datetime types

MaxCompute supports conversion between string and datetime types.

The format used in conversion is yyyy-mm-dd hh:mi:ss.ff3.

Value ranges of units

Unit	String (case-insensitive)	Value range
Year	yyyy	0001-9999
Month	mm	01-12
Day	dd	01-28,29,30,31
Hour	hh	00-23
Minute	mi	00-59
Second	ss	00-59
ms	ff3	00-999

Note

- Leading zeros cannot be omitted. For example, 2017-1-9 12:12:12 is an invalid string and cannot be converted into datetime. It must be written as 2017-01-09 12:12:12.
- Only strings that meet the preceding format requirements can be converted into datetime. For example, cast("2017-12-31 02:34:34" as datetime) converts the "2017-12-31 02:34:34" string into datetime. Similarly, when datetime is converted into strings, the default conversion format is yyyy-mm-dd hh:mi:ss. If you attempt to convert the following examples (or similar strings), the operation will fail and cause an exception.

```
cast("2017/12/31 02/34/34" as datetime)
cast("20171231023434" as datetime)
cast("2017-12-31 2:34:34" as datetime)
```

MaxComppute provides the to_date function, which converts a string type that does not meet the datetime format into datetime type. For more information, see TO_DATE.

1.6.2. Operators

1.6.2.1. Relational operators

This topic describes relational operators in MaxCompute SQL operators.

Relational operators

Operator	Description
A=B	If A or B is NULL, NULL is returned. If A is equal to B, TRUE is returned. Otherwise, FALSE is returned.
A<>B	If A or B is NULL, NULL is returned. If A is not equal to B, TRUE is returned. Otherwise, FALSE is returned.

Operator	Description
A<B	If A or B is NULL, NULL is returned. If A is less than B, TRUE is returned. Otherwise, FALSE is returned.
A<=B	If A or B is NULL, NULL is returned. If A is less or equal to B, TRUE is returned. Otherwise, FALSE is returned.
A>B	If A or B is NULL, NULL is returned. If A is greater than B, TRUE is returned. Otherwise, FALSE is returned.
A>=B	If A or B is NULL, NULL is returned. If A is greater than or equal to B, TRUE is returned. Otherwise, FALSE is returned.
A IS NULL	If A is NULL, TRUE is returned. Otherwise, FALSE is returned.
A IS NOT NULL	If A is not NULL, TRUE is returned. Otherwise, FALSE is returned.
A LIKE B	If A or B is NULL, NULL is returned. A is a string and B is the pattern to be matched. If A matches B, TRUE is returned. Otherwise, FALSE is returned. The percent sign (%) is a wildcard character that matches an arbitrary number of characters. The underscore (_) is a wildcard character that matches a single character. To use these two characters as ordinary characters, use backslashes to escape them: \% and _. 'aaa'like 'a ' = TRUE'aaa' like'a%' = TRUE'aaa'like 'aab' = FALSE'a%b'like 'a\%b' = TRUE'axb'like 'a\%b' = FALSE
A RLIKE B	If A or B is NULL, NULL is returned. A is a string and B is a string constant regular expression. If A matches B, TRUE is returned. Otherwise, FALSE is returned. If B is NULL, the system returns an error and exits.
A IN B	B is a set. If A is NULL, NULL is returned. If A is in B, TRUE is returned. Otherwise, FALSE is returned. If B contains only one element NULL, that is, A IN (NULL), NULL is returned. If B contains NULL, the type of NULL is considered the same as the other elements in B. B must be a constant and have at least one element. All elements must be of the same type.

Double type values have variable precision. We recommend that you do not use the equal sign (=) to compare two double type values. You can subtract between two values of the double type, and then take the absolute value of the result for comparison. When the absolute value is negligible, the two values of the double type are considered equal. For example:

```
abs(0.9999999999 - 1.0000000000) < 0.000000001
-- 0.9999999999 and 1.0000000000 have 10 decimal digits, while 0.000000001 has 9 decimal digits.
-- 0.9999999999 is considered equal to 1.0000000000.
```

Note

- ABS is a built-in function provided by MaxCompute to take the absolute value of its input. For more information, see ABS.
- A value of the double type in MaxCompute can retain 16 valid digits.

1.6.2.2. Arithmetic operators

This topic describes arithmetic operators in MaxCompute SQL operators.

Arithmetic operators

Operator	Description
A + B	If A or B is NULL, NULL is returned. Otherwise, the result of A + B is returned.
A - B	If A or B is NULL, NULL is returned. Otherwise, the result of A - B is returned.
A * B	If A or B is NULL, NULL is returned. Otherwise, the result of A * B is returned.
A / B	If A or B is NULL, NULL is returned. Otherwise, the result of A / B is returned. If both A and B are of the bigint type, the result is of the double type.
A % B	If A or B is NULL, NULL is returned. Otherwise, the result of A % B is returned.
+A	A is returned.
-A	If A is NULL, NULL is returned. Otherwise, -A is returned.

Note

- Only values of the string, bigint, double, and decimal types can be used in arithmetic operations. Values of the datatime and boolean types are not allowed in these operations.
- Before the operation, values of the string type are converted to the double type by implicit type conversion.
- When values of the bigint and double types are involved in an operation, values of the bigint type are converted to the double type by implicit type conversion first. The returned result is a value of the double type.
- When both A and B are of the bigint type, the returned result of A / B is a value of the double type. The returned results of the other arithmetic operations are values of the bigint type.

1.6.2.3. Bitwise operators

This topic describes bitwise operators in MaxCompute SQL operators.

Bitwise operators

Operator	Description
A & B	Returns the bitwise AND result of A and B. For example, 1 & 2 returns 0 and 1 & 3 returns 1. The bitwise AND result of NULL in combination with another value is always NULL. A and B must be of the bigint type.
A | B	Returns the bitwise OR result of A and B. For example, 1 | 2 returns 3 and 1 | 3 returns 3. The bitwise OR result of NULL in combination with another value is always NULL. A and B must be of the bigint type.

Notice Bitwise operators only support bigint type data and do not support implicit type conversion.

1.6.2.4. Logical operators

This topic describes logical operators in MaxCompute SQL operators.

Logical operators

Operator	Description
A and B	TRUE and TRUE = TRUE
	TRUE and FALSE = FALSE
	FALSE and TRUE = FALSE
	FALSE and NULL = FALSE
	FALSE and FALSE = FALSE
	NULL and FALSE = FALSE
	TRUE and NULL = NULL
	NULL and TRUE = NULL
	NULL and NULL = NULL
A or B	TRUE or TRUE = TRUE
	TRUE or FALSE = TRUE
	FALSE or TRUE = TRUE
	FALSE or NULL = NULL
	NULL or FALSE = NULL
	TRUE or NULL = TRUE
	NULL or TRUE = TRUE

Operator	Description
	NULL or NULL = NULL
NOT A	If expression A is NULL, NULL is returned.
	If expression A is TRUE, FALSE is returned.
	If expression A is FALSE, TRUE is returned.

Note Only data of the boolean type can be involved in logic operations. These operations do not support implicit type conversion.

1.6.3. DDL statements

1.6.3.1. Table operations

1.6.3.1.1. Create a table

This topic describes how to run a DDL statement to create a table.

Command syntax:

```
create table [if not exists] table_name
[(col_name data_type [comment col_comment], ...)] [comment table_comment]
[partitioned by (col_name data_type [comment col_comment], ...)] [lifecycle days]
[as select_statement]
create table [if not exists] table_name like existing_table_name
```

Note

- Table names and column names are case-insensitive.
- If the command is run without the IF NOT EXISTS option and another table with the same name exists, an error is returned. With this option, a success is returned regardless of whether a table with the same name exists, even if the structure of the existing table is different from that of the table to be created. The metadata of the existing table does not change.
- Supported data types are bigint, double, boolean, datetime, decimal, string, Array < T >, and Map < T1, T2 >.
- A table name or column name cannot contain special characters. It can contain only lowercase English letters (a to z), uppercase English letters (A to Z), numbers, or underscores (_). A name must start with an English letter and cannot exceed 128 bytes.
- PARTITIONED BY specifies partition fields of the table. Only the string type is supported. A partition name cannot contain double-byte characters. It must start with an English letter (uppercase or lowercase) and contain English letters or numbers. A name cannot exceed 128 bytes. Supported special characters are space, colon (:), underscore (_), dollar sign ($), pound sign (#), period (.), exclamation point (!), and at symbol (@). Other characters such as \t, \n, and forward slash (/) are considered as undefined characters. After you use partition fields to define partitions for a table, a full table scan will not be triggered when you add partitions, update partition data, or read partition data. This improves processing efficiency.
- A comment is a valid string within 1,024 bytes.
- Lifecycle indicates the lifecycle of the table in days. The CREATE TABLE LIKE statement does not replicate the lifecycle attribute from the source table.
- Theoretically, a source table can have up to six levels of partitions. Use as few partitions as possible to avoid extreme table expansion on storage.
- You can configure the maximum number of table partitions for a project. The default number is 60,000.

Example:

Create a table named sale_detail to store sales records. Use the sale_date and region columns of the table as partition columns.

```
create table if not exists sale_detail( shop_name string,
customer_id string,
total_price double)
partitioned by (sale_date string,region string);
 -- Create a partitioned table named sale_detail.
```

You can also run the `create table ··· as select ..` statement to create a table and replicate data to it:

```
create table sale_detail_ctas1 as select * from sale_detail;
```

> **Note** If there is data in sale_detail, all the data is replicated to sale_detail_ctas1. Note that sale_detail is a partitioned table. The `create table ... as select ...` statement does not replicate its partition attribute to sale_detail_ctas1. Partition columns in sale_detail become ordinary columns in sale_detail_ctas1. Therefore, sale_detail_ctas1 is a non-partitioned table with five columns.

In the `create table ... as select ...` statement, if you use constants as column values in the SELECT clause, we recommend that you specify column aliases:

```
create table sale_detail_ctas2 as select shop_name,
customer_id, total_price,
'2017' as sale_date,
'China' as region from sale_detail;
```

> **Note**
>
> If you do not specify column aliases, the fourth and fifth columns of sale_detail_ctas3 created in the following example will have names automatically generated by the system, such as _c3 and _c4.
>
> ```
> create table sale_detail_ctas3 as select shop_name,
> customer_id, total_price, '2017',
> 'China'
> from sale_detail;
> ```
>
> In this case, to reference the columns in sale_detail_ctas3, you must include the column names in grave accents, as shown in the following example. If you run select c3, _c4 from sale_detail_ctas3, the system returns an error and exits. MaxCompute SQL does not support column names starting with an underscore (_). You must enclose column names in grave accents. We recommend that you use aliases to avoid this problem.
>
> ```
> select `_c3`, `_c4` from sale_detail_ctas3;
> ```

Run the following `create table ... like` statement to create a table with the same structure as the source table:

```
create table sale_detail_like like sale_detail;
```

> **Note** The structure of sale_detail_like is exactly the same as that of sale_detail. Both tables have the same attributes, such as the column name, column comment, and table comment, except for lifecycle. However, data in sale_detail is not replicated to sale_detail_like.

1.6.3.1.2. Delete a table

This topic describes how to run a DDL statement to delete a table.

Command syntax:

```
drop table [if exists] table_name;
```

> **Note** If the command is run without the IF EXISTS option and the table does not exist, an exception is returned. With this option, a success is returned regardless of whether the table exists.

Example:

```
create table sale_detail_drop like sale_detail; drop table sale_detail_drop;
-- If the table exists, a success is returned. If not, an exception is returned.
drop table if exists sale_detail_drop2;
-- A success is returned regardless of whether sale_detail_drop2 exists.
```

1.6.3.1.3. Rename a table

This topic describes how to run a DDL statement to rename a table.

Command syntax:

```
alter table table_name rename to new_table_name;
```

> **Note**
> - The rename operation only changes the table name, not the table data.
> - If the table specified by new_table_name already exists, an error is returned.
> - If the table specified by table_name does not exist, an error is returned.

Example:

```
create table sale_detail_rename1 like sale_detail;
alter table sale_detail_rename1 rename to sale_detail_rename2;
```

1.6.3.1.4. Modify the comment of a table

This topic describes how to run a DDL statement to modify the comment of a table.

Command syntax:

```
alter table table_name set comment 'tbl comment';
```

> Note
>
> - table_name must be an existing table.
> - A comment can contain a maximum of 1,024 bytes.

Example:

```
alter table sale_detail set comment 'new coments for table sale_detail';
```

You can run the desc command to view the modified comment in the table. For more information, see Obtain table information.

1.6.3.1.5. Modify the lifecycle of a table

MaxCompute provides the lifecycle management function to release storage space and simplify the data clearance process. This topic describes how to run a DDL statement to modify the lifecycle of a table.

Command syntax:

```
alter table table_name set lifecycle days;
```

> Note
>
> - The days parameter indicates the lifecycle of a table. Unit: days. It must be a positive integer.
> - If the table specified by table_name is a non-partitioned table, and is not modified in the period specified by the days parameter since the last modification date, MaxCompute automatically clears the table (similar to the DROP TABLE operation). In MaxCompute, the LastDataModifiedTime value of a table is updated each time data in the table is modified. MaxCompute determines whether to clear a table based on its LastDataModifiedTime and lifecycle settings.
> - If the table specified by table_name is a partitioned table, MaxCompute determines whether to clear each partition based on the LastDataModifiedTime value. Unlike non-partitioned tables, a partitioned table is not deleted after the last partition is reclaimed.
> - You can configure a lifecycle for tables, but not for partitions.
> - You can specify a lifecycle when creating a table.

Example:

```
create table test_lifecycle(key string) lifecycle 100;
-- Create a table named test_lifecycle with a lifecycle of 100 days.
alter table test_lifecycle set lifecycle 50;
-- Change the lifecycle of the test_lifecycle table to 50 days.
```

1.6.3.1.6. Disable the lifecycle

In special cases, you may not want certain partitions to be automatically recycled by the lifecycle function. In such cases, you can disable the lifecycle function for the partition. This topic describes how to run a DDL statement to disable the lifecycle function.

Command syntax:

```
ALTER TABLE table_name partition[partition_spec] ENABLE|DISABLE LIFECYCLE;
```

Example:

```
ALTER TABLE trans PARTITION(dt='20141111') DISABLE LIFECYCLE;
```

1.6.3.1.7. Modify the LastDataModifiedTime value of a table

MaxCompute SQL supports the TOUCH operation, which allows you to modify the LastDataModifiedTime value of a table. This operation changes the LastDataModifiedTime value of a table to the current time. This topic describes how to run a DDL statement to modify the LastDataModifiedTime value of a table.

Command syntax:

```
alter table table_name touch;
```

> **Note**
>
> - If the specified table_name does not exist, an error is returned.
> - This operation modifies the LastDataModifiedTime value of the table. In this case, MaxCompute considers a change to the table data, and recalculates the lifecycle.

For more information about how to modify the LastDataModifiedTime value of a partition, see Modify the LastDataModifiedTime value of a partition.

1.6.3.1.8. Clear data from a non-partitioned table

This topic describes how to run a DDL statement to clear data from a non-partitioned table.

Command syntax:

```
TRUNCATE TABLE table_name;
```

> **Note** This statement is used to clear data from a specified non-partitioned table. To clear data from a partitioned table, run the `ALTER TABLE table_name DROP PARTITION (partition_spec)` statement.

1.6.3.1.9. Archive table data

This topic describes how to run a DDL statement to archive the data of a table.

If a project does not have enough space, you can use the table archiving feature in MaxCompute to compress data by about 50%. The archiving feature uses a compression algorithm with a higher compression ratio. It saves data as redundant array of independent disks (RAID) files. Data is no longer simply stored in three copies. Instead, six copies and three check blocks are maintained to increase the effective storage ratio from 1:3 to 1:1.5. The archive feature consumes only half of the usual physical space.

However, this feature comes at a price. If a data block or machine is damaged, the time required to restore the data is longer, and the read performance is affected. Therefore, this feature is suitable for compressing cold data for storage. For example, you can store large volumes outdated log data as RAID files for a long time.

Command syntax:

```
ALTER TABLE [table_name] <PARTITION(partition_name='partition_value')> ARCHIVE;
```

Example:

```
alter table my_log partition(ds='20170101') archive;
```

Command output:

```
Summary:
table name: test0128 /pt=a instance count: 1 run time: 21
before merge, file count: 1 file size: 456 file physical size: 1368
after merge, file count: 1 file size: 512 file physical size: 768
```

> **Note**
>
> The output shows the changes in logical size and physical size during the archiving process. In the archiving process, multiple small files are automatically merged. After the archive operation is complete, you can run the `desc extended` command to check whether the data in the partition has been archived, and view the physical space usage:

```
desc extended my_log partition(ds='20170101');
+------------------------------------------------------------------------------------+
PartitionSize: 512 |
+------------------------------------------------------------------------------------+
CreateTime: 2017-01-28 07:05:20 |
LastDDLTime: 2017-01-28 07:05:20 |
LastModifiedTime: 2017-01-28 07:05:21 |
+------------------------------------------------------------------------------------+
```

1.6.3.1.10. Forcibly delete data from a table (partition)

If you need to forcibly and irrecoverably delete data from a table or partition to immediately release storage space, you can perform the deletion operation with the PURGE option. This topic describes how to run a DDL statement to forcibly delete data from a table (partition).

Command syntax:

```
DROP TABLE tblname PURGE;
ALTER TABLE tblname DROP PARTITION(part_spec) PURGE;
```

Example:

```
drop table my_log purge;
alter table my_log drop partition (ds='20170618') purge;
```

1.6.3.2. View-based operation

1.6.3.2.1. Create a view

This topic describes how to run a DDL statement to create a view.

Command syntax:

```
create [or replace] view [if not exists] view_name
[(col_name [comment col_comment], ...)]
[comment view_comment]
[as select_statement]
```

> **Note**
>
> - To create a view, you must have read permissions on the table referenced by the view. Views in MaxCompute are not materialized views. View operations involve accessing data of referenced tables. Note that changes to your permission on the referenced table can result in changes to your permission on the view.
> - A view can contain only one valid SELECT statement.
> - A view can reference other views but cannot reference itself. Circular reference is not supported.
> - You cannot write data to a view. For example, the INSERT INTO and INSERT OVERWRITE operations do not work on views.
> - If the table referenced by a view changes, you may no longer be able to access the view. For example, a view becomes inaccessible after the table it references is deleted. You must maintain the mappings between referenced tables and views properly.
> - If the CREATE VIEW statement is run without the IF NOT EXISTS option and the view already exists, an exception is returned. In this case, you can run the CREATE VIEW or REPLACE VIEW statement to recreate a view. The permissions on the recreated view remain unchanged.

Example:

```
create view if not exists sale_detail_view
(store_name, customer_id, price, sale_date, region)
comment 'a view for table sale_detail'
as select * from sale_detail;
```

1.6.3.2.2. Delete a view

This topic describes how to run a DDL statement to delete a view.

Command syntax:

```
drop view [if exists] view_name;
```

> **Note** If the command is run without the IF EXISTS option and the view does not exist, an error is returned.

Example:

```
drop view if exists sale_detail_view;
```

1.6.3.2.3. Rename a view

This topic describes how to run a DDL statement to rename a view.

Command syntax:

```
alter view view_name rename to new_view_name;
```

> **Note** If a view with the same name already exists, an error is returned.

Example:

```
create view if not exists sale_detail_view
(store_name, customer_id, price, sale_date, region)
comment 'a view for table sale_detail'
as select * from sale_detail;
alter view sale_detail_view rename to market;
```

1.6.3.3. Column and partition operations

1.6.3.3.1. Add a partition

This topic describes how to add a partition by using a DDL statement.

Command syntax:

```
alter table table_name add [if not exists] partition partition_spec
partition_spec:(partition_col1 = partition_col_value1, partition_col2 = partiton_col_value2, ...)
```

> **Note**
>
> - If the command is run without the IF NOT EXISTS option and another partition with the same name exists, an error is returned.
> - You can create up to 60,000 partitions in a single table in MaxCompute.
> - To add a partition to a table that has multi-level partitions, you must specify all partition values.

Example:

The following examples add new partitions to the sale_detail table.

```
alter table sale_detail add if not exists partition (sale_date='201712', region='hangzhou');
-- A partition is added. This partition stores the sales records of the Hangzhou region in December 2017.
alter table sale_detail add if not exists partition (sale_date='201712', region='shanghai');
-- A partition is added. This partition stores the sales records of the Shanghai region in December 2017.
alter table sale_detail add if not exists partition(sale_date='20171011');
-- The command specifies only the sale_date partition, so an error is returned.
alter table sale_detail add if not exists partition(region='shanghai');
-- The command specifies only the region partition, so an error is returned.
```

1.6.3.3.2. Delete a partition

This topic describes how to run a DDL statement to delete a partition.

Command syntax:

```
alter table table_name drop [if exists] partition_spec;
partition_spec:: (partition_col1 = partition_col_value1, partition_col2 = partiton_col_value2, ...)
```

> **Note** If the command is run without the IF EXIST option and the partition does not exist, an error is returned.

Example:

Run the following command to delete a partition from the sale_detail table.

```
alter table sale_detail drop partition(sale_date='201712',region='hangzhou');
-- The sales records of Hangzhou in December 2017 are successfully deleted.
```

1.6.3.3.3. Add a column

This topic describes how to add a column by using a DDL statement.

Command syntax:

```
alter table table_name add columns (col_name1 type1, col_name2 type2...)
```

> **Note**
>
> - A column can only be one of the following types: bigint, double, boolean, datetime, decimal, string, tinyint, smallint, int, float, varchar, binary, timestamp, array, map, or struct.
> - You can create up to 1,200 columns in a single table in MaxCompute.

1.6.3.3.4. Change a column name

This topic describes how to run a DDL statement to change a column name.

Command syntax:

```
alter table table_name change column old_col_name rename to new_col_name;
```

> **Note**
>
> - You must specify an existing column for old_col_name.
> - You cannot name a column in the table new_col_name.

1.6.3.3.5. Modify the comment of a column or partition

This topic describes how to run a DDL statement to modify the comment of a column or partition.

Command syntax:

```
alter table table_name change column col_name comment 'comment';
```

> **Note**
>
> - The comment cannot exceed 1,024 bytes.
> - The data type and position of a column cannot be changed.

1.6.3.3.6. Modify the LastDataModifiedTime value of a partition

MaxCompute SQL supports the TOUCH operation, which allows you to modify the LastDataModifiedTime value of a partition. This operation changes the LastDataModifiedTime value of a partition to the current time. This topic describes how to run a DDL statement to modify the LastDataModifiedTime value of a partition.

Command syntax:

```
alter table table_name touch partition(partition_col='partition_col_value', ...);
```

> **Note**
>
> - If the specified table_name or partition_col does not exist, an error is returned.
> - If the specified partition_col_value does not exist, an error is returned.
> - This operation modifies the LastDataModifiedTime value of the table. In this case, MaxCompute considers a change to the table or partition value, and recalculates the lifecycle.

For more information about how to modify the LastDataModifiedTime value of a table, see Modify the LastDataModifiedTime value of a table.

1.6.3.3.7. Modify partition values

MaxCompute SQL provides the RENAME operation, which allows you to modify partition values of a table. This topic describes how to run a DDL statement to modify partition values.

Command syntax:

```
ALTER TABLE table_name PARTITION (partition_col1 = partition_col_value1, partition_col2 = partiton_col_value2, ...)
RENAME TO PARTITION (partition_col1 = partition_col_newvalue1, partition_col2 = partiton_col_newvalue2, ...);
```

> **Note**
> - This command cannot modify the names of partition columns. It can only modify the values of the columns.
> - To modify the values in one or more partitions in the case of multi-level partitions, you must specify values of partitions at each level.

1.6.4. DML statements

1.6.4.1. INSERT statement

1.6.4.1.1. Update the data of a table

This topic describes how to run an INSERT statement to update the data of a table.

The INSERT OVERWRITE and INSERT INTO statements are commonly used for data processing in MaxCompute SQL. They are used to save the computing results in the target table for the next computing. The INSERT INTO statement adds data to a table or partition. The INSERT OVERWRITE statement clears the original data before inserting data to a table or partition.

Command syntax:

```
insert overwrite|into table tablename [partition (partcol1=val1, partcol2=val2 ...)] select_statement
from from_statement;
```

> **Note** The INSERT syntax in MaxCompute is different from that in MySQL or Oracle. In MaxCompute, INSERT OVERWRITE or INSERT INTO must be followed by the keyword TABLE, not directly by the table name.

Example:

The following example calculates the sales of different regions in the sale_detail table.

```
create table sale_detail_insert like sale_detail;
alter table sale_detail_insert add partition(sale_date='2017', region='china');
insert overwrite table sale_detail_insert partition (sale_date='2017', region='china') select shop_name, customer_id, total_price from sale_detail;
```

> **Note** When data is updated using an INSERT operation, the mapping between the source and target tables depends on the column sequence in the SELECT clause, instead of the mapping of column names between both tables.

The following statement is also valid:

```
insert overwrite table sale_detail_insert partition (sale_date='2017', region='china')
select customer_id, shop_name, total_price from sale_detail;
-- When the sale_detail_insert table is created, the column sequence is shop_name string, customer_id strin
g, and total_price bigint.
-- When data in sale_detail is inserted to sale_detail_insert, the insertion sequence is customer_id, shop_na
me, and total_price.
-- In this case, data in sale_detail.customer_id is inserted into sale_detail_insert.shop_name.
-- Data in sale_detail.shop_name is inserted into sale_detail_insert.customer_id.
```

When data is inserted into a partitioned table, the partition columns cannot appear in the SELECT list.

```
insert overwrite table sale_detail_insert partition (sale_date='2017', region='china') select shop_name, cust
omer_id, total_price, sale_date, region from sale_detail;
-- An error is returned, because partition columns (sale_date and region) cannot appear in an INSERT statem
ent for a static partition.
```

1.6.4.1.2. Output data to multiple objects

This topic describes how to run the INSERT statement to output data to multiple objects.

MaxCompute SQL allows you to insert data to different result tables or partitions by using one SQL statement.

Command syntax:

```
from from_statement
insert overwrite | into table tablename1 [partition (partcol1=val1, partcol2=val2 ...)] select_statement1
[insert overwrite | into table tablename2 [partition ...] select_statement2]
```

> **Note**
>
> - A SQL statement typically supports up to 256 outputs. A syntax error is returned if more than 256 outputs are specified.
> - In a MULTI INSERT statement, you can specify a target partition in a partitioned table or specify a non-partitioned table only once.
> - The INSERT OVERWRITE and INSERT INTO operations cannot be performed simultaneously on different partitions in a partitioned table. Otherwise, an error is returned.

Example:

```
create table sale_detail_multi like sale_detail;
from sale_detail
insert overwrite table sale_detail_multi partition (sale_date='2016', region='china' ) select shop_name, cust
omer_id, total_price
insert overwrite table sale_detail_multi partition (sale_date='2017', region='china' ) select shop_name, cust
omer_id, total_price;
-- A success is returned. Data of the sale_detail table is inserted into the sale records of the China region in 2
016 and 2017 in the sales table.
from sale_detail
insert overwrite table sale_detail_multi partition (sale_date='2017', region='china' ) select shop_name, cust
omer_id, total_price
insert overwrite table sale_detail_multi partition (sale_date='2017', region='china' ) select shop_name, cust
omer_id, total_price;
-- An error is returned. The same partition appears more than once.
from sale_detail
insert overwrite table sale_detail_multi partition (sale_date='2016', region='china' )
select shop_name, customer_id, total_price
insert into table sale_detail_multi partition (sale_date='2017', region='china' ) select shop_name, customer
_id, total_price;
-- An error is returned. The INSERT OVERWRITE and INSERT INTO operations cannot be performed simultane
ously on different partitions in a partitioned table.
```

1.6.4.1.3. Output data to a dynamic partition

This topic describes how to use the INSERT statement to output data to a dynamic partition.

When you run the INSERT OVERWRITE statement on a partitioned table, you can specify the partition values in the statement. Another flexible method is to specify partition column names instead of setting partition values. In the meantime, specify the partition values in the corresponding columns of a SELECT clause.

Command syntax:

```
insert overwrite table tablename partition (partcol1, partcol2 ...) select_statement from from_statement;
```

> **Note**
>
> - When you run a SQL dynamic partition statement in a distributed environment, a single process can output up to 512 dynamic partitions. If the number of dynamic partitions exceeds this limit, an exception is returned.
> - Currently, a SQL dynamic partition statement can generate up to 2,000 dynamic partitions. If the number of dynamic partitions exceeds this limit, an exception is returned.
> - The dynamic partition values cannot be NULL. Otherwise, an exception is returned.
> - If a target table has multi-level partitions, you can specify some partitions as static partitions in an INSERT statement. However, the static partitions must be high-level partitions.

Example:

```
create table total_revenues (revenue bigint) partitioned by (region string); insert overwrite table total_reve
nues partition(region)
select total_price as revenue, region from sale_detail;
```

> **Note** In the preceding example, you do not know which partitions are generated before running the SQL statement. The partitions generated are determined by the value of the region field after the execution of the SELECT statement. This is why the partitions are called dynamic partitions.

Other examples:

```
create table sale_detail_dypart like sale_detail;
insert overwrite table sale_detail_dypart partition (sale_date, region) select * from sale_detail;
-- A success is returned.
insert overwrite table sale_detail_dypart partition (sale_date='2017', region) select shop_name,customer_i
d,total_price,region from sale_detail;
-- A success is returned. The table has multi-level partitions. Specify a primary partition.
insert overwrite table sale_detail_dypart partition (sale_date='2017', region) select shop_name,customer_i
d,total_price from sale_detail;
-- An error is returned. The inserted dynamic partition must be in the SELECT list.
insert overwrite table sales partition (region='china', sale_date) select shop_name,customer_id,total_price,
region from sale_detail;
-- An error is returned. You cannot specify only low-level partitions when dynamically inserting high-level pa
rtitions.
```

1.6.4.2. SELECT statement

1.6.4.2.1. SELECT operation

This topic describes how to use the SELECT statement.

Command syntax:

```
select [all | distinct] select_expr, select_expr, ... from table_reference
[where where_condition] [group by col_list]
[order by order_condition]
[distribute by distribute_condition [sort by sort_condition] ] [limit number]
```

Note the following when using select statements:

- A SELECT operation reads data from a table. You can specify names of the columns to read or use * to represent all columns in the statement.

  Example:

  ```
  select * from sale_detail;
  -- Read all columns in the sale_detail table.
  select shop_name from sale_detail;
  -- Read only the shop_name name in the sale_detail table.
  ```

  > **Note** Currently, the SELECT statement can only return up to 1,000 rows of results. If the SELECT statement serves as a clause, it does not have such a restriction. The SELECT clause returns all results to the outer query. To obtain more than 1,000 rows of results through the SELECT operation, you must use Tunnel to download the entire table or a temporary table returned by a SELECT operation. For more information, see Use Tunnel.

- You can use a WHERE clause to apply filtering conditions.

  Example:

  ```
  select * from sale_detail where shop_name like 'hang%';
  ```

  The following table lists filter conditions supported by the WHERE clause.

Filter conditions

Filter condition	Description
>, < , =, >=, <=, <>	/
like, rlike	/
in, not in	If a sub-query is added following condition 'in/not in', then it can only return one column result and the quantity of returned values cannot exceed 1,000.

You can specify a partition range in WHERE clause of SELECT statement to avoid a full table scan.

Example:

```
select sale_detail.* from sale_detail
where sale_detail.sale_date >= '2015' and sale_detail.sale_date <= '2017';
```

> **Note** WHERE clauses of MaxCompute SQL statements do not support queries with between conditions, and can have no more than 256 conditions.

- Nested subqueries are supported in table_reference.

  Example:

  ```
  select * from (select region from sale_detail) t where region = 'shanghai';
  ```

- distinct: If there are repeated rows, then use distinct in front of the field to remove the duplicated value, and only one value will be returned. Or use all to return all repeated values. Without the distinct option, the statement returns all duplicate values, same as the result obtained with the ALL option.

  Example:

  ```
  select distinct region from sale_detail;
  select distinct region, sale_date from sale_detail;
  -- The distinct option applies to multiple columns. The option takes effect on all columns of a select optio
  n, rather than a single column.
  ```

- GROUP BY: a grouping query clause, usually used with aggregate functions. When the SELECT statement contains an aggregate function, the key of the GROUP BY statement can be the name of a column in the input table or the expression composed of input table columns. However, it cannot be the output column of the SELECT statement.

  Example:

```
select region from sale_detail group by region;
-- Runs successfully with the name of a column in the input table directly used as the group by column
select sum(total_price) from sale_detail group by region;
-- Runs successfully with the table grouped by the region value and returns the total sales of each group
Select region, sum (total_price) from sale_detail group by region;
-- Runs successfully with the table grouped by the region value and returns the region value (unique in th
e group) and total sales of each group
select region as r from sale_detail group by r;
 -- Runs with the alias of the Select column and returns an error
select 'China-' + region as r from sale_detail group by 'China-' + region;
-- Requires a complete expression of the column
Select region, total_price from sale_detail group by region;
-- Returns an error; all columns not using an aggregate function in the Select statement must exist in grou
p by
select region, total_price from sale_detail group by region, total_price;
-- Runs successfully
```

> **Note** The preceding limits are imposed for the following reason: SQL parses the GROUP BY operation prior to the SELECT operation, and therefore the GROUP BY statement can only use the column or expression of the input table as the key. For more information about aggregate functions, see Aggregate functions.

- ORDER BY: Order all data globally based on specified columns. To order records in descending order, use the DESC keyword. For global sorting, ORDER BY must be used together with LIMIT. In the ORDER BY operation, NULL is considered smaller than any value. This is consistent with MySQL, but is not consistent with Oracle. Unlike GROUP BY, ORDER BY must be followed by the aliases of the SELECT columns. If the SELECT operation is performed on a column and the column alias is not specified, the column name is used as the column alias.

  Example:

```
select * from sale_detail order by region;
-- Returns an error because order by is not used together with limit
select * from sale_detail order by region limit 100;
select region as r from sale_detail order by region;
-- An error is returned because ORDER BY is not followed by a column alias.
select region as r from sale_detail order by r;
```

> **Note** The number in [limit number] is a constant that limits the number of returned rows. If a SELECT statement is run without the LIMIT option, it can return at most 5000 rows on screen. The screen display limit may vary with projects and can be set in the console.

- DISTRIBUTE BY: Shard data based on hash values of specified columns, where the alias of SELECT output columns must be used.

Example:

```
select region from sale_detail distribute by region;
-- Runs successfully because the column name is an alias
select region as r from sale_detail distribute by region;
-- Returns an error because DISTRIBUTE BY is not followed by a column alias
select region as r from sale_detail distribute by r;
```

- Sort by: for partial sorting, DISTRIBUTE BY must be added in front of the statement. sort by is used to partially sort the results of distribute by. It must use the alias of the SELECT output column.

  Example:

  ```
  select region from sale_detail distribute by region sort by region; select region as r from sale_detail sort b
  y region;
  -- The statement returns an error and exits because it does not follow a DISTRIBUTE BY statement.
  ```

- ORDER BY and GROUP BY cannot be used together with DISTRIBUTE BY/SORT BY, and must use the alias of SELECT output columns.

  > **Note**
  > - The key of ORDER BY, SORT BY, or DISTRIBUTE BY must be the output column of a SELECT statement, that is, the column alias.
  > - In MaxCompute SQL parsing, ORDER BY, SORT BY, and DISTRIBUTE BY come after the SELECT operation. Therefore, they can only accept the output columns of the SELECT statement as keys.

1.6.4.2.2. Subquery

This topic describes how to use the SELECT statement for subquery operations.

A common SELECT statement reads data from multiple tables, for example, select column_1, column_2 ... from table_name. The query object can be another SELECT operation, which is a subquery.

Command syntax:

```
select * from (select shop_name from sale_detail) a;
```

> **Notice** A subquery must have an alias.

Example:

```
create table shop as select * from sale_detail;
select a.shop_name, a.customer_id, a.total_price from
(select * from shop) a join sale_detail on a.shop_name = sale_detail.shop_name;
```

> **Note** In a FROM clause, a subquery can be used as a table, which supports a JOIN operation with other tables or subqueries.

1.6.4.3. UNION statements

1.6.4.3.1. UNION ALL

This topic describes how to run the SELECT statement to perform the UNION ALL operation.

Command syntax:

```
select_statement union all select_statement
```

> **Note** Combine two or more datasets returned from SELECT operations into one data set. If repeated rows exist in the result, all rows that meet the condition are returned, with duplicated rows retained.

MaxCompute SQL does not support combination of two top-level query results. To combine them, they must be rewritten into a subquery format.

Example of incorrect format before rewriting:

```
Select * From sale_detail where region = 'Hangzhou'
union all
select * from sale_detail where region = 'shanghai';
```

Example of correct format after rewrtiting:

```
select * from (
select * from sale_detail where region = 'hangzhou' union all
select * from sale_detail where region = 'shanghai') t;
```

> **Notice**
>
> - For a UNION ALL operation, all subqueries must have the same number of columns, column names, and column types. If the column names are inconsistent, use a column alias.
> - Generally, MaxCompute allows a UNION ALL operation for a maximum of 256 subqueries. A syntax error is returned if the limit is exceeded.

1.6.4.4. JOIN statement

1.6.4.4.1. JOIN

This topic describes how to use a JOIN statement.

In MaxCompute, JOIN supports multiple connections, but not with Cartesian products (JOIN without the ON condition).

Syntax

```
join_table:
table_reference join table_factor [join_condition]
| table_reference {left outer|right outer|full outer|inner} join table_reference join_condition
table_reference: table_factor
join_table
table_factor: tbl_name [alias]
table_subquery alias
( table_references )
join_condition:
on equality_expression ( and equality_expression )*
```

> **Note** equality_expression is an equality expression.

Pay attention to the following points when you use a JOIN statement:

- LEFT OUTER JOIN: returns all records in the left table (shop in the example below), even if there is no match in the right table (sale_detail in the example below).

  Example

  ```
  select a.shop_name as ashop, b.shop_name as bshop from shop a left outer join sale_detail b on a.shop_
  name=b.shop_name;
  -- Both the shop and sale_detail tables have the shop_name column. You can use aliases to distinguish be
  tween the two columns in the SELECT clause.
  ```

- RIGHT OUTER JOIN: returns all records in the right table (sale_detail in the example below), even if there is no match in the left table (shop in the example below).

  Example

  ```
  select a.shop_name as ashop, b.shop_name as bshop from shop a right outer join sale_detail b on a.shop
  _name=b.shop_name;
  -- Both the shop and sale_detail tables have the shop_name column. You can use aliases to distinguish be
  tween the two columns in the SELECT clause.
  ```

- FULL OUTER JOIN: returns all records in both the left and right tables.

  Example

  ```
  select a.shop_name as ashop, b.shop_name as bshop from shop a full outer join sale_detail b on a.shop_
  name=b.shop_name;
  ```

- INNER JOIN: returns the corresponding record when there is at least one match in both tables. The keyword INNER can be omitted.

  Example

  ```
  select a.shop_name from shop a inner join sale_detail b on a.shop_name=b.shop_name; select a.shop_na
  me from shop a join sale_detail b on a.shop_name=b.shop_name;
  ```

- Connection condition: Only equi-joins connected by AND are allowed, and a maximum of 128 JOIN operations are supported. In MAPJOIN, you can use non-equi joins or use OR to connect multiple conditions.

  Example

  ```
  select a.* from shop a full outer join sale_detail b on a.shop_name=b.shop_name full outer join sale_detai
  l c on a.shop_name=c.shop_name;
  -- A maximum of 128 JOIN operations are supported.
  select a.* from shop a join sale_detail b on a.shop_name <> b.shop_name;
  -- An error is returned because MaxCompute does not support non-equi joins.
  ```

1.6.4.4.2. MAPJOIN HINT

This topic describes how to use a MAPJOIN statement to join a large table with one or more small tables.

A MAPJOIN operation is faster than common JOIN operations.

When the volume of data is small, MAPJOIN accelerates the execution process by using SQL to load all the specified small tables into the program memory through the JOIN operation.

Example

```
select /* + mapjoin(a) */ a.shop_name, b.customer_id, b.total_price
from shop a join sale_detail b
on a.shop_name = b.shop_name;
```

> **Notice**
>
> Note the following points when you use a MAPJOIN statement:
>
> - The left table of a LEFT OUTER JOIN clause must be a large table.
> - The right table of a RIGHT OUTER JOIN clause must be a large table.
> - Both the left and right tables of an INNER JOIN clause can be large tables.
> - MAPJOIN cannot be used in a FULL OUTER JOIN clause.
> - MAPJOIN supports small tables in subqueries.
> - If you need to reference a small table or a subquery when using MAPJOIN, you must reference the alias of the table or subquery.
> - In MAPJOIN, you can use non-equi joins or combine multiple conditions by using OR.
> - If MAPJOIN is used, the total memory occupied by all the small tables cannot exceed 512 MB. However, you can use the *odps.sql.mapjoin.memory.max* parameter to raise this limit up to 2,048 MB.
>
>   The limit here refers to the original size of data. If you run the desc command to obtain the compressed size, you must multiply it by the compression ratio.

In MaxCompute SQL, you cannot use non-equi joins or the OR logic in the ON condition. However, you can do this in MAPJOIN. Example:

```
select /*+ mapjoin(a) */ a.total_price, b.total_price
from shop a join sale_detail b
on a.total_price < b.total_price or a.total_price + b.total_price < 500;
```

1.6.4.5. EXPLAIN statement

This topic describes the EXPLAIN statement in DML statements of MaxCompute SQL.

MaxCompute SQL provides the EXPLAIN operation, which displays the description of the ultimate execution plan structure of DML statements. An execution plan is the program that is ultimately used to execute SQL semantics.

Command syntax:

```
EXPLAIN <DMLquery>;
```

> **Note**
>
> The execution result of an EXPLAIN statement includes the following:
>
> - Dependencies between all the jobs of this DML statement.
> - Dependencies between all the tasks of each job.
> - All operator dependency structures in a task.

Example:

```
EXPLAIN
SELECT abs(a.key), b.value FROM src a JOIN src1 b ON a.value = b.value;
```

The EXPLAIN statement output includes the following:

- The first part is the dependency between jobs.

  Command output:

  ```
  job0 is root job
  ```

  > **Note** Because this query only needs one job (job0), only one line of information is needed.

- The second part is the dependency between tasks.

  Command output:

  ```
  In Job job0:
  root Tasks: M1_Stg1, M2_Stg1
  J3_1_2_Stg1 depends on: M1_Stg1, M2_Stg1
  ```

  > **Note**
  > - Job0 contains three tasks, among which M1_Stg1 and M2_Stg1 are executed first, and J3_1_2_Stg1 is executed after the first two tasks are finished.
  > - Naming rules for tasks: MaxCompute provides four task types: MapTask, ReduceTask, JoinTask, and LocalWork. The first letter of a task name indicates the type of the current task (for example, M2Stg1 is a MapTask). The number immediately following the first letter represents the current Task ID, which is unique among all tasks in the current query. The numbers separated by underscores (_) represent the immediate dependencies of the current task. For example, J3_1_2_Stg1 means that the current task (ID 3) is dependent on tasks with ID 1 and ID 2.

- The third part is the operator structure in the tasks, where each operator string describes the execution semantics of a task.

  Command output:

```
In Task M1_Stg1:
Data source: yudi_2.src #### "Data source" describes the input content of the current task TS: alias: a ###
# TableScanOperator
RS: order: + #### ReduceSinkOperator keys:
a.value values:
a.key partitions:
a.value
In Task J3_1_2_Stg1:
JOIN: a INNER JOIN b #### JoinOperator
SEL: Abs(UDFToDouble(a._col0)), b._col5 #### SelectOperator FS: output: None #### FileSinkOperator
In Task M2_Stg1:
Data source: yudi_2.src1 TS: alias: b
RS: order: + keys:
b.value values:
b.value partitions:
b.value
```

The meanings of the operators are shown as below.

Operators

Operator	Description
TableScanOperator	Describes the logic of FROM statement blocks in a query statement. The input table name (alias) is displayed in the EXPLAIN results.
SelectOperator	Describes the logic of SELECT statement blocks in a query statement. The columns passed to the next operator, separated by commas, are displayed in the EXPLAIN results. If the result is a reference to a column, it is displayed as < alias >. < column_name >. If the result is an expression, it is displayed as a function, for example, func1(arg1_1, arg1_2, func2(arg2_1, arg2_2)). If the result is a constant, the value is displayed directly.
FilterOperator	Describes the logic of WHERE statement blocks in a query statement. A WHERE condition, which complies with a display rule similar to that of selectOperator, is displayed in the EXPLAIN results.
JoinOperator	Describes the logic of JOIN statement blocks in a query statement. The tables involved in the JOIN operation and the mode of JOIN operation are displayed in the EXPLAIN results.
GroupByOperator	Describes the logic of the AGGREGATE operation. This structure is displayed if an aggregate function is used in a query. The content of the aggregate function is displayed in the EXPLAIN results.

Operator	Description
ReduceSinkOperator	Describes the logic of the data distribution operation between tasks. If the result of the current task is transferred to another task, ReduceSinkOperator must be used to distribute data at the end of the current task. The output sorting method, the distributed keys, values, and columns used to calculate the hash value are displayed in the EXPLAIN results.
FileSinkOperator	Describes the final data storage operation. If there is an INSERT statement block in the query statement, the name of the target table is displayed in the EXPLAIN results.
LimitOperator	Describes the logic of LIMIT statement blocks in a query statement. The limit value is displayed in the EXPLAIN results.
MapjoinOperator	Describes JOIN operations in large tables, similar to JoinOperator.

Note

- If a query is complex and has too many EXPLAIN results, the API restriction is triggered, and incomplete results are displayed. In this case, the query can be split, and the EXPLAIN operation can be performed on each part to show the structure of the job.
- The maximum number of partitions in a query is 10,000. Inputting too many partitions leads to over-length Data source content. To circumvent this limit, you can filter out most partitions by adding a query filter.

1.6.4.6. GROUPING SETS

1.6.4.6.1. Overview

For scenarios where you need to aggregate and analyze data of multiple dimensions, you must execute multiple UNION ALL clauses. For example, you wanted to aggregate column a, aggregate column b, and aggregate columns a and b together. The GROUPING SETS clause is a better choice in such cases.

GROUPING SETS is an extension to the GROUP BY clause in the SELECT statement. You can group results in various ways by using GROUPING SETS without executing multiple SELECT statements. This can produce better execution plans and result in higher performance from the MaxCompute engine.

Notice Many examples in this topic are demonstrated using MaxCompute Studio. We recommend that you install MaxCompute Studio before you proceed with subsequent operations.

1.6.4.6.2. Example

The following example is for your reference.

1. Prepare data.

```
create table requests LIFECYCLE 20 as
select * from values
  (1, 'windows', 'PC', 'Beijing'),
  (2, 'windows', 'PC', 'Shijiazhuang'),
  (3, 'linux', 'Phone', 'Beijing'),
  (4, 'windows', 'PC', 'Beijing'),
  (5, 'ios', 'Phone', 'Shijiazhuang'),
  (6, 'linux', 'PC', 'Beijing'),
  (7, 'windows', 'Phone', 'Shijiazhuang')
as t(id, os, device, city);
```

2. Use GROUPING SETS.

```
SELECT os,device, city ,COUNT(*)
FROM requests
GROUP BY os, device, city GROUPING SETS((os, device), (city), ());
```

A similar output is displayed.

Command output

	os	device	city	_c3
1	ios	Phone	\N	1
2	linux	PC	\N	1
3	linux	Phone	\N	1
4	windows	PC	\N	3
5	windows	Phone	\N	1
6	\N	\N	Beijing	4
7	\N	\N	Shijiazhuang	3
8	\N	\N	\N	7

Note You can also execute multiple SELECT statements to obtain the same result.

```
SELECT NULL, NULL, NULL, COUNT(*)
FROM requests
UNION ALL
SELECT os, device, NULL, COUNT(*)
FROM requests GROUP BY os, device
UNION ALL
SELECT null, null, city, COUNT(*)
FROM requests GROUP BY city;
```

However, the GROUPING SETS method is simpler and more efficient.

Notice Expressions not used in GROUPING SETS use NULL as placeholders. You can execute UNION statements on grouping sets.

1.6.4.6.3. CUBE and ROLLUP

CUBE and ROLLUP are special GROUPING SETS functions. CUBE lists all possible combinations of specified columns as grouping sets. ROLLUP aggregates data by level to produce grouping sets.

Example:

```
GROUP BY CUBE(a, b, c)
```

```
GROUPING SETS((a,b,c),(a,b),(a,c),(b,c),(a),(b),(c),())
```

The preceding two clauses are equivalent.

```
GROUP BY ROLLUP(a, b, c)
```

```
GROUPING SETS((a,b,c),(a,b),(a))
```

The preceding two clauses are equivalent.

1.6.4.6.4. GROUPING and GROUPING_ID

NULL is used as placeholders in grouping sets, but it can also be a value that is manually entered. In the code, however, placeholder NULLs are indistinguishable from value NULLs. The GROUPING function is provided to address this issue.

GROUPING allows you to specify the name of a column as a parameter. If the specified lines are aggregated based on a column whose name is used as a parameter in this function, 0 is returned, indicating that NULL is an entered value. Otherwise, 1 is returned, indicating that NULL is a placeholder.

GROUPING_ID can be used to specify the names of one or more columns as parameters. The GROUPING results in these columns are formed into integers by using BitMap.

Example:

```
SELECT a,b,c ,COUNT(*),
GROUPING(a) ga, GROUPING(b) gb, GROUPING(c) gc, GROUPING_ID(a,b,c) groupingid
FROM VALUES (1,2,3) as t(a,b,c)
GROUP BY CUBE(a,b,c);
```

A similar output is displayed.

Command output

	a	b	c	_c3	ga	gb	gc	groupingid
1	\N	\N	\N	1	1	1	1	7
2	\N	\N	3	1	1	1	0	6
3	\N	2	\N	1	1	0	1	5
4	\N	2	3	1	1	0	0	4
5	1	\N	\N	1	0	1	1	3
6	1	\N	3	1	0	1	0	2
7	1	2	\N	1	0	0	1	1
8	1	2	3	1	0	0	0	0

1.6.5. SELECT TRANSFORM

1.6.5.1. Overview

SELECT TRANSFORM implements features that MaxCompute SQL does not provide. SELECT TRANSFORM allows you to start a specified child process and enter data of a required format into the child process through standard input (stdin). Then, you can parse the standard output (stdout) of the child process to obtain the final output. This process does not require you to compile UDFs.

SELECT TRANSFORM simplifies the reference of script code and supports programming languages such as Java, Python, Shell, and Perl. It is suitable for ad hoc data analysis. MaxCompute Select Transform is fully compatible with Hive syntax, features, and actions, including input/output row format and reader/writer. Most Hive scripts can be added directly to the SELECT TRANSFORM statement. Others can be used after a few changes.

Command syntax:

```
SELECT TRANSFORM(arg1, arg2 ...)
(ROW FORMAT DELIMITED (FIELDS TERMINATED BY field_delimiter (ESCAPED BY character_escape)?)? (LINES
SEPARATED BY line_separator)? (NULL DEFINED AS null_value)?)?
USING 'unix_command_line'
(RESOURCES 'res_name'  (',' 'res_name')  *)?
( AS col1, col2 ...)?
(ROW FORMAT DELIMITED (FIELDS TERMINATED BY field_delimiter (ESCAPED BY character_escape)?)? (LINES
SEPARATED BY line_separator)? (NULL DEFINED AS null_value)?)?
```

Description:

- SELECT TRANSFORM: The **SELECT TRANSFORM** keyword can be replaced with the **MAP** or **REDUCE** keyword while maintaining the same semantic meaning. However, we recommend that you use**SELECT TRANSFORM** because its syntax is simpler.
- (arg1, arg2 ...): arguments in the TRANSFORM clause. Their format is similar to those of items in the SELECT clause. In the default format, the results of expressions for each argument are combined by using **\t** after they are implicitly converted into strings. The arguments are then entered into the specified child process.

  > **Note** The default format is configurable. For more information, see **ROW FORMAT**.

- USING: specifies the command used to start a child process. Note the following points about the USING clause.
  - In most MaxCompute SQL statements, the USING clause can only specify resources. However, in the SELECT TRANSFORM statement, the USING clause can specify commands to ensure compatibility with Hive syntax.
  - The format of the USING clause is similar to the syntax of a Shell script. However, a Shell script is not actually expected to start the child process. The child process is created based on the command input. Because of this, a number of Shell functions, such as input and output redirection, pipe, and loop, are unavailable. A Shell script can be used as to start a child process if necessary.
- RESOURCES: specifies the resources that the specified child process can access. You can use one of

the following methods to specify resources:

- Use the RESOURCES clause. Example: `using 'sh foo.sh bar.txt' Resources 'foo.sh','bar.txt'`.
- Add the `set odps.sql.session.resources=foo.sh,bar.txt;` clause before SQL statements.

> **Notice** This clause takes effect globally once it is specified. All SELECT TRANSFORM statements will be able to access the resources specified by this clause.

- ROW FORMAT: specifies the input or output format. Two ROW FORMAT clauses are used in the syntax: the first one specifies the input format, and the second one specifies the output format. **\t** is used to separate columns, **\n** is used to separate rows, and NULL is represented by **\N**.

> **Notice**
> - For field_delimiter, character_escape, and line_separator, only one character can be accepted. If you specify a string, the first character in the string takes priority over the others.
> - There are a variety of Hive syntaxes to specify formats. MaxCompute supports syntaxes such as inputRecordReader, outputRecordReader, and Serdeinput. To use these formats, you must enable Hive compatibility by adding the `set odps.sql.hive.compatible=true;` clause before SQL statements. If you specify a syntax such as inputRecordReader or outputRecordReader supported by Hive, statements may be executed at lower speeds.

- AS: specifies output columns.

> **Note**
> - You can specify data types in the AS clause, as in as(col1:bigint, col2:boolean). By default, strings are returned if you do not specify data types, as in as(col1, col2).
> - The output is obtained by parsing the stdout of the child process. If the specified data types do not include STRING, the system implicitly calls the CAST function. Runtime exceptions may occur when the CAST function is called.
> - You cannot specify data types for only some of the columns, as in as(col1, col2:bigint).
> - If you skip the AS clause, the field preceding the first **\t** in the stdout is a key, and all the following parts are a value. This is equivalent to as(key, value).

1.6.5.2. SELECT TRANSFORM examples

1.6.5.2.1. Call Shell scripts

In this example, a Shell script is used to generate 50 lines of data starting from 1 to 50. The output of the data field is as follows:

```
SELECT TRANSFORM(script) USING 'sh' AS (data)
FROM (
    SELECT 'for i in `seq 1 50`; do echo $i; done' AS script
  ) t
;
```

The Shell commands are used as the input of the TRANSFORM clause.

> **Note** In addition to language extensions, SELECT TRANSFORM also provides simple features of AWK, Python, Perl, and Shell to compile scripts in commands. You do not need to compile script files or upload resources separately.

You can upload script files for complex cases, as in the following example Python script call.

1.6.5.2.2. Call Python scripts

This topic provides an example of how to use SELECT TRANSFORM to call Python scripts.

1. Compile a Python script file. In this example, the file name is myplus.py.

   ```
   #! /usr/bin/env python
   import sys
   line = sys.stdin.readline()
   while line:
     token = line.split('\t')
     if (token[0] == '\\N') or (token[1] == '\\N'):
       print '\\N'
     else:
       print int(token[0]) + int(token[1])
     line = sys.stdin.readline()
   ```

2. Add the Python script file as a resource to MaxCompute.

   ```
   add py ./myplus.py -f;
   ```

   > **Note** You can also add resources from the DataWorks console.

3. Execute the SELECT TRANSFORM statement to call the resource.

```
Create table testdata(c1 bigint,c2 bigint); -- Create a test table.
insert into Table testdata values (1,4),(2,5),(3,6); -- Insert test data into the test table.
-- Execute the SELECT TRANSFORM statement:
SELECT
TRANSFORM (testdata.c1, testdata.c2)
USING 'python myplus.py'resources 'myplus.py'
AS (result bigint)
FROM testdata;
-- Or
set odps.sql.session.resources=myplus.py;
SELECT
TRANSFORM (testdata.c1, testdata.c2)
USING 'python myplus.py'
AS (result bigint)
FROM testdata;
```

4. A similar output is displayed:

```
+-----+
| cnt |
+-----+
| 5   |
| 7   |
| 9   |
+-----+
```

Python scripts are not subject to any format requirements and do not require a Python framework to be run in MaxCompute. In MaxCompute, Python commands can be used as the input of the TRANSFORM clause. For example, you can call Shell scripts by running Python commands.

```
SELECT TRANSFORM('for i in xrange(1, 50): print i;') USING 'python' AS (data);
```

1.6.5.2.3. Call Java scripts

Java scripts are called in a similar manner to Python scripts. In this example, you need to compile a Java script file, export it as a JAR package, and then run the add command to add the JAR package as a resource to MaxCompute. The resource will be called by using SELECT TRANSFORM.

1. Compile a Java script file and export it as a JAR package. In this example, the name of the JAR package is Sum.jar.

```
package com.aliyun.odps.test;
import java.util.Scanner;
public class Sum {
 public static void main(String[] args) {
  Scanner sc = new Scanner(System.in);
  while (sc.hasNext()) {
   String s = sc.nextLine();
   String[] tokens = s.split("\t");
   if (tokens.length < 2) {
    throw new RuntimeException("illegal input");
   }
   if (tokens[0].equals("\\N") || tokens[1].equals("\\N")) {
    System.out.println("\\N");
   }
   System.out.println(Long.parseLong(tokens[0]) + Long.parseLong(tokens[1]));
  }
 }
}
```

2. Add the JAR package as a resource to MaxCompute.

```
add jar ./Sum.jar -f;
```

3. Execute the SELECT TRANSFORM statement to call the resource.

```
Create table testdata(c1 bigint,c2 bigint); -- Create a test table.
insert into Table testdata values (1,4),(2,5),(3,6); -- Insert test data into the test table.
-- Execute the SELECT TRANSFORM statement:
SELECT TRANSFORM(testdata.c1, testdata.c2)
  USING 'java -cp Sum.jar com.aliyun.odps.test.Sum' resources 'Sum.jar'
from testdata;
-- Or
set odps.sql.session.resources=Sum.jar;
SELECT TRANSFORM(testdata.c1, testdata.c2)
  USING 'java -cp Sum.jar com.aliyun.odps.test.Sum'
FROM testdata;
```

4. A similar output is displayed:

```
+-----+
| cnt |
+-----+
| 5   |
| 7   |
| 9   |
+-----+
```

You can use the preceding method to run most Java utilities.

Although UDTF frameworks are provided for Java and Python, it is easier to compile code by using SELECT TRANSFORM. SELECT TRANSFORM is a simpler process because it is not subject to any format requirements and can be called offline. The paths for Java and Python offline scripts can be obtained from the JAVA_HOME and PYTHON_HOME environment variables.

1.6.5.2.4. Call scripts of other languages

In addition to language extensions, SELECT TRANSFORM also supports commonly used Unix command and script interpreters, such as AWK and Perl.

An example of calling AWK:

```
SELECT TRANSFORM(*) USING "awk '//{print $2}'" as (data) from testdata;
```

An example of calling Perl:

```
SELECT TRANSFORM (testdata.c1, testdata.c2) USING "perl -e 'while($input = <STDIN>){print $input;}'" FRO
M testdata;
```

Notice PHP and Ruby are not deployed in the MaxCompute cluster and cannot be called.

1.6.5.2.5. Call scripts in series

SELECT TRANSFORM allows you to call scripts in series. For example, you can use DISTRIBUTE BY and SORT BY to pre-process data.

```
SELECT TRANSFORM(key, value) USING 'cmd2' from
(
  SELECT TRANSFORM(*) USINg 'cmd1' from
  (
    SELECt * FROM data distribute by col2 sort by col1
  ) t distribute by key sort by value
) t2;
```

More often, you can use either the map or reduce keywords to produce the same results.

```
@a := select * from data distribute by col2 sort by col1;
@b := map * using 'cmd1' distribute by col1 sort by col2 from @a;
reduce * using 'cmd2' from @b;
```

1.6.5.3. Performance advantages

The performance of SELECT TRANSFORM and UDTF varies depending on the specific scenario. In general, SELECT TRANSFORM performs better. However, UDTF performs better as the volume of data increases. Because the development of transform is easier, SELECT TRANSFORM is more suitable for ad hoc data analysis.

The advantages of UDTFs and SELECT TRANSFORM are listed in the following sections.

Advantages of UDTFs

- Output and input follow specified data types and do not require conversion.
- Processes are not suspended if the operating system pipe is empty or fully occupied. The operating system pipe has a 4 KB buffer.
- Constant parameters do not need to be transmitted.

Advantages of SELECT TRANSFORM

- Supports child and parent processes and can utilize multiple server cores when high CPU usage and low throughput is needed.
- Calls underlying systems to read and write data to be transmitted, giving it a higher performance than Java.
- Supports tools such as AWK and can run native code.

1.6.6. UNION, INTERSECT, and EXCEPT

This topic describes SQL syntax, descriptions and examples of UNOIN ALL, UNION DISTINCT, INTERSECT ALL, INTERSECT DISTINCT, EXCEPT ALL, and EXCEPT DISTINCT.

Syntax:

```
select_statement UNION ALL select_statement;
select_statement UNION [DISTINCT] select_statement;
select_statement INTERSECT ALL select_statement;
select_statement INTERSECT [DISTINCT] select_statement;
select_statement EXCEPT ALL select_statement;
select_statement EXCEPT [DISTINCT] select_statement;
select_statement MINUS ALL select_statement;
select_statement MINUS [DISTINCT] select_statement;
```

Purpose: It is used to return the union of two data sets, the intersection of two data sets, or the complement of the second dataset in the first dataset.

Description:

- UNION: returns the union of two datasets. It combines the two datasets into one dataset.
- INTERSECT: returns the intersection of two datasets. It outputs the records contained in both datasets.
- EXCEPT: returns the complement of the second dataset in the first dataset. It outputs the records that are contained in the first dataset, but not in the second dataset.
- MINUS: equivalent to EXCEPT.

Examples:

- **UNOIN ALL example:**

```
SELECT * FROM VALUES (1, 2), (1, 2), (3, 4) t(a, b)
 UNION ALL
SELECT * FROM VALUES (1, 2), (1, 4) t(a, b);
```

Returned result: two datasets are combined.

```
+------------+------------+
| a     | b     |
+------------+------------+
| 1     | 2     |
| 1     | 4     |
| 1     | 2     |
| 1     | 2     |
| 3     | 4     |
+------------+------------+
```

- **UNION DISTINCT example:**

```
SELECT * FROM VALUES (1, 2), (1, 2), (3, 4) t(a, b)
UNION
SELECT * FROM VALUES (1, 2), (1, 4) t(a, b);
```

Returned result: equivalent to `SELECT DISTINCT * FROM (< the result of UNOIN ALL >) t;` .

```
+------------+------------+
| a     | b     |
+------------+------------+
| 1     | 2     |
| 1     | 4     |
| 3     | 4     |
+------------+------------+
```

- **INTERSECT ALL example:**

```
SELECT * FROM VALUES (1, 2), (1, 2), (3, 4), (5, 6) t(a, b)
INTERSECT ALL
SELECT * FROM VALUES (1, 2), (1, 2), (3, 4), (5, 7) t(a, b);
```

Returned result: deduplication is skipped in INTERSECT ALL. It seems that there is a hidden serial number behind the same row and each row can be displayed separately.

```
+------------+------------+
| a    | b    |
+------------+------------+
| 1    | 2    |
| 1    | 2    |
| 3    | 4    |
+------------+------------+
```

- INTERSECT DISTINCT example:

```
SELECT * FROM VALUES (1, 2), (1, 2), (3, 4), (5, 6) t(a, b)
INTERSECT
SELECT * FROM VALUES (1, 2), (1, 2), (3, 4), (5, 7) t(a, b);
```

Returned result: `SELECT DISTINCT * FROM (< the result of INTERSECT ALL >) t;` .

```
+------------+------------+
| a    | b    |
+------------+------------+
| 1    | 2    |
| 3    | 4    |
+------------+------------+
```

- EXCEPT ALL example:

```
SELECT * FROM VALUES (1, 2), (1, 2), (3, 4), (3, 4), (5, 6), (7, 8) t(a, b)
EXCEPT ALL
SELECT * FROM VALUES (3, 4), (5, 6), (5, 6), (9, 10) t(a, b);
```

Returned result: deduplication is skipped in EXCEPT ALL. There is a hidden serial number behind the same row and each row can be displayed separately.

```
+------------+------------+
| a     | b     |
+------------+------------+
| 1     | 2     |
| 1     | 2     |
| 3     | 4     |
| 7     | 8     |
+------------+------------+
```

- EXCEPT DISTINCT example:

```
SELECT * FROM VALUES (1, 2), (1, 2), (3, 4), (3, 4), (5, 6), (7, 8) t(a, b)
EXCEPT
SELECT * FROM VALUES (3, 4), (5, 6), (5, 6), (9, 10) t(a, b);
```

Returned result: equivalent to `Select distinct * FROM left_branch limit t all select distinct * FROM right_branch;` .

```
+------------+------------+
| a     | b     |
+------------+------------+
| 1     | 2     |
| 7     | 8     |
+------------+------------+
```

Note

- Sorting may be skipped in the preceding operations.
- The left and right branches in the preceding operations must have the same number of columns. In addition, if data types in the left and right branches are not consistent, they may be implicitly converted. Due to compatibility issues, implicit conversion is not carried out between STRING and no-STRING types for the preceding operations.
- Up to 256 branches are allowed in the preceding operations. An error is returned if more branches are used.
- If the UNION statement is followed by the CLUSTER BY, DISTRIBUTE BY, SORT BY, ORDER BY or LIMIT clause and you add `set odps.sql.type.system.odps2=false;`, the SET statement is applicable to the last `select_statement;` of the UNION statement. If you add `set odps.sql.type.system.odps2=true;`, the SET statement is applicable to all select_statements of the UNION statement. Example:

```
set odps.sql.type.system.odps2=true;
SELECT explode(array(3, 1)) AS (a) UNION ALL SELECT explode(array(0, 4, 2)) AS (a) ORDER
BY a LIMIT 3;
```

Returned result:

```
+------+
| a  |
+------+
| 0  |
| 1  |
| 2  |
+------+
```

1.6.7. Built-in functions

1.6.7.1. Mathematical functions

1.6.7.1.1. ABS

This topic describes the ABS function.

Function declaration:

```
double abs(double number)
bigint abs(bigint number)
decimal abs(decimal number)
```

Purpose: It is used to return absolute values.

Description:

number: double, bigint or decimal type. When the input is of the bigint type, a value of the bigint type is returned; when the input is of the double type, a value of the double type is returned. If the input is of the string type, it is implicitly converted into a value of the double type before this computation. If the input is of another type, an error is returned.

Returned value: double, bigint, or decimal type, depending on the type of the input. If the input is NULL, NULL is returned.

> **Note** When the input is of the bigint type and is out of the maximum range of the bigint type, the returned value is of the double type. In this case, the precision may be diminished.

Example:

```
abs(null) = null
abs(-1) = 1
abs(-1.2) = 1.2
abs("-2") = 2.0
abs(12232083745629837659238745692 3748) = 1.2232083745629837e32
```

The following example shows the usage of a complete ABS function in SQL. Other built-in functions (except window functions and aggregation functions) are in similar usage to this function and are not shown here.

```
select abs(id) from tbl1;
-- Take the absolute value of the id field in tbl1.
```

1.6.7.1.2. ACOS

Function declaration:

```
double acos(double number)
decimal acos(decimal number)
```

Purpose: It is used to calculate the arccosine of a number.

Description:

number: double or decimal type. Value range: -1 to 1. If the input is of the string or bigint type, it is implicitly converted into a value of the double type before this computation. For all other input types, an error is returned.

Returned value: double or decimal type. Value range: 0 to π. If number is NULL, NULL is returned.

Example:

```
acos("0.87") = 0.5155940062460905
acos(0) = 1.5707963267948966
```

1.6.7.1.3. ASIN

Function declaration:

```
double asin(double number)
decimal asin(DECIMAL number)
```

Purpose: It is used to calculate the arcsine of a number.

Description:

number: double or decimal type. Value range: -1 to 1. If the input is of the string or bigint type, it is implicitly converted into a value of the double type before this computation. For all other input types, an error is returned.

Returned value: double or decimal type. Value range: -π/2 to π/2. If number is NULL, NULL is returned.

Example:

```
asin(1) = 1.5707963267948966
asin(-1) = -1.5707963267948966
```

1.6.7.1.4. ATAN

Function declaration:

```
double atan(double number)
```

Purpose: It is used to calculate the arctangent of a number.

Description:

number: double type. If the input is of the string or bigint type, it is implicitly converted into a value of the double type before this computation. For all other input types, an error is returned.

Returned value: double type. Value range: -π/2 to π/2. If number is NULL, NULL is returned.

Example:

```
atan(1) = 0.7853981633974483;
atan(-1) = -0.7853981633974483
```

1.6.7.1.5. CEIL

Command syntax:

```
bigint ceil(double value)
bigint ceil(decimal value)
```

Purpose: It is uesed to return the smallest integer that is equal to or greater than the input value.

Description:

value: double or decimal. If the value is of the string or bigint type, it is implicitly converted to the double type. For all other input types, an error is returned.

Returned value: bigint type. If the input is NULL, NULL is returned.

Example:

```
ceil(1.1) = 2
ceil(-1.1) = -1
```

1.6.7.1.6. CONV

Command syntax:

```
string conv(string input, bigint from_base, bigint to_base)
```

Purpose: It is ued to convert a number from one numeric base number system to another.

Description:

- input: an integer of the string type to be converted. It accepts values of the bigint and double types by means of implicit conversion.
- from_base, to_base: a number system value in decimal form. Value range: 2, 8, 10, and 16. It accepts values of the string and double types by means of implicit conversion.

Returned value: string type. If any input is NULL, NULL is returned. The conversion process runs at a 64-bit precision. An error is returned when overflow occurs. If the input is a negative value (beginning with '-'), an error is returned. If the input is a decimal, it is converted to an integer before hex conversion. The decimal part is left out.

Example:

```
conv('1100', 2, 10) = '12'
conv('1100', 2, 16) = 'c'
conv('ab', 16, 10) = '171'
conv('ab', 16, 16) = 'ab'
```

1.6.7.1.7. COS

Command syntax:

```
double cos(double number)
decimal cos(decimal number)
```

Purpose: It is used to return the cosine of a number. The input must be a radian value.

Description:

number: double or decimal type. If the input is of the string or bigint type, it is implicitly converted to a value of the double type. For all other input types, an error is returned.

Returned value: double or decimal type. If the input is NULL, NULL is returned.

Example:

```
cos(3.1415926/2) = 2.6794896585028633e-8
cos(3.1415926) = -0.9999999999999986
```

1.6.7.1.8. COSH

Command syntax:

```
double cosh(double number)
decimal cosh(decimal number)
```

Purpose: It is used to return the hyperbolic cosine of a number.

Description:

number: double or decimal. If the input is of the string or bigint type, it is implicitly converted to a value of the double type. For all other input types, an error is returned.

Returned value: double or decimal. If the input is NULL, NULL is returned.

1.6.7.1.9. COT

Function declaration:

```
double cot(double number)
decimal cot(decimal number)
```

Purpose: It is used to return the cotangent of a number. The input must be a radian value.

Description:

number: double or decimal. If the input is of the string or bigint type, it is implicitly converted a value of the double type. For all other input types, an error is returned.

Returned value: double or decimal type. If the input is NULL, NULL is returned.

1.6.7.1.10. EXP

Function declaration:

```
double exp(double number)
decimal exp(decimal number)
```

Purpose: It is used to return the exponent value of number.

Description:

number: double or decimal type. If the input is of the string or bigint type, it is implicitly converted into a value of the double type before this computation. For all other input types, an error is returned.

Returned value: double or decimal type. If number is NULL, NULL is returned.

1.6.7.1.11. FLOOR

Function declaration:

```
bigint floor(double number)
bigint floor(decimal number)
```

Purpose: It is used to return the round-down integer that is less than or equal to number.

Description:

number: double or decimal type. If the input is of the string or bigint type, it is implicitly converted into a value of the double type before this computation. For all other input types, an error is returned.

Returned value: bigint type. If number is NULL, NULL is returned.

Example:

```
floor(1.2) = 1
floor(1.9) = 1
floor(0.1) = 0
floor(-1.2) = -2
floor(-0.1) = -1
floor(0.0) = 0
floor(-0.0) = 0
```

1.6.7.1.12. LN

Function declaration:

```
double ln(double number)
decimal ln(decimal number)
```

Purpose: It is used to return the natural logarithm of a number.

Description:

number: double or decimal type. If the input is of the string or bigint type, it is implicitly converted into a value of the double type before this computation. For all other input types, an error is returned.

Returned value: double or decimal type. If the input is NULL, negative, or zero, NULL is returned.

1.6.7.1.13. LOG

Function declaration:

```
double log(double base, double x)
decimal log(decimal base, DECIMAL x)
```

Purpose: It is used to return the logarithm of x to base.

Description:

- base: double or decimal type. If the input is of the string or bigint type, it is implicitly converted into a value of the double type before this computation. For all other input types, an error is returned.
- x: double or decimal type. If the input is of the string or bigint type, it is implicitly converted into a value of the double type before this computation. For all other input types, an error is returned.

Returned value: logarithm value of the double or decimal type. If either base or x is NULL, negative, or zero, NULL is returned. If base is 1 (which leads to division by zero), NULL is returned.

1.6.7.1.14. POW

Command syntax:

```
double pow(double x, double y)
decimal pow(decimal x, decimal y)
```

Purpose: It is used to return the yth power of x, that is, x^y.

Description:

- x: double or decimal type. If the input is of the string or bigint type, it is implicitly converted into a value of the double type before this computation. For all other input types, an error is returned.
- y: double or decimal type. If the input is of the string or bigint type, it is implicitly converted into a value of the double type before this computation. For all other input types, an error is returned.

Returned value: double or decimal type. If x or y is NULL, NULL is returned.

1.6.7.1.15. RAND

Command syntax:

```
double rand(bigint seed)
```

Purpose: It is used to return a random number of the double type from 0 to 1 based on the seed.

Description:

Seed: optional, bigint type. It is the seed of a random number, and determines the start value of the random number sequence.

Returned value: double type.

Example:

```
select rand() from dual;
select rand(1) from dual;
```

1.6.7.1.16. ROUND

Function declaration:

```
double round(double number, [bigint decimal_places])
decimal round(decimal number, [bigint decimal_places])
```

Purpose: It is used to return a number rounded to the specified decimal place.

Description:

- number: double or decimal type. If the input is of the string or bigint type, it is implicitly converted into a value of the double type before this computation. If the input is of another type, an error is returned.
- decimal_place: a constant of the bigint type. It indicates the specified decimal place to which the result is to be rounded off. For all other input types, an error is returned. If it is omitted, the number is rounded to the ones place. The default value is 0.

Returned value: double or decimal type. If number or decimal_places is NULL, NULL is returned.

> **Note** decimal_places can be negative. Negative numbers are counted from the decimal point to left and the decimal part is left out; if the value of decimal_places is greater than the length of the integer part, 0 is returned.

Example:

```
round(125.315) = 125.0
round(125.315, 0) = 125.0
Round (125.315, 1) = 125.3
round(125.315, 2) = 125.32
round(125.315, 3) = 125.315
round(-125.315, 2) = -125.32
round(123.345, -2) = 100.0
round(null) = null
round(123.345, 4) = 123.345
round(123.345, -4) = 0.0
```

1.6.7.1.17. SIN

Function declaration:

```
double sin(double number)
decimal sin(decimal number)
```

Purpose: It is used to return the sine of a number. The input must be a radian value.

Description:

number: double or decimal type. If the input is of the string or bigint type, it is implicitly converted into a value of the double type before this computation. For all other input types, an error is returned.

Returned value: double or decimal type. If number is NULL, NULL is returned.

1.6.7.1.18. SINH

Function declaration:

```
double sinh(double number)
decimal sinh(decimal number)
```

Purpose: It is used to return the hyperbolic sine of a number.

Description:

number: double or decimal type. If the input is of the string or bigint type, it is implicitly converted into a value of the double type before this computation. For all other input types, an error is returned.

Returned value: double or decimal type. If number is NULL, NULL is returned.

1.6.7.1.19. SQRT

Function declaration:

```
double sqrt(double number)
decimal sqrt(decimal number)
```

Purpose: It is used to return the square root of a number.

Description:

number: double or decimal type. It must be greater than 0. If it is less than 0, an error is returned. If the input is of the string or bigint type, it is implicitly converted into a value of the double type before this computation. For all other types of inputs, an error is returned.

Returned value: double or decimal type. If number is NULL, NULL is returned.

1.6.7.1.20. TAN

Function declaration:

```
double tan(double number)
decimal tan(decimal number)
```

Purpose: It is used to return the tangent of a number. The input must be a radian value.

Description:

number: double or decimal type. If the input is of the string or bigint type, it is implicitly converted into a value of the double type before this computation. For all other types of inputs, an error is returned.

Returned value: double or decimal type. If number is NULL, NULL is returned.

1.6.7.1.21. TANH

Function declaration:

```
double tanh(double number)
decimal tanh(decimal number)
```

Purpose: It is used to return the hyperbolic tangent of a number.

Description:

number: double or decimal type. If the input is of the string or bigint type, it is implicitly converted into a value of the double type before this computation. For all other types of inputs, an error is returned.

Returned value: double or decimal type. If number is NULL, NULL is returned.

1.6.7.1.22. TRUNC

Function declaration:

```
double trunc(double number[, bigint decimal_places])
decimal trunc(decimal number[, bigint decimal_places])
```

Purpose: It is used to truncate 'number' to the specified decimal place.

Description:

- number: double or decimal type. If the input is of the string or bigint type, it is implicitly converted into a value of the double type before this computation. For all other types of inputs, an error is returned.
- decimal_places: a constant of the bigint type. It indicates the decimal place to which a number is to be truncated. Numbers of other types are implicitly converted into values of the bigint type. If it is omitted, the result is truncated to the ones place by default.

Returned value: double or decimal type. If number or decimal_places is NULL, NULL is returned.

> **Note**
>
> - The truncated part is supplemented with 0.
> - decimal_places can be negative. Negative numbers are truncated from the decimal point to the left and the decimal part is left out. If the value of decimal_places is greater than the length of the integer part, 0 is returned.

Example:

```
trunc(125.815) = 125.0
trunc(125.815, 0) =125.0
trunc(125.815, 1) = 125.80000000000001
trunc(125.815, 2) = 125.81
trunc(125.815, 3) = 125.815
trunc(-125.815, 2) = -125.81
trunc(125.815, -1) = 120.0
trunc(125.815, -2) = 100.0
trunc(125.815, -3) = 0.0
trunc(123.345, 4) = 123.345
trunc(123.345, -4) = 0.0
```

1.6.7.1.23. Additional mathematical functions

MaxCompute 2.0 provides additional mathematical functions. You must add the following SET statement before SQL statements contained in the UNHEX function:

```
set odps.sql.type.system.odps2=true;
```

> **Note** You must submit and execute the SET statement and the SQL statements of the new functions simultaneously.

The mathematical functions described in subsequent topics are new in MaxCompute 2.0.

1.6.7.1.24. LOG2

Function declaration:

```
Double log2(DOUBLE number)
Double log2(DECIMAL number)
```

Purpose: It is used to return the logarithm of number to base 2.

Description:

number: double or decimal type.

Returned value: double type. If the input is 0 or NULL, NULL is returned.

Example:

```
log2(null) = null
log2(0) = null
log2(8) = 3.0
```

1.6.7.1.25. LOG10

Function declaration:

```
Double log10(Double number)
Double log10(Decimal number)
```

Purpose: It is used to return the logarithm of number to base 10.

Description:

number: double or decimal type.

Returned value: double type. If the input is 0 or NULL, NULL is returned.

Example:

```
log10(null) = null
log10(0) = null
log10(8) = 0.9030899869919435
log10('abc') = null
```

1.6.7.1.26. BIN

Command syntax:

```
string bin(bigint number)
```

Purpose: It is used to return the binary format of a number.

Description:

number: bigint.

Returned value: string type. If the input is 0, 0 is returned. If the input is NULL, NULL is returned.

Example:

```
bin(0) = '0'
bin(null) = 'null'
bin(12) = '1100'
```

1.6.7.1.27. HEX

Function declaration:

```
STRING hex(BIGINT number)
STRING hex(STRING number)
STRING hex(BINARY number)
```

Purpose: It is used to convert an integer or character into hexadecimal format.

Description:

number: If this value is of the bigint type, the hexadecimal format of the number is returned. If this value is of the string type, the hexadecimal value of the string is returned.

Returned value: string type. If the input is 0, 0 is returned. If the input is NULL, NULL is returned.

Example:

```
hex(0) = '0'
hex('abc') = '616263'
hex(17) = '11'
hex('17') = '3137'
hex(null) = 'null'
```

1.6.7.1.28. UNHEX

Function declaration:

```
BINARY unhex(STRING number)
```

Purpose: It is used to return the regular character string represented in the hexadecimal format.

Description:

number: a hexadecimal string.

Returned value: binary type. If the input is 0, a failure is returned. If the input is NULL, NULL is returned.

Example:

```
unhex('616263') = 'abc'
unhex(616263) = 'abc'
```

1.6.7.1.29. RADIANS

Command syntax:

```
double radians(double number)
```

Purpose: It is used to convert degrees into radians.

Description:

number: double type

Returned value: double type. If the input is NULL, NULL is returned.

Example:

```
radians(90) = 1.5707963267948966
radians(0) = 0.0
radians(null) = null
```

1.6.7.1.30. DEGREES

Function declaration:

```
DOUBLE degrees(DOUBLE number)
DOUBLE degrees(DECIMAL number)
```

Purpose: It is used to convert radians into degrees.

Description:

number: double or decimal type.

Returned value: double type. If the input is NULL, NULL is returned.

Example:

```
degrees(1.5707963267948966) = 90.0
degrees(0) = 0.0
degrees(null) = null
```

1.6.7.1.31. SIGN

Function declaration:

```
DOUBLE sign(DOUBLE number)
DOUBLE sign(DECIMAL number)
```

Purpose: It is used to indicate the sign of the input data. 1.0 indicates positive and -1.0 indicates negative. 0.0 indicates 0.

Description:

number: double or decimal type.

Returned value: double type. If the input is 0, 0.0 is returned. If the input is NULL, NULL is returned.

Example:

```
sign(-2.5) = -1.0
sign(2.5) = 1.0
sign(0) = 0.0
sign(null) = null
```

1.6.7.1.32. E

Function declaration:

```
DOUBLE e()
```

Purpose: It is used to return the value of e (Euler's number).

Returned value: double type.

Example:

```
e() = 2.718281828459045
```

1.6.7.1.33. PI

Function declaration:

```
DOUBLE pi()
```

Purpose: It is used to return the value of π.

Returned value: double type.

Example:

```
pi() = 3.141592653589793
```

1.6.7.1.34. FACTORIAL

Function declaration:

```
BIGINT factorial(INT number)
```

Purpose: It is used to return the factorial of number.

Description:

number: int type. Value range: 0 to 20.

Returned value: bigint type. If the input is 0, 1 is returned. If the input is NULL or any value outside the range of 0 to 20, NULL is returned.

Example:

```
factorial(5) = 120 --5! = 5*4*3*2*1 = 120
```

1.6.7.1.35. CBRT

Command syntax:

```
double cbrt(double number)
```

Purpose: It is used to return the cube root of a number.

Description:

number: double type.

Returned value: double type. If the input is NULL, NULL is returned.

Example:

```
cbrt(8) = 2
cbrt(null) = null
```

1.6.7.1.36. SHIFTLEFT

Function declaration:

```
INT shiftleft(TINYINT|SMALLINT|INT number1, INT number2)
BIGINT shiftleft(BIGINT number1, INT number2)
```

Purpose: It is used to shift left a value by a given number of places (<<).

Description:

- number1: an integer of the tinyint, smallint, int, or bigint type.
- number2: an integer of the int type.

Returned value: int or bigint type.

Example:

```
shiftleft(1,2) = 4
-- Shift left the binary value of 1 by two places (1<<2, 0001 changed to 0100)
shiftleft(4,3) = 32
-- Shift left the binary value of 4 by three places (4<<3, 0100 changed to 100000)
```

1.6.7.1.37. SHIFTRIGHT

Function declaration:

```
INT shiftright(TINYINT|SMALLINT|INT number1, INT number2)
BIGINT shiftright(BIGINT number1, INT number2)
```

Purpose: It is used to shift right a value by a given number of places (>>).

Description:

- number1: an integer of the tinyint, smallint, int, or bigint type.

- number2: an integer of the int type.

Returned value: int or bigint type.

Example:

```
shiftright(4,2) = 1
-- Shift right the unsigned binary value of 4 by two places (4>>2, 0100 changed to 0001)
shiftright(32,3) = 4
-- Shift right the unsigned binary value of 32 by two places (32>>3, 100000 changed to 0100)
```

1.6.7.1.38. SHIFTRIGHTUNSIGNED

Function declaration:

```
INT shiftrightunsigned(TINYINT|SMALLINT|INT number1, INT number2)
BIGINT shiftrightunsigned(BIGINT number1, INT number2)
```

Purpose: It is used to shift right an unsigned value by a given number of places (>>>).

Description:

- number1: an integer of the tinyint, smallint, int, or bigint type.
- number2: an integer of the int type.

Returned value: int or bigint type.

Example:

```
shiftrightunsigned(8,2) = 2
-- In this example, shift right the unsigned binary value of 8 (1000 in binary) by two places and return 2 (0010 in binary).
shiftrightunsigned(-14,2) = 1073741820
-- Shift right the unsigned binary value of -14 by two places (-14>>>2, 11111111 11111111 11111111 11110010 changed to 00111111 11111111 11111111 11111100)
```

1.6.7.2. String processing functions

1.6.7.2.1. CHAR_MATCHCOUNT

Command syntax:

```
bigint char_matchcount(string str1, string str2)
```

Purpose: It is used to return the number of characters in str1 that appear in str2 (repeated characters are not counted).

Description:

str1 and str2: string type. Both must be valid UTF-8 strings. If invalid characters are found during matching, a negative value is returned.

Returned value: bigint type. If any input is NULL, NULL is returned.

Example:

```
char_matchcount('abd', 'aabc') = 2
-- The a and b characters in str1 appear in str2.
```

1.6.7.2.2. CHR

Command syntax:

```
string chr(bigint ascii)
```

Purpose: It is used to convert an ASCII code into the corresponding character.

Description:

ascii: ASCII value of the bigint type. If the input is of the string, double, or decimal type, it is implicitly converted into a value of the bigint type before this computation. If the input is of another type, an error is returned.

Returned value: string type. The parameter value range is from 0 to 255. A value out of range will cause an error. If the input is NULL, NULL is returned.

1.6.7.2.3. CONCAT

Command syntax:

```
string concat(string a, string b...)
```

Purpose: It is used to join input strings into a single string.

Description:

a, b...: string type. If the input is of the bigint, decimal, double, or datetime type, it is implicitly converted into a value of the string type. For all other input types, an error is returned.

Returned value: string type. If there is no input or if any input is NULL, NULL is returned.

Example:

```
concat('ab', 'c') = 'abc'
concat() = null
concat('a', null, 'b') = null
```

1.6.7.2.4. INSTR

Function declaration:

```
bigint instr(string str1, string str2[, bigint start_position[, bigint nth_appearance]])
```

Purpose: It is used to calculate the position of substring str2 in string str1.

Description:

- str1: string type. It indicates a string to be searched. If the input is of the bigint, decimal, double, or datetime type, it is implicitly converted into a value of the string type before this computation. For all other input types, an error is returned.
- str2: string type. It indicates a substring to be searched out. If the input is of the bigint, decimal, double, or datetime type, it is implicitly converted into a value of the string type before this computation. For all other input types, an error is returned.
- start_position: bigint type. If it is of another type, an error is returned. It indicates which character in str1 the search will start with. The default start position is the first character, marked as 1.
- nth_appearance: bigint type. If it is greater than 0, it indicates the position where the substring matches the string for the nth_appearance time. If it is of another type or if it is less than or equal to 0, an error is returned.

Returned value: bigint type.

> **Note**
>
> - If str2 is not found in str1, 0 is returned.
> - If any input is NULL, NULL is returned.
> - If str2 is NULL, the matching will always be successful. Therefore, 1 is returned for instr('abc', '').

Example:

```
instr('Tech on the net', 'e') = 2
instr('Tech on the net', 'e', 1, 1) = 2
instr('Tech on the net', 'e', 1, 2) = 11
instr('Tech on the net', 'e', 1, 3) = 14
```

1.6.7.2.5. IS_ENCODING

Function declaration:

```
boolean is_encoding(string str, string from_encoding, string to_encoding)
```

Purpose: It is used to determine whether an input string can be converted from a specified character set (from_encoding) to another character set (to_encoding). It can be used to determine whether the input is garbled. from_encoding is usually set to utf-8, and to_encoding is set to gbk.

Description:

- str: string type. If the input is NULL, NULL is returned. Null is considered to belong to any character set.
- from_encoding, to_encoding: string type. They indicate the source and the destination character sets respectively. If the input is NULL, NULL is returned.

Returned value: boolean type. If a string is converted successfully, true is returned. Otherwise, false is returned.

Example:

```
is_encoding('test', 'utf-8', 'gbk') = true
is_encoding('test', 'utf-8', 'gbk') = true
-- These two traditional Chinese characters are in GBK stock in China.
is_encoding('test', 'utf-8', 'gb2312') = false
-- The grapheme inventory of 'GB2312' does not contain these two Chinese characters.
```

1.6.7.2.6. KEYVALUE

Function declaration:

```
KEYVALUE(STRING srcStr, STRING split1, STRING split2, STRING key)
KEYVALUE(STRING srcStr, STRING key) //split1 = ";", split2 = ":"
```

Purpose: It is used to split the source string into key-value pairs by split1, separate key-value pairs by split2, and return the value of the corresponding key.

Description:

- srcStr: the source string to be split.
- key: string type. After the source string is split by 'split1' and 'split2', return the corresponding value according to the specification of the 'key' value.
- split1 and split2: strings used as separators. The source string is split by the two separators. If these two parameters are not specified in the expression, split1 is a semicolon (;) and split2 is a colon (:) by default. If a string that has been split by split1 has multiple split2 values, the returned result is undefined.

Returned value: string type.

- If 'split1' or 'split2' is NULL, return NULL.
- If 'scrStr' and 'key' are NULL or if there is no matched 'key', return NULL.
- If multiple 'key-value' matches, return the value corresponding to the first matched key.

Example:

```
keyvalue('0:1\;1:2', 1) = '2'
-- The source string is "0:1\;1:2". Because split1 and split2 are not specified, split1 is a semicolon (;) and split2 is a colon (:) by default. After split1 split, the key-value pair is:
0:1\,1:2
After split2 split, it becomes:
0 1/
1 2
Returns the value(2) of the key corresponding to 1.
keyvalue("\;decreaseStore:1\;xcard:1\;isB2C:1\;tf:21910\;cart:1\;shipping:2\;pf:0\;market:shoes\;instPayAmount:0\;", "\;",":","tf") = "21910"
-- The source string is "\;decreaseStore:1\;xcard:1\;isB2C:1\;tf:21910\;cart:1\;shipping:2\;pf:0\;market:shoes\;instPayAmount:0\;". After the source string is split by split1 "\;", the key-value pairs are as follows:
decreaseStore:1, xcard:1, isB2C:1, tf:21910, cart:1, shipping:2, pf:0, market:shoes, instPayAmount:0
 If split2 is ":", after split it becomes:
decreaseStore 1
xcard 1
isB2C 1
tf 21910
cart 1
shipping 2
pf 0
market shoes
instPayAmount 0
For the key parameter whose value is "tf", the returned value of the corresponding value parameter is 21910
.
```

1.6.7.2.7. LENGTH

Function declaration:

```
bigint length(string str)
```

Purpose: It is used to return the length of a string.

Description:

str: string type. If the input is of the bigint, decimal, double, or datetime type, it is implicitly converted into a value of the string type before this computation. For all other input types, an error is returned.

Returned value: bigint type. If a string is NULL, NULL is returned. If a string is not UTF-8 encoded, -1 is returned.

Example:

```
length('hi! China') = 6
```

1.6.7.2.8. LENGTHB

Function declaration:

```
bigint lengthb(string str)
```

Purpose: It is used to return the length of a string. Unit: byte.

Description:

str: string type. If the input is of the bigint, double, decimal, or datetime type, it is implicitly converted into a value of the string type before this computation. If the input is of another type, an error is returned.

Returned value: bigint type. If the input is NULL, NULL is returned.

Example:

```
lengthb('hi! china') = 10
```

1.6.7.2.9. MD5

Function declaration:

```
string md5(string value)
```

Purpose: It is used to calculate the MD5 value of the input string value.

Description:

value: string type. If the input is of the bigint, decimal, double, or datetime type, it is implicitly converted into a value of the string type before this computation. If the input is of another type, an error is returned.

Returned value: string type. If the input is NULL, NULL is returned.

1.6.7.2.10. PARSE_URL

Function declaration:

```
STRING PARSE_URL(STRING url, STRING part[,STRING key])
```

Purpose: It is used to parse a URL and extract information by key.

Description:

- If URL or part is NULL, NULL is returned. If URL is invalid, an error is returned.
- part: string type. It supports HOST, PATH, QUERY, REF, PROTOCOL, AUTHORITY, FILE, and USERINFO, and is case insensitive. If it is none of the preceding values, an error is returned.
- If part is QUERY, the value in query string that corresponds to the key value is extracted. Otherwise,

the parameter key is ignored.

Returned value: string type.

Example:

```
url = file://username:password@example.com:8042/over/there/index.dtb? type=animal&name=narwhal#no
se
parse_url('url', 'HOST') = "example.com"
parse_url('url', 'PATH') = "/over/there/index.dtb"
parse_url('url', 'QUERY') = "type=animal&name=narwhal"
parse_url('url', 'QUERY', 'name') = "narwhal"
parse_url('url', 'REF') = "nose"
parse_url('url', 'PROTOCOL') = "file"
parse_url('url', 'AUTHORITY') = "username:password@example.com:8042"
parse_url('url', 'FILE') = "/over/there/index.dtb? type=animal&name=narwhal"
parse_url('url', 'USERINFO') = "username:password"
```

1.6.7.2.11. REGEXP_EXTRACT

Command syntax:

```
string regexp_extract(string source, string pattern[, bigint occurrence])
```

Purpose: It is used to return part of the source string that matches the regular expression and the occurrence of the matches.

Description:

- source: string type. It indicates a string to be searched.
- pattern: string type. If pattern is NULL or if there is no specified group in pattern, an error is returned.
- occurrence: bigint type. It must be a number that is greater than or equal to 0. Otherwise, an error is returned. The default value is 1 if it is not specified. If it is 0, a substring which meets all pattern requirements is returned.

Returned value: string type. If any input is NULL, NULL is returned.

Example:

```
regexp_extract('foothebar', 'foo(. *?)( bar)', 1) = the
regexp_extract('foothebar', 'foo(. *?)( bar)', 2) = bar
regexp_extract('foothebar', 'foo(. *?)( bar)', 0) = foothebar
regexp_extract('8d99d8', '8d(\\d+)d8') = 99
-- If the regular expression is submitted at the MaxCompute client, two backslashes (\) are needed to be used
as the escape character.
regexp_extract('foothebar', 'foothebar')
-- An error is returned because no part is specified in the pattern.
```

1.6.7.2.12. REGEXP_INSTR

Function declaration:

```
bigint regexp_instr(string source, string pattern[,bigint start_position[, bigint nth_occurrence[, bigint retur
n_option]])
```

Purpose: It is used to return the start or end position of the substring that matches the pattern in the source string from start_position for the nth_occurrence time.

Description:

- source: string type. It indicates a string to be searched.
- pattern: a constant of the string type. If pattern is null, an error is returned.
- start_position: a constant of 'bigint' type. It is the start position for the search. When it is not specified, it is 1 by default. If it is of another type or less than or equal to 0, an error is returned.
- nth_occurrence: a constant of the bigint type. When it is not specified, it is 1 by default, indicating the position where a substring matches pattern in search for the first time. If it is of another type or if it is less than or equal to 0, an error is returned.
- return_option: a constant of the bigint type. The value is either 0 or 1. If it is of another type or the value is not supported, an error is returned. 0 indicates that the start position of the matched substring is returned, and 1 indicates that the end position of the matched substring is returned.

Returned value: bigint type. It is the start or end position of the matched substring in source string according to the type specified by return_option. If any input is NULL, NULL is returned.

Example:

```
regexp_instr("i love www.taobao.com", "o[[:alpha:]]{1}", 3, 2) = 14
```

1.6.7.2.13. REGEXP_SUBSTR

Function declaration:

```
string regexp_substr(string source, string pattern[, bigint start_position[, bigint nth_occurrence]])
```

Purpose: It is used to return the string that matches pattern in the source string from position start_position for the nth_occurence time.

Description:

- source: string type. It indicates a string to be searched.
- pattern: a constant of the string type. It indicates a pattern to be matched. If pattern is null, an error is returned.
- start_position: a constant of the bigint type. It must be greater than 0. If it is another type or if it is less than or equal to 0, an error is reported. When it is not specified, it is regarded as 1 by default, so the matching starts from the first character of 'source'.
- nth_occurrence: a constant of the bigint type. It must be greater than 0. If it is another type or is less than or equal to 0, an error is returned. If it is not specified, it is regarded as 1 by default, indicating that the string in the first match is returned.

Returned value: string type. If any input is NULL, NULL is returned. If there is no matching, NULL is returned.

Example:

```
regexp_substr ("I love aliyun very much", "a[[:alpha:]]{5}") = "aliyun"
regexp_substr('I have 2 apples and 100 bucks!', '[[:blank:]][[:alnum:]]*', 1, 1) = " have"
regexp_substr('I have 2 apples and 100 bucks!', '[[:blank:]][[:alnum:]]*', 1, 2) = "2"
```

1.6.7.2.14. REGEXP_COUNT

Command syntax:

```
bigint regexp_count(string source, string pattern[, bigint start_position])
```

Purpose: It is used to return the number of occurrences that a string pattern appears in the source string, starting from start_position.

Description:

- source: string type. It indicates a string to be searched. For all other input types, an error is returned.
- pattern: string type. It indicates a pattern to be matched. If the pattern is NULL or of another type, an error is returned.
- start_position: bigint start_position must be a number that is greater than 0. Otherwise, an error is returned. If start_position is not specified, the default value is 1 which means starting from the first character of the source string.

Returned value: bigint type. If any input is NULL, NULL is returned. If there is no matching, 0 is returned.

Example:

```
regexp_count('abababc', 'a.c') = 1
regexp_count('abcde', '[[:alpha:]]{2}', 3) = 1
```

1.6.7.2.15. SPLIT_PART

Function declaration:

```
string split_part(string str, string delimiter, bigint start[, bigint end])
```

Purpose: It is used to split a string with the specified delimiter, and return the string between the specified start segment and end segment (inclusive).

Description:

- str: string type. It indicates a string to be split. If the input is of the bigint, decimal, double, or datetime type, it is implicitly converted into a value of the string type before this computation. If the input is of any other type, an error is returned.
- delimiter: a constant of the string type. It indicates the delimiter used to split a string. It can be a character or a string. If it is neither a character nor a string, an error is returned.

- start: a constant of the bigint type. It must be greater than 0. If it is not a constant or is of a different type, an error is returned. It indicates the start number (starting from 1) of the segment to be returned. If end is not specified, the segment specified by start is returned.
- end: a constant of the bigint type. It must be greater than or equal to the value of start; otherwise, an error is returned. It indicates the end number of the segment to be returned. If it is not a constant or is of a different type, an error is returned. If end is not specified, the last segment is returned.

Returned value: string type. If any input is NULL, NULL is returned. If delimiter is NULL, the original string is returned.

> Note
>
> - If delimiter does not exist in str, and start is set to 1, the entire str is returned. If the input is NULL, NULL is returned.
> - If start is set to a value greater than the number of segments (for example, the string has 6 segments but the start value is greater than 6), NULL is returned.
> - If end is set to a value greater than the number of segments, the string between start and the last segment is returned.

Example:

```
split_part('a,b,c,d', ',', 1) = 'a'
split_part('a,b,c,d', ',', 1, 2) = 'a,b'
split_part('a,b,c,d', ',', 10) = ''
```

1.6.7.2.16. REGEXP_REPLACE

Function declaration:

```
string regexp_replace(string source, string pattern, string replace_string[, bigint occurrence])
```

Purpose: It is used to search a source string for substrings that match a given pattern, replace them with the specified replace_string, and return the result.

Description:

- source: string type. It indicates a string to be replaced.
- pattern: a constant of the string type. It indicates a pattern to be matched. If pattern is null, an error is returned.
- replace_string: string type. It is used to replace the matched pattern.
- occurrence: a constant of the bigint type. It must be greater than or equal to 0. This parameter indicates the number of times at which the substring matches the pattern for replacement with replace_string. If the input value is 0, all matched substrings are replaced. If it is of another type or less than 0, an error is returned. It can be omitted. The default value is 0.

Returned value: string type. When the referenced group does not exist, the replace operation is not performed. When the input parameters source, pattern, and occurrence are NULL, NULL is returned. If replace_string is NULL and the pattern is matched, NULL is returned. If replace_string is NULL but the pattern is not matched, the original string is returned.

> **Note** When the referenced group does not exist, the action is not defined.

Example:

```
regexp_replace("123.456.7890", "([[:digit:]]{3})\\.([[:digit:]]{3})\\.([[:digit:]]{4})", "(\\1)\\2-\\3", 0) = "(123)456-7890"
regexp_replace("abcd", "(.)", "\\1 ", 0) = "a b c d "
regexp_replace("abcd", "(.)", "\\1 ", 1) = "a bcd"
regexp_replace("abcd", "(.)", "\\2", 1) = "abcd"
-- Only a group is defined in pattern and the referenced second group is not existent.
-- Please avoid this. The result to reference nonexistent group is not defined.
regexp_replace("abcd", "(. *)(.)$", "\\2", 0) = "d"
regexp_replace("abcd", "a", "\\1", 0) = "bcd"
-- No group definition is in pattern, so '\1' references a nonexistent group.
-- Try to avoid this. The result of referencing a nonexistent group is not defined.
```

1.6.7.2.17. SUBSTR

Function declaration:

```
string substr(string str, bigint start_position[, bigint length])
```

Purpose: It is used to return a substring of 'length' from 'str' starting from 'start_position'.

Description:

- str: string type. If the input is of the bigint, decimal, double, or datetime type, it is implicitly converted into a value of the string type before this computation. For all other types of inputs, an error is returned.
- start_position: bigint type. The start position is 1. If start_position is a negative value, the counting starts from the end to the start of the string and the last character is -1. If the input is of another type, an error is returned.
- length: bigint type. It indicates the length of the substring, which is greater than 0. If it is of another type or less than or equal to 0, an error is returned.

Returned value: string type. If any input is NULL, NULL is returned.

> **Note** If the length is omitted, the substring from start to end is returned.

Example:

```
substr("abc", 2) = "bc"
substr("abc", 2, 1) = "b"
substr("abc",-2,2) = "bc"
substr("abc",-3) = "abc"
```

1.6.7.2.18. TOLOWER

Function declaration:

```
string tolower(string source)
```

Purpose: It is used to convert 'source' into a lowercase string and return the value.

Description:

source: string type. If the input is of the bigint, decimal, double, or datetime type, it is implicitly converted into a value of the string type before this computation. For all other input types, an error is returned.

Returned value: string type. If the input is NULL, NULL is returned.

Example:

```
tolower("aBcd") = "abcd"
tolower("Haha Cd") = "haha cd"
```

1.6.7.2.19. TOUPPER

Function declaration:

```
string toupper(string source)
```

Purpose: It is used to convert 'source' into an uppercase string and return the value.

Description:

source: string type. If the input is of the bigint, decimal, double, or datetime type, it is implicitly converted into a value of the string type before this computation. For all other types of inputs, an error is returned.

Returned value: string type. If the input is NULL, NULL is returned.

Example:

```
toupper("aBcd") = "ABCD"
toupper("HahaCd") = "HAHACD"
```

1.6.7.2.20. TO_CHAR

Function declaration:

```
string to_char(boolean value)
string to_char(bigint value)
string to_char(double value)
string to_char(decimal value)
```

Purpose: It is used to convert the input of the boolean, bigint, decimal, or double type into a value of the string type.

Description:

value: boolean, bigint, or double type. For all other types of inputs, an error is returned. For more information about the formatted output of data of the datetime type, see Date processing functions — TO_CHAR.

Returned value: string type. If the input is NULL, NULL is returned.

Example:

```
to_char(123) = '123'
to_char(true) = 'TRUE'
to_char(1.23) = '1.23'
to_char(null) = 'null'
```

1.6.7.2.21. TRIM

Function declaration:

```
string trim(string str)
```

Purpose: It is used to remove the spaces from both ends of 'str'.

Description:

str: string type. If the input is of the bigint, decimal, double, or datetime type, it is implicitly converted into a value of the string type before this computation. For all other types of inputs, an error is returned.

Returned value: string type. If the input is NULL, NULL is returned.

1.6.7.2.22. LTRIM

Function declaration:

```
string ltrim(string str)
```

Purpose: It is used to remove the left spaces for input string str.

Description:

str: string type. If the input is of the bigint, decimal, double, or datetime type, it is implicitly converted into a value of the string type before this computation. For all other input types, an error is returned.

Returned value: string type. If the input is NULL, NULL is returned.

Example:

```
select ltrim(' abc ') from dual;
-- Returned result:
+-----+
| _c0 |
+-----+
| abc |
+-----+
```

1.6.7.2.23. RTRIM

Function declaration:

```
string rtrim(string str)
```

Purpose: It is used to remove the rightmost spaces from the input string 'str'.

Description:

str: string type. If the input is of the bigint, decimal, double, or datetime type, it is implicitly converted into a value of the string type before this computation. For all other input types, an error is returned.

Returned value: string type. If the input is NULL, NULL is returned.

Example:

```
select rtrim('a abc ') from dual;
-- Returned result:
+-----+
| _c0 |
+-----+
| a abc |
+-----+
```

1.6.7.2.24. REVERSE

Function declaration:

```
STRING REVERSE(string str)
```

Purpose: It is used to return a reverse string.

Description:

str: string type. If the input is of the bigint, decimal, double, or datetime type, it is implicitly converted into a value of the string type before this computation. For all other input types, an error is returned.

Returned value: string type. If the input is NULL, NULL is returned.

Example:

```
select reverse('abcedfg') from dual;
-- Returned result:
+-----+
| _c0 |
+-----+
| gfdecba |
+-----+
```

1.6.7.2.25. SPACE

Function declaration:

```
STRING SPACE(bigint n)
```

Purpose: It is used to return a string with 'n' consecutive space characters.

Description:

n: bigint type. The length cannot exceed 2 MB. If the input is NULL, an error is returned.

Returned value: string type.

Example:

```
select length(space(10)) from dual;
-- 10 is returned.
select space(400000000000) from dual;
-- An error is returned as the length exceeds 2 MB.
```

1.6.7.2.26. REPEAT

Function declaration:

```
STRING REPEAT(string str, bigint n)
```

Purpose: It is used to return string 'str' that has been repeated n times.

Description:

- str: string type. If the input is of the bigint, decimal, double, or datetime type, it is implicitly converted into a value of the string type before this computation. For all other input types, an error is returned.
- n: bigint type. The length cannot exceed 2 MB. If it is NULL, an error is returned.

Returned value: string type.

Example:

```
select repeat('abc',5) from lxw_dual;
-- abcabcabcabcabc is returned.
```

1.6.7.2.27. ASCII

Function declaration:

```
Bigint ASCII(string str)
```

Purpose: It is used to return the ASCII code of the first character of string 'str'.

Description:

str: string type. If the input is of the bigint, decimal, double, or datetime type, it is implicitly converted into a value of the string type before this computation. For all other input types, an error is returned.

Returned value: bigint type.

Example:

```
select ascii('abcde') from dual;
-- 97 is returned.
```

1.6.7.2.28. URL_ENCODE

Function declaration:

```
STRING URL_ENCODE(STRING input[, STRING encoding])
```

Purpose: It is used to encode the input string in the application/x-www-form-urlencoded MIME format:

- a-z and A-Z remain unchanged.
- ".", "-", "*", and "_" remain unchanged.
- Spaces are converted into "+".
- The rest of the characters are converted into byte values according to the specified encoding. If encoding is not specified, UTF-8 is used by default. In this case, each byte value is represented in the %xy format, where xy represents the hexadecimal form of the character.

Description:

- input: string type.
- encoding: specifies an encoding format. If it is not specified, UTF-8 is used by default.

Returned value: string type. If the input is NULL, NULL is returned.

Example:

```
url_encode('Example for url_encode:// (fdsf)') = "%E7%A4%BA%E4%BE%8Bfor+url_encode%3A%2F%2F+%28fdsf%29"
url_encode('Example for url_encode :// dsf(fasfs)', 'GBK') = "Example+for+url_encode+%3A%2F%2F+dsf%28fasfs%29"
```

1.6.7.2.29. URL_DECODE

Function declaration:

```
STRING URL_DECODE(STRING input[, STRING encoding])
```

Purpose: It is used to convert an input string from the application/x-www-form-urlencoded MIME format into a normal string. This is the inverse function of URL_ENCODE:

- a-z and A-Z remain unchanged.
- ".", "-", "*", and "_" remain unchanged.
- "+" is converted into a space.
- The %xy formatted sequence is converted into byte values. Consecutive byte values are interpreted as the corresponding strings based on the input encoding.
- Other characters remain unchanged.
- The final returned value of the function is a UTF-8 string.

Description:

- input: string type.
- encoding: specifies an encoding format. If it is not specified, UTF-8 is used by default.

Returned value: string type. If the input is NULL, NULL is returned.

Example:

```
url_decode('%E7%A4%BA%E4%BE%8Bfor+url_encode%3A%2F%2F+%28fdsf%29')= "Example for url_encode:// (fdsf)"
url_decode('Exaple+for+url_encode+%3A%2F%2F+dsf%28fasfs%29', 'GBK') = "Exaple for url_encode :// dsf(fasfs)" ```
```

1.6.7.2.30. Additional string processing functions

MaxCompute 2.0 provides additional string processing functions. You must add the following SET statement before SQL statements contained in the LPAD, RPAD, and TRANSLATE functions:

```
set odps.sql.type.system.odps2=true;
```

Note You must submit and execute the SET statement and the SQL statements of the new functions simultaneously.

The string processing functions described in subsequent topics are new in MaxCompute 2.0.

1.6.7.2.31. CONCAT_WS

Command syntax:

```
string concat_ws(string SEP, string a, string b...)
```

Purpose: It is used to join input strings starting from the second with the first string as the separator.

Description:

- SEP: delimiter of the tring type. If it is not specified, an error is returned.
- a, b...: string type. If the input is of the bigint, decimal, double, or datetime type, it is implicitly converted into a value of the string type. For all other input types, an error is returned.

Returned value: string type. If there is no input or if any input is NULL, NULL is returned.

Example:

```
concat_ws(':','name','bob') = 'name:bob'
concat_ws(':','avg',null,'34')= 'null'
```

1.6.7.2.32. LPAD

Function declaration:

```
string lpad(string a, int len, string b)
```

Purpose: It is used to pad the left side of string a with string b until the new padded string has len bits.

Description:

- len: int type.
- a, b: string type.

Returned value: string type. If len is less than the number of bits in a, a is truncated from the left to obtain a string with the number of bits specified by len. If len is 0, NULL is returned.

Example:

```
lpad('abcdefgh',10,'12')='12abcdefgh'
lpad('abcdefgh',5,'12')='abcde'
lpad('abcdefgh',0,'12')
-- NULL is returned.
```

1.6.7.2.33. RPAD

Function declaration:

```
string rpad(string a, int len, string b)
```

Purpose: It is used to pad the right side of string 'a' with string 'b' until the new padded string has 'len' places.

Description:

- len: int type.
- a, b: string type.

Returned value: string type. If len is smaller than the number of characters in a, a is truncated from the left to obtain a string with the number of characters specified by len. If len is 0, NULL is returned.

Example:

```
rpad('abcdefgh',10,'12')='abcdefgh12'
rpad('abcdefgh',5,'12')='abcde'
rpad('abcdefgh',0,'12')
-- NULL is returned.
```

1.6.7.2.34. REPLACE

Function declaration:

```
string replace(string a, string OLD, string NEW)
```

Purpose: It is used to replace the part of string a that is exactly the same as string OLD with string NEW, and return string a.

Description:

All parameters are of the string type.

Returned value: string type. If any input is NULL, NULL is returned.

Example:

```
replace('abababab','abab','12') = '12ab'
replace('abababab','cdf','123') = 'abababab'
replace('123abab456ab',null,'abab') = 'null'
```

1.6.7.2.35. SOUNDEX

Function declaration:

```
string soundex(string a)
```

Purpose: It is used to convert an ordinary string into a soundex string.

Description:

All parameters are of the string type.

Returned value: string type. If the input is NULL, NULL is returned.

Example:

```
soundex('hello') = 'H400'
```

1.6.7.2.36. SUBSTRING_INDEX

Function declaration:

```
string substring_index(string a, string SEP, int count))
```

Purpose: It is used to return the substring in 'a' that comes before the 'count' (nth) delimiter ('SEP'). If 'count' is a positive value, it starts from the left of the string. If 'count' is a negative value, it starts from the right of the string.

Description:

- a, SEP: string type.
- count: int type.

Returned value: string type. If the input is NULL, NULL is returned.

Example:

```
substring_index('https://help.aliyun.com', '.', 2) = 'https://help.aliyun'
substring_index('https://help.aliyun.com', '.', -2) = 'aliyun.com'
substring_index('https://help.aliyun.com', null, 2) = 'null'
```

1.6.7.2.37. TRANSLATE

Function declaration:

```
string translate(string|varchar str1, string|varchar str2, string|varchar str3)
```

Purpose: It is used to replace str2 in str1 with str3.

Returned value: STRING type. If any input is NULL, NULL is returned.

Example:

```
translate('MaxComputer','puter','pute')='MaxCompute'
translate('aaa','b','c')='aaa'
translate('MaxComputer','puter',null)=null
```

1.6.7.3. Date processing functions

1.6.7.3.1. DATEADD

Function declaration:

```
datetime dateadd(datetime date, bigint delta, string datepart)
```

Purpose: It is used to modify date based on delta and datepart.

Description:

- date: This value must be a string type date.If the input is of the string type, it is implicitly converted into a value of the datetime type before this computation. For all other types of inputs, an error is returned.
- delta: bigint type. It indicates the scope of modification. If the input is of the string or double type, it is implicitly converted into a value of the bigint type before this computation. If the input is of another type, an error is returned. If delta is greater than 0, the delta is added to the value. If delta is less than 0, the delta is subtracted from the value.
- datepart: a constant of the string type. This field is set based on the string-datetime conversion convention. yyyy indicates year and mm indicates month. For rules of type conversion, see Conversion between the string type and datetime type. In addition, the extended date format is also supported: year, month or mon, day, and hour. If the parameter value is not a constant or of an unsupported format or another type, an error is returned.

Returned value: datetime type. If any input is NULL, NULL is returned.

> **Note**
>
> - When delta is added to or subtracted from the value, carrying and borrowing are base-10 for year, base-12 for month, base-24 for hour, and base-60 for minute and second. If delta is measured in months, the following calculation is applied: If the month in the datetime value does not cause the day value to become invalid after delta is added, the day value is kept. Otherwise, the day value is adjusted to the last day of the resulting month.
> - This field is set based on the string-datetime conversion convention. yyyy indicates the year and mm indicates the month. Unless otherwise specified, all built-in functions related to the datetime type follow this convention. Unless otherwise specified, the datepart of all built-in functions related to the datetime type also supports the extended date format: year, month or mon, day, and hour.

Example:

```
If trans_date = 2017-02-28 00:00:00:
dateadd(trans_date, 1, 'dd') = 2017-03-01 00:00:00
-- Add one day. The result is beyond the last day of February. The actual value is the first day of next month.
dateadd(trans_date, -1, 'dd') = 2017-02-27 00:00:00
-- Subtract one day.
dateadd(trans_date, 20, 'mm') = 2018-10-28 00:00:00
-- 20 months are added. The month overflows, and 1 is added to the year.
trans_date = 2017-02-28 00:00:00, dateadd(transdate, 1, 'mm') = 2017-03-28 00:00:00
trans_date = 2017-01-29 00:00:00, dateadd(transdate, 1, 'mm') = 2017-02-28 00:00:00
-- February has 28 days only, so the last day of the month is returned.
trans_date = 2017-03-30 00:00:00, dateadd(transdate, -1, 'mm') = 2017-02-28 00:00:00
```

The values of trans_date used only serve as examples. The datetime examples in this document use simple formats. In MaxCompute SQL, a constant cannot be of the datetime type. The following syntax is incorrect:

```
select dateadd(2017-03-30 00:00:00, -1, 'mm') from tbl1;
```

If you must use a constant of the datetime type, use the following method:

```
select dateadd(cast("2017-03-30 00:00:00" as datetime), -1, 'mm') from tbl1;
-- The String type constant is converted to datatime type by explicit conversion.
```

1.6.7.3.2. DATEDIFF

Function declaration:

```
bigint datediff(datetime date1, datetime date2, string datepart)
```

Purpose: It is used to calculate the difference between date1 and date2 based on the specified datepart.

Description:

- date1 and date2: minuend and subtrahend of the datetime type respectively. If the input is a string, it is implicitly converted into a value of the datetime type before this computation. For all other input types, an error is returned.
- datapart: A constant of the string type. It supports the extended date format. If datepart is not in the specified format or is of another type, an error is returned.

Returned value: bigint type. If any input is NULL, NULL is returned. If date1 is less than date2, the returned value may be negative.

> **Note** The lower unit part is truncated based on 'datepart' in the computation process and then the result is calcualted.

Example:

```
If start = 2017-12-31 23:59:59 and end = 2018-01-01 00:00:00:
datediff(end, start, 'dd') = 1
datediff(end, start, 'mm') = 1
datediff(end, start, 'yyyy') = 1
datediff(end, start, 'hh') = 1
datediff(end, start, 'mi') = 1
datediff(end, start, 'ss') = 1
datediff('2017-05-31 13:00:00', '2017-05-31 12:30:00', 'ss') = 1800
datediff('2017-05-31 13:00:00', '2017-05-31 12:30:00', 'mi') = 30
```

1.6.7.3.3. DATEPART

Function declaration:

```
bigint datepart(datetime date, string datepart)
```

Purpose: It is used to extract the value of the specified datepart in date.

Description:

- date: datetime type. If the input is a string, it is implicitly converted into a value of the datetime type before this computation. For all other input types, an error is returned.
- datepart: a constant of the string type. It supports the extended date format. If datepart is not in the specified format or is of another type, an error is returned.

Returned value: bigint type. If any input is NULL, NULL is returned.

Example:

```
datepart('2017-06-08 01:10:00', 'yyyy') = 2017
datepart('2017-06-08 01:10:00', 'mm') = 6
```

1.6.7.3.4. DATETRUNC

Function declaration:

```
datetime datetrunc (datetime date,string datepart)
```

Purpose: It is used to return the value of a date after the specified datepart is truncated.

Description:

- date: datetime type. If the input is a string, it is implicitly converted into a value of the datetime type before this computation. For all other input types, an error is returned.
- datepart: a constant of the string type. It supports the extended date format. If datepart is not in the specified format or is of another type, an error is returned.

Returned value: datetime type. If any input is NULL, NULL is returned.

Example:

```
datetrunc('2017-12-07 16:28:46', 'yyyy') = 2017-01-01 00:00:00
datetrunc('2017-12-07 16:28:46', 'month') = 2017-12-01 00:00:00
datetrunc('2017-12-07 16:28:46', 'DD') = 2017-12-07 00:00:00
```

1.6.7.3.5. GETDATE

Function declaration:

```
datetime getdate()
```

Purpose: It is used to obtain the current system time. Use UTC+8 as the standard time of MaxCompute.

Returned value: the current date and time of the datetime type.

> **Note** In a MaxCompute SQL task (executed in a distributed manner), 'getdate' always returns a fixed value. The returned result is any time in MaxCompute. The time returned is precise to the second. In later versions, the time will be precise to the milisecond.

1.6.7.3.6. ISDATE

Function declaration:

```
boolean isdate(string date, string format)
```

Purpose: It is used to determine whether a date string can be converted into a date value based on the corresponding format string. If the conversion can be performed, true is returned. Otherwise, false is returned.

Description:

- date: This value must be a string type date. If the input is of the bigint, decimal, double, or datetime type, it is implicitly converted into a value of the string type before this computation. For all other input types, an error is returned.
- format: a constant of the string type. The extended date format is not supported. If it is of another type or an unsupported format, an error is returned. If there are redundant format strings appearing in 'format', the date value corresponding to the first format string is used. Other strings are taken as delimiters. If isdate("1234-yyyy", "yyyy-yyyy"), true is returned.

Returned value: boolean type. If any input is NULL, NULL is returned.

1.6.7.3.7. LASTDAY

Function declaration:

```
datetime lastday(datetime date)
```

Purpose: It is used to return the last day of the current month to which the date belongs. The value is accurate to day. The hour, minute, and second part is expressed as 00:00:00.

Description:

date: datetime type. If the input is a string, it is implicitly converted into a value of the datetime type before this computation. For all other input types, an error is returned.

Returned value: datetime type. If the input is NULL, NULL is returned.

1.6.7.3.8. TO_DATE

Function declaration:

```
datetime to_date(string date, string format)
```

Purpose: It is used to convert the 'date' string into a date value.

Description:

- date: string type. It indicates the date value of the string type to be converted. If the input is of the bigint, decimal, double, or datetime type, it is implicitly converted into a value of the string type before this computation. For all other types of inputs or NULL, an error is returned.
- format: a constant of the string type in the date format. For all other types of inputs and non-constant values, an error is returned. It does not support the extended date format. Other characters are ignored as invalid characters in parsing. The format parameter must contain yyyy. Otherwise, an error is returned. If there are redundant format strings in the format, the corresponding date value of the first format string is used, and the rest are processed as separators. For example, to_date('1234-2234', 'yyyy-yyyy') returns '1234-01-01 00:00:00'.

Returned value: datetime type. The format is *yyyy-mm-dd hh:mi:ss*. If any input is NULL, NULL is returned.

Example:

```
to_date('Alibaba2017-12*03', 'Alibabayyyy-mm*dd') = 2017-12-03 00:00:00
to_date('20170718', 'yyyymmdd') = 2017-07-18 00:00:00
to_date('201707182030','yyyymmddhhmi')=2017-07-18 20:30:00
to_date('2017718', 'yyyymmdd')
-- Invalid format. NULL is returned.
to_date('Alibaba2017-12*3', 'Alibabayyyy-mm*dd')
-- Invalid format. NULL is returned.
to_date('2017-24-01', 'yyyy')
-- Invalid format. NULL is returned.
```

1.6.7.3.9. TO_CHAR

Function declaration:

```
string to_char(datetime date, string format)
```

Purpose: It is used to convert a value of the date type into a string based on the specified format.

Description:

- date: date value of the datetime type to be converted. If the input is a string, it is implicitly converted into a value of the datetime type before this computation. For all other types of inputs, an error is returned.
- format: a constant of the string type. If it is not a constant or is of a different type, an error is returned. In format, the date format part is replaced with the corresponding data and other characters are output directly.

Returned value: string type. If any input is NULL, NULL is returned.

Example:

```
to_char('2017-12-03 00:00:00', 'Alibabayyyy-mm*dd') = 'Alibaba2017-12*03'
to_char('2017-07-18 00:00:00', 'yyyymmdd') = '20170718'
to_char('Alibaba 2017-12*3', 'Alibaba yyyy-mm*dd')
-- Null is returned.
to_char('2017-24-01', 'yyyy')
-- Null is returned.
to_char('2017718', 'yyyymmdd')
-- Null is returned.
```

> **Note** For more information about conversion from other types into the string type, see String functions — TO_CHAR.

1.6.7.3.10. UNIX_TIMESTAMP

Function declaration:

```
bigint unix_timestamp(datetime date)
```

Purpose: It is used to convert a date into a datetime value of the integer type in the Unix format.

Description:

date: datetime type. It indicates the date. If the input is a string, it is implicitly converted into a value of the datetime type before this computation. For all other input types, an error is returned.

Returned value: bigint type. It indicates the date value in Unix format. If date is NULL, NULL is returned.

1.6.7.3.11. FROM_UNIXTIME

Function declaration:

```
datetime from_unixtime(bigint unixtime)
```

Purpose: It is used to convert a Unix date value from the BIGINT type to the DATETIME type.

Description:

unixtime: BIGINT type. It is a date value in the Unix format. If the input is of the STRING, DECIMAL, or DOUBLE type, it is implicitly converted into a value of the BIGINT type before computation.

Returned value: DATETIME type. If unixtime is NULL, NULL is returned.

> **Note** In the HIVE-compatible mode (where `set odps.sql.hive.compatible=true;` has been executed), if the input is of the STRING type, a date value of the STRING type is returned.

Example:

```
from_unixtime(123456789) = 1973-11-30 05:33:09;
```

1.6.7.3.12. WEEKDAY

Function declaration:

```
bigint weekday (datetime date)
```

Purpose: It is used to return the day of week for the specified date.

Description:

date: datetime type. If the input is of the string type, it is implicitly converted to a value of the datetime type before this computation. For all other input types, an error is returned.

Returned value: bigint type. If the input is NULL, NULL is returned. Monday is the first day of a week and the returned value is 0. Days are numbered in ascending order starting from 0. If the day is Sunday, the returned value is 6.

1.6.7.3.13. WEEKOFYEAR

Function declaration:

```
bigint weekofyear(datetime date)
```

Purpose: It is used to return the calendar week of the year that the specified date falls in. The system uses Monday as the first day of the week.

> **Note** If a week extends into the next year, the week belongs to the year containing four days or more. If more days fall in the first year, the week is considered as the last week of the first year. If more days fall in the second year, the week is considered as the first week of the second year.

Description:

date: the date of the datetime type. If the input is of the string type, it is implicitly converted to a value of the datetime type before this computation. For all other input types, an error is returned.

Returned value: bigint type. If the input is NULL, NULL is returned.

Example:

```
select weekofyear(to_date("20171229", "yyyymmdd")) from dual;
Returned value:
+------------+
| _c0      |
+------------+
| 1        |
+------------+
-- 20171229 is in year 2017, but the most days of the week are in year 2018. Therefore, the returned value is 1
, which indicates the first week of year 2018.
select weekofyear(to_date("20171231", "yyyymmdd")) from dual;
-- 1 is returned.
select weekofyear(to_date("20181229", "yyyymmdd")) from dual;
-- The returned value is 53.
```

1.6.7.3.14. Additional date functions

MaxCompute 2.0 provides additional date functions. You must add the following SET statement before SQL statements contained in the date functions:

```
set odps.sql.type.system.odps2=true;
```

> **Note** You must submit and execute the SET statement and the SQL statements of the new functions simultaneously.

Example:

```
set odps.sql.type.system.odps2=true;
select year('2017-01-01 12:30:00') = 2017 from dual;
```

The date functions described in subsequent topics are new in MaxCompute 2.0.

1.6.7.3.15. YEAR

Function declaration:

```
INT year(string date)
```

Purpose: It is used to return the year of the specified date.

Description:

date: the date of the string type. The date format must include yyyy-mm-dd and have no redundant strings. Otherwise, NULL is returned.

Returned value: int type.

Example:

```
year('2017-01-01 12:30:00') = 2017
year('2017-01-01') = 2017
year('17-01-01') = 17
year(2017-01-01) = null
year('2017/03/09') = null
year(null) = null
```

1.6.7.3.16. QUARTER

Command syntax:

```
int quarter(datetime/timestamp/string date)
```

Purpose: It is used to return the quarter of the input date, ranging from 1 to 4.

Description:

date: datetime, timestamp, or string type. The date format must include yyyy-mm-dd and have no redundant strings. Otherwise, NULL is returned.

Returned value: int type. If the input is NULL, NULL is returned.

Example:

```
quarter('2017-11-12 10:00:00') = 4
quarter('2017-11-12') = 4
```

1.6.7.3.17. MONTH

Function declaration:

```
INT month(string date)
```

Purpose: It is used to return the month of the input date.

Description:

date: This value must be a date of the string type. For all other input types, an error is returned.

Returned value: int type.

Example:

```
month('2017-09-01') = 9
month('20170901') = null
```

1.6.7.3.18. DAY

Function declaration:

```
INT day(string date)
```

Purpose: It is used to return the day of the input date.

Description:

date: This value must be a string type date. For all other input types, an error is returned.

Returned value: int type.

Example:

```
day('2017-09-01') = 1
day('20170901') = null
```

1.6.7.3.19. DAYOFMONTH

Function declaration:

```
INT dayofmonth(date)
```

Purpose: It is used to return the day of the month for the input date.

Description:

date: This value must be a string type date. For all other input types, an error is returned.

Returned value: int type.

Example:

```
dayofmonth('2017-09-01') = 1
dayofmonth('20170901') = null
```

1.6.7.3.20. HOUR

Function declaration:

```
INT hour(string date)
```

Purpose: It is used to return the hour of the input date.

Description:

date: This value must be a string type date. For all other input types, an error is returned.

Returned value: int type.

Example:

```
hour('2017-09-01 12:00:00') = 12
hour('12:00:00') = 12
hour('20170901120000') = null
```

1.6.7.3.21. MINUTE

Function declaration:

```
INT minute(string date)
```

Purpose: It is used to return the minute of the input date.

Description:

date: This value must be a string type date. For all other input types, an error is returned.

Returned value: int type.

Example:

```
minute('2017-09-01 12:30:00') = 30
minute('12:30:00') = 30
minute('20170901120000') = null
```

1.6.7.3.22. SECOND

Function declaration:

```
INT second(string date)
```

Purpose: It is used to return the second of the input date.

Description:

date: This value must be a string type date. For all other input types, an error is returned.

Returned value: int type.

Example:

```
second('2017-09-01 12:30:45') = 45
second('12:30:45') = 45
second('20170901123045') = null
```

1.6.7.3.23. FROM_UTC_TIMESTAMP

Function declaration:

```
timestamp from_utc_timestamp({any primitive type}*, string timezone)
```

Purpose: It is used to convert a UTC timestamp to a timestamp for a specified timezone.

Description:

- {any primitive type}*: the timestamp. The type can be TIMESTAMP, DATETIME, TINYINT, SMALLINT, INT, or BIGIN.
- timezone: Specifies the destination timezone, such as PST.

Returned value: DATETIME type.

Example:

```
select from_utc_timestamp(1501557840,'PST') = '1970-01-18 09:05:57.84'
select from_utc_timestamp('1970-01-30 16:00:00','PST') = '1970-01-30 08:00:00.0'
select from_utc_timestamp('1970-01-30','PST') = '1970-01-29 16:00:00.0'
```

1.6.7.3.24. CURRENT_TIMESTAMP

Function declaration:

```
timestamp current_timestamp()
```

Purpose: The current timestamp is returned as a Timestamp-type value. The value is not fixed.

Returned value: timestamp type.

Example:

```
select current_timestamp() from dual;
-- '2017-08-03 11:50:30.661'is returned.
```

1.6.7.3.25. ADD_MONTHS

Function declaration:

```
string add_months(string startdate, int nummonths)
```

Purpose: It is used to return the date, which is 'nummonths' months later than 'startdate'.

Description:

- startdate: This value must be a string type date. The date format must contain yyyy-mm-dd. Otherwise, NULL is returned.
- num_months: int type.

Returned value: This value must be a string type date. The format is yyyy-mm-dd.

Example:

```
Add_months ('2017-02-14', 3) = '2017-05-14'
add_months('17-2-14',3) = '0017-05-14'
add_months('2017-02-14 21:30:00',3) = '2017-05-14'
add_months('20170214',3) = null
```

1.6.7.3.26. LAST_DAY

Function declaration:

```
string last_day(string date)
```

Purpose: It is used to return the last date of the month.

Description:

date: string type. The format is yyyy-MM-dd HH:mi:ss or yyyy-mm-dd.

Returned value: This value must be a datetime type date. The format is yyyy-mm-dd.

Example:

```
last_day('2017-03-04') = '2017-03-31'
last_day('2017-07-04 11:40:00') = '2017-07-31'
last_day('20170304') = null
```

1.6.7.3.27. NEXT_DAY

Function declaration:

```
string next_day(string startdate, string week)
```

Purpose: It is used to return the next date that is later than startdate and matches the week value. That is, the date of the day specified of the next week.

Description:

- startdate: string type. The format is yyyy-MM-dd HH:mi:ss or yyyy-mm-dd.
- week: string type. The name of a day, or the first 2 or 3 letters of the day, for example, Mo, TUE, or FRIDAY.

Returned value: This value must be a string type date. The format is yyyy-mm-dd.

Example:

```
next_day('2017-08-01','TU') = '2017-08-08'
next_day('2017-08-01 23:34:00','TU') = '2017-08-08'
Next_day ('20170801 ', 'tu') = NULL
```

1.6.7.3.28. MONTHS_BETWEEN

Function declaration:

```
double months_between(datetime/timestamp/string date1, datetime/timestamp/string date2)
```

Purpose: It is used to return the number of months between date1 and date2.

Description:

- date1: datetime, timestamp, or string type. The format is yyyy-MM-dd HH:mi:ss or yyyy-mm-dd.
- date2: datetime, timestamp, or string type. The format is yyyy-MM-dd HH:mi:ss or yyyy-mm-dd.

Returned value: double type.

- If 'date1' is later than 'date2', the returned value is positive. If 'date2' is later than 'date1', the returned value is negative.
- When date1 and date2 correspond to the last days of two months, the returned value is an integer representing the number of months. Otherwise, the formula is (date1 - date2)/31.

Example:

```
months_between('1997-02-28 10:30:00', '1996-10-30') = 3.9495967741935485
months_between('1996-10-30','1997-02-28 10:30:00' ) = -3.9495967741935485
months_between('1996-09-30','1996-12-31') = -3.0
```

1.6.7.4. Window functions

1.6.7.4.1. Overview

In MaxCompute SQL statements, you can use the window function to analyze and process data flexibly. The window function can only appear in SELECT clauses. It does not support nested Window or aggregation functions. The window function cannot be used with the same-level aggregation functions at the same time.

A MaxCompute SQL statement supports up to five window functions.

Syntax:

```
window_func() over (partition by col1, [col2...]
[order by col1 [asc|desc][, col2[asc|desc]...]] windowing_clause)
```

Description:

- PARTITION BY specifies partition columns. The rows on which the partition column values are the same are considered to be in the same window. A window can contain up to 100 million rows of data (we recommend that the number of rows does not exceed 5 million). Otherwise, an error is returned.
- Use ORDER BY to specify the rule for sorting data in a window.
- You can use ROWS in windowing_clause to specify the partitioning method. There are two methods:

- rows between x preceding|following and y preceding|following indicates a window range from the xth row preceding or following the current row to the yth row preceding or following the current row.
- rows x preceding|following indicates a window range from the xth row preceding or following the current row to the current row.

> **Note**
> - x and y must be integer constants greater than or equal to 0. Their values range from 0 to 10,000. 0 indicates the current row.
> - You must specify ORDER BY before using ROWS to specify a window range.
> - Not all window functions open windows using the method specified by ROWS. The method is only supported by the following functions: AVG, COUNT, MAX, MIN, STDDEV, and SUM.

1.6.7.4.2. COUNT

Command syntax:

```
bigint count([distinct] expr) over(partition by col1[, col2…]
[order by col1 [asc|desc][, col2[asc|desc]…]] [windowing_clause])
```

Purpose: It is used to return the number of values on the expr column.

Description:

- expr: any type. When it is NULL, this row is not involved in computation. If the distinct keyword is specified, this parameter indicates that only distinct values are counted.
- partition by col1[, col2...]: specifies the partitions used in the computation.
- order by col1 [asc|desc],col2[asc|desc]: The count value of expr in the current window is returned if ORDER BY is not set. The returned results are sorted in the specified order if ORDER BY is specified, and the value is the count value from the start row to the current row in the current window.

Returned value: bigint.

> **Note** If the distinct keyword is specified, ORDER BY cannot be used.

Example:

The user_id column of the bigint type exists in the test_src table.

```
select user_id,count(user_id) over (partition by user_id) as count from test_src;
+---------+------------+
| user_id | count    |
+---------+------------+
| 1    | 3      |
| 1    | 3      |
| 1    | 3      |
| 2 | 1 |
| 3 | 1 |
+---------+------------+
+---------+------------+
-- If ORDER BY is not specified, the number of values on the user_id column from the current partition is retu
rned.
select user_id,count(user_id) over (partition by user_id order by user_id) as count from test_src;
+---------+------------+
| user_id | count    |
+---------+------------+
| 1 | 1 | -- start row of the window
| 1 | 2 | --two records exist from start row to current row. Return 2.
| 1    | 3      |
| 2    | 1      |
| 3    | 1      |
+---------+------------+
-- If ORDER BY is specified, the count value from the start row to the current row from the current partition is
returned.
```

1.6.7.4.3. AVG

Function declaration:

```
avg([distinct] expr) over(partition by col1[, col2…]
[order by col1 [asc|desc] [, col2[asc|desc]…]] [windowing_clause])
```

Purpose: It is used to calculate the average value.

Description:

- distinct: If the distinct keyword is specified, this parameter indicates that the average value of distinct values is calculated.
- expr: double type. If the input is of the string or bigint type, it is implicitly converted into a value of the double type before computation. If the input is of another type, an error is returned. If the input is NULL, this row is not used in computation. The input cannot be of the boolean type.
- partition by col1[, col2]...: specifies the partitions used in the computation.

- order by col1 [asc|desc], col2[asc|desc]: The count value of expr in the current window is returned if ORDER BY is not set. The returned results are sorted in the specified order if ORDER BY is specified, and the value is the count value from the start row to the current row in the current window.

Returned value: double type.

> **Note** If the distinct keyword is specified, ORDER BY cannot be set.

1.6.7.4.4. MAX

Function declaration:

```
max([distinct] expr) over(partition by col1[, col2…]
[order by col1 [asc|desc][, col2[asc|desc]…]] [windowing_clause])
```

Purpose: It is used to return the maximum value.

Description:

- expr: any types except the boolean type. If the value is NULL, the corresponding row is not involved in the operation. If the distinct keyword is specified, this parameter indicates that the maximum value of the distinct values is taken (whether this parameter is set or not does not affect the result).
- partition by col1[, col2...]: specifies the partitions used in the computation.
- order by col1 [asc|desc], col2[asc|desc]: The maximum value in the current window is returned if ORDER BY is not set. If ORDER BY is set, the returned results are sorted in the specified order, and the values are the maximum values from the start row to the current row in the current window.

Returned value: The type is the same as that of expr.

> **Note** If the distinct keyword is specified, ORDER BY cannot be set.

1.6.7.4.5. MIN

Function declaration:

```
min([distinct] expr) over(partition by col1[, col2…]
[order by col1 [asc|desc][, col2[asc|desc]…]] [windowing_clause])
```

Purpose: It is used to return the minimum value.

Description:

- expr: any types except the boolean type. If the value is NULL, the corresponding row is not involved in the operation. If the distinct keyword is specified, this parameter indicates that the minimum value of distinct values is taken (whether this parameter is set or not does not affect the result).
- partition by col1[, col2...]: specifies the partitions used in the computation.
- order by col1 [asc|desc], col2[asc|desc]: The minimum value in the current window is returned if ORDER BY is not set. If ORDER BY is set, the returned results are sorted in the specified order, and the returned value is the minimum value in the current window from the start row to the current row.

Returned value: The type is the same as that of expr.

> **Note** If the distinct keyword is specified, ORDER BY cannot be set.

1.6.7.4.6. MEDIAN

Function declaration:

```
double median(double number) over(partition by col1[, col2…])
decimal median(decimal number) over(partition by col1[,col2…])
```

Purpose: It is used to calculate the median.

Description:

- number: double or decimal type. If the input is of the string or bigint type, it is implicitly converted into a value of the double type before this computation. For all other input types, an error is returned. If the input is NULL, NULL is returned.
- partition by col1[, col2...]: specifies the partitions used in the computation.

Returned value: double type.

1.6.7.4.7. STDDEV

Function declaration:

```
double stddev([distinct] expr) over(partition by col1[, col2…] [order by col1 [asc|desc][, col2[asc|desc]…]] [w
indowing_clause])
decimal stddev([distinct] expr) over(partition by col1[,col2…] [order by col1 [asc|desc][, col2[asc|desc]…]] [w
indowi ng_clause])
```

Purpose: It is used to calculate the population standard deviation.

Description:

- expr: double or decimal type. If the input is of the string or bigint type, it is implicitly converted into a value of the double type before this computation. For all other types of inputs, an error is returned. If the input value is NULL, then NULL is returned. If the distinct keyword is specified, this parameter indicates that the population standard deviation of distinct values is calculated.
- partition by col1[, col2...]: specifies the partitions used in the computation.
- order by col1 [asc|desc], col2[asc|desc]: The population standard deviation of the current window is returned if ORDER BY is not set. If ORDER BY is set, the returned results are sorted in the specified order, and the values are the population standard deviation of the start row to the current row in the current window.

Returned value: When the input is of the decimal type, a value of the decimal type is returned. Otherwise, a value of the double type is returned.

> **Note** If the distinct keyword is specified, ORDER BY cannot be set.

1.6.7.4.8. STDDEV_SAMP

Function declaration:

```
double stddev_samp([distinct] expr) over(partition by col1[, col2···] [order by col1 [asc|desc][, col2[asc|desc]···]] [windowing_clause])
decimal stddev_samp([distinct] expr) over(partition by col1[,col2···] [order by col1 [asc|desc][, col2[asc|desc]···]] [windowing_clause])
```

Purpose: It is used to calculate the sample standard deviation.

Description:

- expr: double or decimal type. If the input is of the string or bigint type, it is implicitly converted into a value of the double type before this computation. For all other types of inputs, an error is returned. If the input is NULL, NULL is returned. If the distinct keyword is specified, this parameter indicates that the sample standard deviation of distinct values is calculated.
- partition by col1[, col2...]: specifies the partitions used in the computation.
- order by col1 [asc|desc], col2[asc|desc]: The sample standard deviation of the current window is returned if ORDER BY is not set. If ORDER BY is set, the returned results are sorted in the specified order, and the values are the sample standard deviation of the start row to the current row in the current window.

Returned value: When the input is of the decimal type, a value of the decimal type is returned. Otherwise, a value of the double type is returned.

> **Note** If the distinct keyword is specified, ORDER BY cannot be set.

1.6.7.4.9. SUM

Function declaration:

```
sum([distinct] expr) over(partition by col1[, col2···]
[order by col1 [asc|desc][, col2[asc|desc]···]] [windowing_clause])
```

Purpose: It is used calculate the sum.

Description:

- expr: double, decimal, or bigint type. If the input is of the string type, it is implicitly converted into a value of the double type before computation. If the input is of another type, an error is returned. If the value is NULL, this row is not calculated. If the distinct keyword is specified, this parameter indicates that the sum of distinct values is calculated.
- partition by col1[, col2...]: specifies the partitions used in the computation.
- order by col1 [asc|desc], col2[asc|desc]: The sum of the expr value in the current window is returned if ORDER BY is not set. If ORDER BY is set, the returned results are sorted in the order specified. The returned results are the cumulative sum of start row to the current row in the current window.

Returned value: When the input is of the bigint type, a value of the bigint type is returned. When the input is of the double or string type, a value of the double type is returned.

> **Note** If the distinct keyword is specified, ORDER BY cannot be set.

1.6.7.4.10. DENSE_RANK

Function declaration:

```
bigint dense_rank() over(partition by col1[, col2…]
order by col1 [asc|desc][, col2[asc|desc]…])
```

Purpose: It is used to calculate the consecutive ranking of values. The data in the same row of col2 has the same rank.

Description:

- partition by col1[, col2...]: specifies the partitions used in the computation.
- order by col1 [asc|desc], col2[asc|desc]: This parameter specifies the value for deciding the ranking.

Returned value: bigint type.

Example:

The emp table contains the following data:

```
| empno | ename | job | mgr | hiredate| sal| comm | deptno |
7369,SMITH,CLERK,7902,1980-12-17 00:00:00,800,,20
7499,ALLEN,SALESMAN,7698,1981-02-20 00:00:00,1600,300,30
7521,WARD,SALESMAN,7698,1981-02-22 00:00:00,1250,500,30
7566,JONES,MANAGER,7839,1981-04-02 00:00:00,2975,,20
7654,MARTIN,SALESMAN,7698,1981-09-28 00:00:00,1250,1400,30
7698,BLAKE,MANAGER,7839,1981-05-01 00:00:00,2850,,30
7782,CLARK,MANAGER,7839,1981-06-09 00:00:00,2450,,10
7788,SCOTT,ANALYST,7566,1987-04-19 00:00:00,3000,,20
7839,KING,PRESIDENT,,1981-11-17 00:00:00,5000,,10
7844,TURNER,SALESMAN,7698,1981-09-08 00:00:00,1500,0,30
7876,ADAMS,CLERK,7788,1987-05-23 00:00:00,1100,,20
7900,JAMES,CLERK,7698,1981-12-03 00:00:00,950,,30
7902,FORD,ANALYST,7566,1981-12-03 00:00:00,3000,,20
7934,MILLER,CLERK,7782,1982-01-23 00:00:00,1300,,10
7948,JACCKA,CLERK,7782,1981-04-12 00:00:00,5000,,10
7956,WELAN,CLERK,7649,1982-07-20 00:00:00,2450,,10
7956,TEBAGE,CLERK,7748,1982-12-30 00:00:00,1300,,10
```

To obtain their serial number, the employees must be group by their departments and sorted by SAL in descending order.

```
SELECT deptno
    , ename
    , sal
    , DENSE_RANK() OVER (PARTITION BY deptno ORDER BY sal DESC) AS nums
-- DEPTNO (department) is the partition used in the computation, and SAL (salary) is used as basis for sortin
g returned results.
  FROM emp;
-- Returned result:
+------------+-------+------------+------------+
| deptno    | ename | sal      | nums     |
+------------+-------+------------+------------+
| 10      | JACCKA | 5000.0    | 1       |
| 10 | King | 5000.0 | 1 |
| 10 | CLARK | 2450.0 | 2 |
| 10 | WELAN | 2450.0 | 2 |
| 10 | TEBAGE | 1300.0 | 3 |
10 | Miller | 1300.0 | 3 |
| 20      | SCOTT | 3000.0    | 1       |
| 20 | Ford | 3000.0 | 1 |
| 20 | JONES | 2975.0 | 2 |
| 20 | ADAMS | 1100.0 | 3 |
| 20 | SMITH | 800.0 | 4 |
| 30      | BLAKE | 2850.0    | 1       |
| 30      | ALLEN | 1600.0    | 2       |
| 30      | TURNER | 1500.0    | 3       |
| 30      | MARTIN | 1250.0    | 4       |
| 30 | WARD | 1250.0 | 4 |
| 30 | JAMES | 950.0 | 5 |
+------------+-------+------------+------------+
```

1.6.7.4.11. RANK

Command syntax:

```
bigint rank() over(partition by col1[, col2…] order by col1 [asc|desc][, col2[asc|desc]…])
```

Purpose: It is used to return a ranking value. The ranking of the same row data with col2 drops.

Description:

- partition by col2[, col2..]: specifies the partitions used in the computation.
- order by col1 [asc|desc], col2[asc|desc]: specifies the rule for deciding the ranking.

Returned value: bigint type.

Example:

Table emp contains the following data:

```
| empno | ename | job | mgr | hiredate| sal| comm | deptno |
7369,SMITH,CLERK,7902,1980-12-17 00:00:00,800,,20
7499,ALLEN,SALESMAN,7698,1981-02-20 00:00:00,1600,300,30
7521,WARD,SALESMAN,7698,1981-02-22 00:00:00,1250,500,30
7566,JONES,MANAGER,7839,1981-04-02 00:00:00,2975,,20
7654,MARTIN,SALESMAN,7698,1981-09-28 00:00:00,1250,1400,30
7698,BLAKE,MANAGER,7839,1981-05-01 00:00:00,2850,,30
7782,CLARK,MANAGER,7839,1981-06-09 00:00:00,2450,,10
7788,SCOTT,ANALYST,7566,1987-04-19 00:00:00,3000,,20
7839,KING,PRESIDENT,,1981-11-17 00:00:00,5000,,10
7844,TURNER,SALESMAN,7698,1981-09-08 00:00:00,1500,0,30
7876,ADAMS,CLERK,7788,1987-05-23 00:00:00,1100,,20
7900,JAMES,CLERK,7698,1981-12-03 00:00:00,950,,30
7902,FORD,ANALYST,7566,1981-12-03 00:00:00,3000,,20
7934,MILLER,CLERK,7782,1982-01-23 00:00:00,1300,,10
7948,JACCKA,CLERK,7782,1981-04-12 00:00:00,5000,,10
7956,WELAN,CLERK,7649,1982-07-20 00:00:00,2450,,10
7956,TEBAGE,CLERK,7748,1982-12-30 00:00:00,1300,,10
```

Now group the employees by department. Sort the employees in each group in descending order based on the salary. Each employee obtains a number that represents their position in the group.

```
SELECT deptno
    , ename
    , sal
    , RANK() OVER (PARTITION BY deptno ORDER BY sal DESC) AS nums
-- DEPTNO (department) is the partitioning column. The sal column is sorted to generate the ranking value f
or each employee.
  FROM emp;
-- Returned result:
+------------+-------+------------+------------+
| deptno    | ename | sal     | nums     |
+------------+-------+------------+------------+
| 10      | JACCKA | 5000.0    | 1       |
| 10      | KING  | 5000.0    | 1       |
| 10      | CLARK | 2450.0    | 3       |
| 10 | WELAN | 2450.0 | 3 |
| 10      | TEBAGE | 1300.0    | 5       |
| 10 | MILLER | 1300.0 | 5 |
| 20      | SCOTT | 3000.0    | 1       |
| 20      | FORD  | 3000.0    | 1       |
| 20      | JONES | 2975.0    | 3       |
| 20      | ADAMS | 1100.0    | 4       |
| 20      | SMITH | 800.0     | 5       |
| 30      | BLAKE | 2850.0    | 1       |
| 30      | ALLEN | 1600.0    | 2       |
| 30      | TURNER | 1500.0    | 3       |
| 30      | MARTIN | 1250.0    | 4       |
| 30      | WARD  | 1250.0    | 4       |
| 30      | JAMES | 950.0     | 6       |
+------------+-------+------------+------------+
```

1.6.7.4.12. LAG

Function declaration:

```
lag(expr, bigint offset, default) over(partition by col1[, col2…] [order by col1 [asc|desc][, col2[asc|desc]…]])
```

Purpose: It is used to retrieve the value in the row with a negative offset from the current row. For example, if the current row is rn, the value retrieved is from the row rn - offset.

Description:

- expr: any type.

- offset: a constant of the bigint type. If the input is of the string or double type, it is implicitly converted into a value of the bigint type before computation, and the offset is greater than 0.
- default: a constant. It specifies the default value when the offset is out of the valid range. The default value is NULL.
- partition by col1[, col2...]: specifies the partitions used in the computation.
- order by col1 [asc|desc], col2[asc|desc]: indicates the sorting order of the returned results.

Returned value: The type is the same as that of expr.

1.6.7.4.13. LEAD

Function declaration:

```
lead(expr, bigint offset, default) over(partition by col1[, col2···][order by col1 [asc|desc][, col2[asc|desc]···]])
```

Purpose: It is used to retrieve the value in the row with a positive offset from the current row. For example, if the current row is rn, the value retrieved is from the row rn + offset.

Description:

- expr: any type.
- offset: a constant of the bigint type. If the input is of the string or double type, it is implicitly converted into a value of the bigint type before computation, and the offset is greater than 0.
- default: a constant. It specifies the default value when the offset is out of the valid range.
- partition by col1[, col2...]: specifies the partitions used in the computation.
- order by col1 [asc|desc], > col2[asc|desc]: indicates the sorting order of the returned results.

Returned value: The type is the same as that of expr.

Example:

```
select c_double_a,c_string_b,c_int_a,lead(c_int_a,1) over(partition by c_double_a order by c_string_b) fro
m dual;
select c_string_a,c_time_b,c_double_a,lead(c_double_a,1) over(partition by c_string_a order by c_time_b) f
rom dual;
select c_string_in_fact_num,c_string_a,c_int_a,lead(c_int_a) over(partition by c_string_in_fact_num order
by c_string_a) from dual;
```

1.6.7.4.14. PERCENT_RANK

Function declaration:

```
percent_rank() over(partition by col1[, col2···] order by col1 [asc|desc][, col2[asc|desc]···])
```

Purpose: It is used to return the relative ranking of a row in a group of data.

Description:

- partition by col1[, col2...]: specifies the partitions used in the computation.
- order by col1 [asc|desc], col2[asc|desc]: specifies the value for the ranking.

Returned value: double type. Value range: 0 to 1. The relative ranking is calculated using the following formula: (rank-1)/(number of rows -1).

> **Note** The number of rows in a window cannot exceed 10,000,000.

1.6.7.4.15. ROW_NUMBER

Function declaration:

```
row_number() over(partition by col1[, col2…] order by col1 [asc|desc][, col2[asc|desc]…])
```

Purpose: It is used to calculate the row number, which starts from 1.

Description:

- partition by col1[, col2...]: specifies the partitions used in the computation.
- order by col1 [asc|desc], > col2[asc|desc]: indicates the sorting value of the returned result.

Returned value: bigint type.

Example:

If table emp contains the following data:

```
| Empno | ename | job | Mgr | hiredate | Sal | REM | deptno |
7369, Smith, clerk, maid-12-17 00:00:00, 800, 20
7499, Allen, salesman, maid-02-20 00:00:00, 1600,300, 30
7521, Ward, salesman, maid-02-22 00:00:00, 1250,500, 30
7566, Jones, Manager, fig-04-02 00:00:00, 2975, 20
7654 Martin, salesman, fig-09-28 00:00:00, fig, 30
7698, Blake, Manager, fig-05-01 00:00:00, 2850, 30
7782, Clark, Manager, fig-06-09 00:00:00, 2450, 10
7788, Scott, analyst, fig-04-19 00:00:00, 3000, 20
00:00:00, King, President, 1991-11-17 5000, 7839, 10
7844, Turner, salesman, fig-09-08 00:00:00, 1500,0, 30
7876, Adams, clerk, maid-05-23 00:00:00, 1100, 20
7900 James, clerk, maid-12-03 00:00:00, 950, 30
7902 Ford, analyst, fig-12-03 00:00:00, 3000, 20
7934 Miller, clerk, fig-01-23 00:00:00, 1300, 10
7948, jaccka, clerk, fig-04-12 00:00:00, 5000, 10
7956, welan, clerk, fig-07-20 00:00:00, 2450, 10
7956,TEBAGE,CLERK,7748,1982-12-30 00:00:00,1300,,10
```

Now, all employees need to be grouped by department, and each group must be sorted in descending order according to SAL to obtain the serial number in own group.

```
SELECT deptno
    , ename
    ,sal
    , ROW_NUMBER() OVER (PARTITION BY deptno ORDER BY sal DESC) AS nums
-- DEPTNO (department) is the partition used in the computation, and SAL (salary) is used as basis for sortin
g results.
  FROM emp;
-- Returned result:
+------------+-------+------------+------------+
| deptno    | ename | sal      | nums     |
+------------+-------+------------+------------+
| 10 | JACCKA | 5000.0 | 1 |
| 10 | KING | 5000.0 | 2 |
| 10 | CLARK | 2450.0 | 3 |
| 10 | WELAN | 2450.0 | 4 |
| 10 | TEBAGE | 1300.0 | 5 |
| 10 | MILLER | 1300.0 | 6 |
| 20 | SCOTT | 3000.0 | 1 |
| 20 | FORD | 3000.0 | 2 |
| 20 | JONES | 2975.0 | 3 |
| 20 | ADAMS | 1100.0 | 4 |
| 20 | SMITH | 800.0 | 5 |
| 30 | BLAKE | 2850.0 | 1 |
| 30 | ALLEN | 1600.0 | 2 |
| 30 | TURNER | 1500.0 | 3 |
| 30 | MARTIN | 1250.0 | 4 |
| 30 | WARD | 1250.0 | 5 |
| 30 | JAMES | 950.0 | 6 |
+------------+-------+------------+------------+
```

1.6.7.4.16. CLUSTER_SAMPLE

Command syntax:

```
boolean cluster_sample(bigint x[, bigint y]) over(partition by col1[, col2..])
```

Purpose: It is used to conduct cluster sampling.

Description:

- x: bigint type. x>=1. If the parameter y is specified, x indicates that a window is divided into x parts. Otherwise, x indicates that x rows of records are extracted from a window (that is, the returned value is true if there are x rows). If x is NULL, NULL is returned.

- y: a constant of the bigint type. y>=1, y<=x. This parameter extracts y records from x parts into which a window is divided (that is, the returned value is true if y records exist). If y is NULL, NULL is returned.
- partition by col1[, col2]: specifies the partitions used in the computation.

Returned value: boolean type.

Example:

The test_tbl table has two columns: key and value. The key column stores the group name of each value. The group names are groupa and groupb. The value column stores the values. The table structure is like this:

```
+------------+-------------------+
| key      | value          |
+------------+-------------------+
| groupa | -1.34764165478145 |
| groupa | 0.740212609046718 |
| groupa | 0.167537127858695 |
| groupa | 0.630314566185241 |
| GroupA | 0.0112401388646925 |
| groupa | 0.199165745875297 |
| groupa | -0.320543343353587 |
| groupa | -0.273930924365012 |
| groupa | 0.386177958942063 |
| groupa | -1.09209976687047 |
| groupb | -1.10847690938643 |
| groupb | -0.725703978381499 |
| groupb | 1.05064697475759 |
| groupb | 0.135751224393789 |
| groupb | 2.13313102040396 |
| groupb | -1.11828960785008 |
| groupb | -0.849235511508911 |
| groupb | 1.27913806620453 |
| groupb | -0.330817716670401 |
| groupb | -0.300156896191195 |
| groupb | 2.4704244205196 |
| groupb | -1.28051882084434 |
+------------+-------------------+
```

Run the following SQL statement to take a sample of 10% of the values in each group:

```
select key, value from (select key, value, cluster_sample(10, 1) over(partition by key) as flag from tbl) sub wh
ere flag = true;
-- Returned result:
+--------+--------------------+
| key    | value              |
+--------+--------------------+
| groupa | -0.273930924365012 |
| groupb | -1.11828960785008 |
+-----+----------------------
```

1.6.7.4.17. NTILE

Function declaration:

```
BIGINT ntile(BIGINT n) over(partition by col1[, col2…] [order by col1 [asc|desc] [, col2[asc|desc]…]] [windowi
ng_clause]))
```

Purpose: It is used to split grouped data into n slices and return the current slice number. If the slice is uneven, the distribution of the first slice is increased.

Description:

n: BIGINT type.

Returned value: BIGINT type.

Example:

Table emp has the following data:

```
| empno | ename | job | mgr | hiredate| sal| comm | deptno |
7369,SMITH,CLERK,7902,1980-12-17 00:00:00,800,,20
7499,ALLEN,SALESMAN,7698,1981-02-20 00:00:00,1600,300,30
7521,WARD,SALESMAN,7698,1981-02-22 00:00:00,1250,500,30
7566,JONES,MANAGER,7839,1981-04-02 00:00:00,2975,,20
7654,MARTIN,SALESMAN,7698,1981-09-28 00:00:00,1250,1400,30
7698,BLAKE,MANAGER,7839,1981-05-01 00:00:00,2850,,30
7782,CLARK,MANAGER,7839,1981-06-09 00:00:00,2450,,10
7788,SCOTT,ANALYST,7566,1987-04-19 00:00:00,3000,,20
7839,KING,PRESIDENT,,1981-11-17 00:00:00,5000,,10
7844,TURNER,SALESMAN,7698,1981-09-08 00:00:00,1500,0,30
7876,ADAMS,CLERK,7788,1987-05-23 00:00:00,1100,,20
7900,JAMES,CLERK,7698,1981-12-03 00:00:00,950,,30
7902,FORD,ANALYST,7566,1981-12-03 00:00:00,3000,,20
7934,MILLER,CLERK,7782,1982-01-23 00:00:00,1300,,10
7948,JACCKA,CLERK,7782,1981-04-12 00:00:00,5000,,10
7956,WELAN,CLERK,7649,1982-07-20 00:00:00,2450,,10
7956,TEBAGE,CLERK,7748,1982-12-30 00:00:00,1300,,10
```

Group all employees by department, sort each group in descending order by salary, and then obtain sequence numbers of employees in each group.

```
-- Execute the following statement:
select  deptno, ename,sal,NTILE(3) OVER(PARTITION BY deptno ORDER BY sal desc) AS nt3 from emp;
-- Returned result:
+------------+-------+------------+------------+
| deptno     | ename | sal        | nt3        |
+------------+-------+------------+------------+
| 10         | JACCKA | 5000.0    | 1          |
| 10         | KING  | 5000.0     | 1          |
| 10         | WELAN | 2450.0     | 2          |
| 10         | CLARK | 2450.0     | 2          |
| 10         | TEBAGE | 1300.0    | 3          |
| 10         | MILLER | 1300.0    | 3          |
| 20         | SCOTT | 3000.0     | 1          |
| 20         | FORD  | 3000.0     | 1          |
| 20         | JONES | 2975.0     | 2          |
| 20         | ADAMS | 1100.0     | 2          |
| 20         | SMITH | 800.0      | 3          |
| 30         | BLAKE | 2850.0     | 1          |
| 30         | ALLEN | 1600.0     | 1          |
| 30         | TURNER | 1500.0    | 2          |
| 30         | MARTIN | 1250.0    | 2          |
| 30         | WARD  | 1250.0     | 3          |
| 30         | JAMES | 950.0      | 3          |
+------------+-------+------------+------------+
```

1.6.7.4.18. NTH_VALUE

Function declaration:

```
nth_value(expr, bigint n [, boolean skipNulls]) over(partition by col1[, col2…] order by col1 [asc|desc][, col2[
asc|desc]…]])
```

Purpose: It is used to return the nth value in partitions used in the computation.

Description:

- expr: required. Any type.
- n: returns the nth value. It starts from 1 and is of the BIGINT type.
- skipNulls: specifies whether to ignore the rows whose values are NULL. This parameter is of the BOOLEAN type. The default value is false.

Returned value: the nth value in partitions used in the computation.

> **Note** If skipNulls is set to true, the nth non-NULL value is returned. If the nth non-NULL value does not exist, NULL is returned.

Example:

```
select a, nth_value(a + 1, 1) over (partition by a order by a) from values (3), (1), (2) as t(a);
-- If n is 1, NTH_VALUE is equivalent to FIRST_VALUE.
-- Returned results:
--1  2
--2  3
--3  4
```

1.6.7.4.19. CUME_DIST

Function declaration:

```
cume_dist() over(partition by col1[, col2…] order by col1 [asc|desc][, col2[asc|desc]…]])
```

Purpose: It is used to return the cumulative distribution. The cumulative distribution is the ratio between the number of rows whose values are less than or equal to the current value of the group and the total number of rows in the group.

Description: None.

> **Note** The order by column specifies values to be compared.

Returned value: the ratio of the number of rows whose values are equal to or less than the current value in the group to the total number of rows in the group.

Example:

Table emp has the following data:

```
| empno | ename | job | mgr | hiredate| sal| comm | deptno |
7369,SMITH,CLERK,7902,1980-12-17 00:00:00,800,,20
7499,ALLEN,SALESMAN,7698,1981-02-20 00:00:00,1600,300,30
7521,WARD,SALESMAN,7698,1981-02-22 00:00:00,1250,500,30
7566,JONES,MANAGER,7839,1981-04-02 00:00:00,2975,,20
7654,MARTIN,SALESMAN,7698,1981-09-28 00:00:00,1250,1400,30
7698,BLAKE,MANAGER,7839,1981-05-01 00:00:00,2850,,30
7782,CLARK,MANAGER,7839,1981-06-09 00:00:00,2450,,10
7788,SCOTT,ANALYST,7566,1987-04-19 00:00:00,3000,,20
7839,KING,PRESIDENT,,1981-11-17 00:00:00,5000,,10
7844,TURNER,SALESMAN,7698,1981-09-08 00:00:00,1500,0,30
7876,ADAMS,CLERK,7788,1987-05-23 00:00:00,1100,,20
7900,JAMES,CLERK,7698,1981-12-03 00:00:00,950,,30
7902,FORD,ANALYST,7566,1981-12-03 00:00:00,3000,,20
7934,MILLER,CLERK,7782,1982-01-23 00:00:00,1300,,10
7948,JACCKA,CLERK,7782,1981-04-12 00:00:00,5000,,10
7956,WELAN,CLERK,7649,1982-07-20 00:00:00,2450,,10
7956,TEBAGE,CLERK,7748,1982-12-30 00:00:00,1300,,10
```

Group all employees by department, and then obtain the cumulative distribution of salary for each group.

```
SELECT deptno
  , ename
, sal
, concat(round(cume_dist() OVER(PARTITION BY deptno ORDER BY sal desc)*100,2),'%') as cume_dist
FROM emp;
```

Returned result is as follows.

Returned result

deptno	ename	sal	cume_dist
10	JACCKA	5000.0	33.33%
10	KING	5000.0	33.33%
10	CLARK	2450.0	66.67%
10	WELAN	2450.0	66.67%
10	TEBAGE	1300.0	100.0%
10	MILLER	1300.0	100.0%

deptno	ename	sal	cume_dist
20	SCOTT	3000.0	40.0%
20	FORD	3000.0	40.0%
20	JONES	2975.0	60.0%
20	ADAMS	1100.0	80.0%
20	SMITH	800.0	100.0%
30	BLAKE	2850.0	16.67%
30	ALLEN	1600.0	33.33%
30	TURNER	1500.0	50.0%
30	MARTIN	1250.0	83.33%
30	WARD	1250.0	83.33%
30	JAMES	950.0	100.0%

1.6.7.4.20. FIRST_VALUE

Function declaration:

```
first_value(expr) over(partition by col1[, col2…] order by col1 [asc|desc][, col2[asc|desc]…]])
```

Purpose: It is used to sort partitions and return the first value in the range from the beginning to the current row.

Description:

expr: required. Any type.

Returned value: the first expr value in partitions used in the computation.

Example:

Table emp has the following data:

```
| empno | ename | job | mgr | hiredate| sal| comm | deptno |
7369,SMITH,CLERK,7902,1980-12-17 00:00:00,800,,20
7499,ALLEN,SALESMAN,7698,1981-02-20 00:00:00,1600,300,30
7521,WARD,SALESMAN,7698,1981-02-22 00:00:00,1250,500,30
7566,JONES,MANAGER,7839,1981-04-02 00:00:00,2975,,20
7654,MARTIN,SALESMAN,7698,1981-09-28 00:00:00,1250,1400,30
7698,BLAKE,MANAGER,7839,1981-05-01 00:00:00,2850,,30
7782,CLARK,MANAGER,7839,1981-06-09 00:00:00,2450,,10
7788,SCOTT,ANALYST,7566,1987-04-19 00:00:00,3000,,20
7839,KING,PRESIDENT,,1981-11-17 00:00:00,5000,,10
7844,TURNER,SALESMAN,7698,1981-09-08 00:00:00,1500,0,30
7876,ADAMS,CLERK,7788,1987-05-23 00:00:00,1100,,20
7900,JAMES,CLERK,7698,1981-12-03 00:00:00,950,,30
7902,FORD,ANALYST,7566,1981-12-03 00:00:00,3000,,20
7934,MILLER,CLERK,7782,1982-01-23 00:00:00,1300,,10
7948,JACCKA,CLERK,7782,1981-04-12 00:00:00,5000,,10
7956,WELAN,CLERK,7649,1982-07-20 00:00:00,2450,,10
7956,TEBAGE,CLERK,7748,1982-12-30 00:00:00,1300,,10
```

Group all employees by department, sort each group in descending order by salary, and then obtain the name of the first employee in each group.

```
SELECT deptno
    , ename
    , sal
    , FIRST_VALUE(ename) OVER(PARTITION BY deptno ORDER BY sal desc) AS first1-- Obtain the name of the first employee in each group after descending sorting by salary.
  FROM emp;
```

Returned result is as follows.

Returned result

deptno	ename	sal	first1
10	JACCKA	5000.0	JACCKA
10	KING	5000.0	JACCKA
10	CLARK	2450.0	JACCKA
10	WELAN	2450.0	JACCKA
10	TEBAGE	1300.0	JACCKA

deptno	ename	sal	first1
10	MILLER	1300.0	JACCKA
20	SCOTT	3000.0	SCOTT
20	FORD	3000.0	SCOTT
20	JONES	2975.0	SCOTT
20	ADAMS	1100.0	SCOTT
20	SMITH	800.0	SCOTT
30	BLAKE	2850.0	BLAKE
30	ALLEN	1600.0	BLAKE
30	TURNER	1500.0	BLAKE
30	MARTIN	1250.0	BLAKE
30	WARD	1250.0	BLAKE
30	JAMES	950.0	BLAKE

1.6.7.4.21. LAST_VALUE

Function declaration:

```
last_value(expr) over(partition by col1[, col2···] order by col1 [asc|desc][, col2[asc|desc]···]])
```

Purpose: It is used to sort partitions and return the last value in the range from the beginning to the current row.

Description:

expr: required. Any type.

Returned value: the last expr value in partitions used in the computation.

Example:

Table emp has the following data:

```
| empno | ename | job | mgr | hiredate| sal| comm | deptno |
7369,SMITH,CLERK,7902,1980-12-17 00:00:00,800,,20
7499,ALLEN,SALESMAN,7698,1981-02-20 00:00:00,1600,300,30
7521,WARD,SALESMAN,7698,1981-02-22 00:00:00,1250,500,30
7566,JONES,MANAGER,7839,1981-04-02 00:00:00,2975,,20
7654,MARTIN,SALESMAN,7698,1981-09-28 00:00:00,1250,1400,30
7698,BLAKE,MANAGER,7839,1981-05-01 00:00:00,2850,,30
7782,CLARK,MANAGER,7839,1981-06-09 00:00:00,2450,,10
7788,SCOTT,ANALYST,7566,1987-04-19 00:00:00,3000,,20
7839,KING,PRESIDENT,,1981-11-17 00:00:00,5000,,10
7844,TURNER,SALESMAN,7698,1981-09-08 00:00:00,1500,0,30
7876,ADAMS,CLERK,7788,1987-05-23 00:00:00,1100,,20
7900,JAMES,CLERK,7698,1981-12-03 00:00:00,950,,30
7902,FORD,ANALYST,7566,1981-12-03 00:00:00,3000,,20
7934,MILLER,CLERK,7782,1982-01-23 00:00:00,1300,,10
7948,JACCKA,CLERK,7782,1981-04-12 00:00:00,5000,,10
7956,WELAN,CLERK,7649,1982-07-20 00:00:00,2450,,10
7956,TEBAGE,CLERK,7748,1982-12-30 00:00:00,1300,,10
```

Group all employees by department, and then obtain the name of the last employee in each group.

```
SELECT deptno
    , ename
    , sal
    , LAST_VALUE(ename) OVER(PARTITION BY deptno  ) AS last1
  FROM emp;
```

The returned result is as follows.

Returned result

deptno	ename	sal	last1
10	TEBAGE	1300.0	WELAN
10	CLARK	2450.0	WELAN
10	KING	5000.0	WELAN
10	MILLER	1300.0	WELAN
10	JACCKA	5000.0	WELAN
10	WELAN	2450.0	WELAN

deptno	ename	sal	last1
20	FORD	3000.0	JONES
20	SCOTT	3000.0	JONES
20	SMITH	800.0	JONES
20	ADAMS	1100.0	JONES
20	JONES	2975.0	JONES
30	TURNER	1500.0	BLAKE
30	JAMES	950.0	BLAKE
30	ALLEN	1600.0	BLAKE
30	WARD	1250.0	BLAKE
30	MARTIN	1250.0	BLAKE
30	BLAKE	2850.0	BLAKE

1.6.7.5. Aggregate functions

1.6.7.5.1. Overview

An aggregate function aggregates multiple input records into an output record. The input is mapped many-to-one to the output. An aggregate function can be used with the GROUP BY clause at the same time.

1.6.7.5.2. COUNT

Command syntax:

```
bigint count([distict|all] value)
```

Purpose: It is used to return the number of records.

Description:

- distinct|all: indicates whether duplicate records are cleared in counting. The default value is all, indicating that records are counted. If it is set to distinct, only records with distinct values are counted.
- value: any type. When it is NULL, this row is not involved in computation. value can be *. When it is set to count(*), the number of all rows is returned.

Returned value: bigint type.

Example:

In the tbla table, the col1 column is of the bigint type.

```
+------+
| COL1 |
+------+
| 1    |
+------+
| 2    |
+------+
| NULL |
+------+
select count(*) from tbla;
-- 3 is returned.
select count(col1) from tbla;
-- The value is 2.
```

Aggregate functions can be used with the GROUP BY statement. For example, table test_src contains two columns: key (string type), and value (double type).

The data in the test_src table:

```
+-----+-------+
| key | value |
+-----+-------+
| a   | 2.0   |
+-----+-------+
| a   | 4.0   |
+-----+-------+
| b   | 1.0   |
+-----+-------+
| b   | 3.0   |
+-----+-------+
select key, count(value) as count from test_src group by key;
-- Run the preceding SQL statement. The output is:
+-----+-------+
| key | count |
+-----+-------+
| a   | 2     |
+-----+-------+
| b   | 2     |
+-----+-------+
```

Aggregate functions perform aggregation on values of the same key. The usage of the following aggregate functions is the same as that of this function and is not described in detail in this document.

1.6.7.5.3. AVG

Function declaration:

```
double avg(double value)
decimal avg(decimal value)
```

Purpose: It is used to calculate the average value.

Description:

value: double type or decimal type. If the input is of the string or bigint type, it is implicitly converted into a value of the double type before this computation. For all other input types, an error is returned. If the value is NULL, this row is not used for calculation. The input cannot be of the boolean type.

Returned value: If the input is of the decimal type, a value of the decimal type is returned. For all other valid input types, a value of the double type is returned.

Example:

In the tbla table, the value column is of the bigint type.

```
+-------+
| value |
+-------+
| 1     |
| 2     |
| NULL  |
+-------+
select avg(value) as avg from tbla;
+------+
| avg  |
+------+
| 1.5  |
+------+
-- The avg result of this column is as follows: (1 + 2) / 2 = 1.5.
```

1.6.7.5.4. MAX

Function declaration:

```
max(value)
```

Purpose: It is used to return the maximum value.

Description:

value: can be any data type. If the column value is NULL, the corresponding row is not involved in the operation. Values of the boolean type are excluded from the computation.

Returned value: The type is the same as that of value.

Example:

In the tbla table, the col1 column is of the bigint type.

```
+------+
| col1 |
+------+
| 1    |
+------+
| 2    |
+------+
| NULL |
+------+
select max(value) from tbla;
-- 2 is returned.
```

1.6.7.5.5. MIN

Function declaration:

```
MIN(value)
```

Purpose: It is used to return the minimum value.

Description:

value: a column of any data type. If a value in the column is NULL, the corresponding row is not involved in the operation. Boolean types are not allowed in this operation.

Returned value: The type is the same as that of value.

Example:

In the tbla table, the value column is of the bigint type.

```
+------+
| value|
+------+
| 1    |
+------+
| 2    |
+------+
| NULL |
+------+
select min(value) from tbla;
-- 1 is returned.
```

1.6.7.5.6. MEDIAN

Function declaration:

```
double median(double number)
decimal median(decimal number)
```

Purpose: It is used to calculate the median.

Description:

number: double or decimal type. If the input is of the string or bigint type, it is implicitly converted into a value of the double type before this computation. For all other input types, an error is returned. If the input is NULL, a failure is returned.

Returned value: double or decimal type.

1.6.7.5.7. STDDEV

Function declaration:

```
double stddev(double number)
decimal stddev(decimal number)
```

Purpose: It is used to calculate the population standard deviation.

Description:

number: double or decimal type. If the input is of the string or bigint type, it is implicitly converted into a value of the double type before this computation. For all other types of inputs, an error is returned. If the input value is NULL, a failure is returned.

Returned value: double or decimal type.

1.6.7.5.8. STDDEV_SAMP

Function declaration:

```
double stddev_samp(double number)
decimal stddev_samp(decimal number)
```

Purpose: It is used to calculate the sample standard deviation.

Description:

number: double or decimal type. If the input is of the string or bigint type, it is implicitly converted into a value of the double type before this computation. For all other types of inputs, an error is returned. If the input is NULL, a failure is returned.

Returned value: double or decimal type.

1.6.7.5.9. SUM

Function declaration:

```
sum(value)
```

Purpose: It is used to calculate the sum.

Description:

value: double, decimal, or bigint type. If the input is of the string type, it is implicitly converted into a value of the double type before computation. If a value in the column is NULL, this row is not used for calculation. Values of the boolean type are excluded from calculation.

Returned value: When the input is of the bigint type, a value of the bigint type is returned. When the input is of the double or string type, a value of the double type is returned.

Example:

In the tbla table, the value column is of the bigint type.

```
+------+
| value|
+------+
| 1  |
+------+
| 2  |
+------+
| NULL |
+------+
select sum(value) from tbla;
-- 3 is returned.
```

1.6.7.5.10. WM_CONCAT

Function declaration:

```
string wm_concat(string separator, string str)
```

Purpose: It is used to use the specified separator as the delimiter to link values in a string.

Description:

- separator: the delimiter, which is a constant of the string type. If it is of another type or is not a constant, an error is returned.
- str: string type. If the input is of the bigint, double, or datetime type, it is implicitly converted to a value of the string type before this computation. For all other input types, an error is returned.

Returned value: string type.

> **Note** If test_src in the select wm_concat(',', name) from > test_src; statement is an empty set, NULL is returned.

1.6.7.5.11. PERCENTILE

Function declaration:

```
DOUBLE percentile(BIGINT col, p)
array<double> percentile(BIGINT col, array(p1 [, p2]...))
```

Purpose: It is used to return the pth percentile of the specified column. p must be between 0 and 1.

> **Notice** You can only calculate true percentiles for integer values.

Description:

- col: BIGINT type.
- p: must be between 0 and 1.

Example:

Column c1 in table test has the following data:

```
+------------+
| c1     |
+------------+
| 8      |
| 9      |
| 10     |
| 11     |
+------------+
```

Calculate the pth percentile of column c1 in table test.

```
-- Execute the following statement:
select percentile(c1,0),percentile(c1,0.3),percentile(c1,0.5),percentile(c1,1) from test;
-- Returned result:
+------------+------------+------------+------------+
| _c0      | _c1      | _c2      | _c3      |
+------------+------------+------------+------------+
| 8.0      | 8.9      | 9.5      | 11.0     |
+------------+------------+------------+------------+
-- Execute the following statement:
select percentile(c1,array(0,0.3,0.5,1))from test;
-- Returned result:
+------+
| _c0 |
+------+
| [8, 8.9, 9.5, 11] |
+------+
```

1.6.7.5.12. Additional aggregate functions

MaxCompute 2.0 provides additional aggregate functions. You must add the following SET statement before SQL statements contained in the aggregate functions:

```
set odps.sql.type.system.odps2=true;
```

Note You must submit and execute the SET statement and the SQL statements of the new functions simultaneously.

The aggregate functions described in subsequent topics are new in MaxCompute 2.0.

1.6.7.5.13. COLLECT_LIST

Command syntax:

```
ARRAY collect_list(col)
```

Purpose: It is used to convert the values on the col column into an array.

Description:

col: a table column of any data type.

Returned value: array type.

1.6.7.5.14. COLLECT_SET

Command syntax:

```
ARRAY collect_set(col)
```

Purpose: It is used to convert the values on the col column with duplicates removed into an array.

Description:

col: a table column of any data type.

Returned value: array type.

1.6.7.5.15. VARIANCE/VAR_POP

Function declaration:

```
DOUBLE variance(col)
DOUBLE var_pop(col)
```

Purpose: It is used to calculate the variance of the specified numeric column.

Description:

col: numeric type column. NULL is returned for other types.

Returned value: DOUBLE type.

Example:

Column c1 in table test has the following data:

```
+------------+
| c1     |
+------------+
| 8      |
| 9      |
| 10     |
| 11     |
+------------+
```

Calculate the variance of column c1 in table test.

```
-- Execute the following statement:
select variance(c1) from test;
-- or
select var_pop(c1) from test;
-- Returned result:
+------------+
| _c0      |
+------------+
| 1.25     |
+------------+
```

1.6.7.5.16. VAR_SAMP

Function declaration:

```
DOUBLE var_samp(col)
```

Purpose: It is used to calculate the sample variance of the specified numeric column.

Description:

col: numeric type column. NULL is returned for other types.

Returned value: DOUBLE type.

Example:

Column c1 in table test has the following data:

```
+------------+
| c1       |
+------------+
| 8        |
| 9        |
| 10       |
| 11       |
+------------+
```

Calculate the variance of column c1 in table test.

```
-- Execute the following statement:
select var_samp(c1) from test;
-- Returned result:
+------------+
| _c0      |
+------------+
| 1.6666666666666667 |
+------------+
```

1.6.7.5.17. COVAR_POP

Function declaration:

```
DOUBLE covar_pop(col1, col2)
```

Purpose: It is used to calculate the population covariance of two specified numeric columns.

Description:

col1 and col2: numeric type columns. NULL is returned for other types.

Example:

Columns c1 and c2 in table test have the following data:

```
+------------+------------+
| c1       | c2       |
+------------+------------+
| 3        | 2        |
| 14       | 5        |
| 50       | 14       |
| 26       | 75       |
+------------+------------+
```

Calculate the population covariance of columns c1 and c2.

```
-- Execute the following statement:
select covar_pop(c1,c2) from test;
-- Returned result:
+------------+
| _c0      |
+------------+
| 123.49999999999997|
+------------+
```

1.6.7.5.18. COVAR_SAMP

Function declaration:

```
DOUBLE covar_samp(col1, col2)
```

Purpose: It is used to calculate the sample covariance of two specified numeric columns.

Description:

col1 and col2: numeric type columns. NULL is returned for other types.

Example:

Columns c1 and c2 in table test have the following data:

```
+------------+------------+
| c1      | c2      |
+------------+------------+
| 3       | 2       |
| 14      | 5       |
| 50      | 14      |
| 26      | 75      |
+------------+------------+
```

Calculate the sample covariance of columns c1 and c2.

```
-- Execute the following statement:
select covar_samp(c1,c2) from test;
-- Returned result:
+------------+
| _c0      |
+------------+
| 164.66666666666663|
+------------+
```

1.6.7.6. Other functions

1.6.7.6.1. ARRAY

Function declaration:

```
array(value1,value2, ...)
```

Purpose: It is used to create an array by using input values.

Description:

value: any type. All the values must be of the same type.

Returned value: ARRAY type.

Example:

```
select array(123,456,789) from dual;
-- Returned result:
[123, 456, 789]
```

1.6.7.6.2. ARRAY_CONTAINS

Function declaration:

```
array_contains(ARRAY<T> a, value v)
```

Purpose: It is used to check whether array a contains value v.

Description:

- a: array type.
- v: The given value v must be of the same type as the data in the array.

Returned value: boolean type.

Example:

```
select array_contains(array('a','b'), 'a') from dual;
-- True is returned.
select array_contains(array(456,789),123) from dual;
-- False is returned.
```

1.6.7.6.3. CAST

Command syntax:

```
cast(expr as <type>)
```

Purpose: It is used to convert an expression of one data type to another. For example, cast ('1' as bigint) converts 1 of the string type to the integer type. If the conversion fails, an error is returned.

Note

- cast(double as bigint) converts a value of the double type into a value of the bigint type.
- cast(string as bigint) converts a value of the string type into a value of the bigint type. If the string is composed of numerals expressed in integer form, it is directly converted into a value of the bigint type. If the string is comprised of numerals expressed in the 'float' or 'exponent' form, it is converted to 'double' type first and then to 'bigint' type.
- For cast(string as datetime) or cast(datetime as > string), the datatime format is yyyy-mm-dd hh:mi:ss by default.

1.6.7.6.4. COALESCE

Command syntax:

```
coalesce(expr1, expr2, ...)
```

Purpose: It is used to return the first non-NULL value in the list. If all values in the list are NULL, NULL is returned.

Description:

expr: a value to be tested. All these values must be of the same type or be NULL. Otherwise, an error is returned.

Returned value: The type is the same as that of the input.

Note At least one parameter is provided. Otherwise, an error is returned.

1.6.7.6.5. DECODE

Function declaration:

```
decode(expression, search, result[, search, result]...[, default])
```

Purpose: It is used to implement the if-then-else conditional branching feature.

Description:

- expression: expression to be compared.
- search: search string to be compared with the expression.
- result: the value returned when the value of search matches the expression.
- default: optional. If no search string matches the expression, the default value is returned. If it is not specified, NULL is returned.

Returned value: The matched search is returned. If there are no matches, the default value is returned. If default is not specified, NULL is returned.

Note

- At least three parameters are specified.
- All results must share the same type or be NULL. Inconsistent data types will cause an error. All values of search and expression must be of the same type. Otherwise, an error is returned.
- If the search option in decode has repeated records and matches the expression, the first search value is returned.

Example:

```
select decode(customer_id,
1, 'Taobao',
2, 'Alipay',
3, 'Aliyun',
NULL, 'N/A',
'Others') as result from sale_detail;
```

The preceding DECODE function implements the feature in the following if-then-else statement:

```
if customer_id = 1 then result := 'Taobao';
elsif customer_id = 2 then result := 'Alipay';
elsif customer_id = 3 then result := 'Aliyun';
...
else
result := 'Others';
end if;
```

Notice The MaxCompute SQL statement returns NULL when calculating NULL = NULL. However, in the DECODE function, values of NULL and NULL are equal. In the preceding example, when the value of customer_id is NULL, the DECODE function returns N/A.

1.6.7.6.6. EXPLODE

Function declaration:

```
explode (var)
```

Purpose: It is used to convert one row of data into multiple rows of UDTF. If var is of the array type, the array stored in the column is converted into multiple rows. If var is of the map type, each key-value pair of the map stored in the column is converted into a row with two columns, with one column for the key and the other for the value.

Description:

var: array < T > type or map < K,V > type.

Returned value: transposed rows.

> **Note**
>
> Limits on the use of UDTFs:
>
> - Only one UDTF is allowed in a SELECT statement, and other columns are not allowed.
> - One select can only have one UDTF and no other columns can appear.

Example:

```
explode(array(null, 'a', 'b', 'c')) col
```

1.6.7.6.7. GET_IDCARD_AGE

Function declaration:

```
get_idcard_age(idcardno)
```

Purpose: It is used to return the current age based on the ID card number. The current age is the current year minus the birth year on the ID card.

Description:

idcardno: string type, ID number of 15-digit or 18-digit. During the calculation, the validity of the ID card is verified based on the province code and the last check code. If the verification fails, NULL is returned.

Returned value: bigint type. If the input is NULL, NULL is returned. If the difference of the current year minus the birth year is greater than 100, then NULL is returned.

1.6.7.6.8. GET_IDCARD_BIRTHDAY

Function declaration:

```
get_idcard_birthday(idcardno)
```

Purpose: It is used to return the date of birth based on the ID card number.

Description:

idcardno: string type, a 15-digit or 18-digit ID card number. During computation, the validity of the ID card is verified based on the province code and the last check code. If the verification fails, NULL is returned.

Returned value: datetime type. If the input is NULL, NULL is returned.

1.6.7.6.9. GET_IDCARD_SEX

Function declaration:

```
get_idcard_sex(idcardno)
```

Purpose: It is used to return the gender based on the ID card number. The returned value is M (male) or F (female).

Description:

idcardno: string type, a 15-digit or 18-digit ID card number. During computation, the validity of the ID card is verified based on the province code and the last check code. If the verification fails, NULL is returned.

Returned value: string type. If the input is NULL, NULL is returned.

1.6.7.6.10. GREATEST

Function declaration:

```
greatest(var1, var2, ...)
```

Purpose: It is used to return the maximum value among the input values.

Description:

var: bigint, double, datetime, or string type. If all values are NULL, NULL is returned.

Returned value:

- The greatest value in input parameter. If the implicit conversion is not needed, return type is the same as input parameter type.
- NULL is interpreted as the minimum value.
- If the input parameters are of different types, values of the double, bigint, and string types are converted into values of the double type for comparison, and values of the string and datetime types are converted into values of the datetime type for comparison. Implicit conversion of other types is not allowed.

1.6.7.6.11. INDEX

Function declaration:

```
index(var1[var2])
```

Purpose: It is used to return the specified element in a given array, or return the value of the specified key in a given map.

Description:

- var1: array < T > type or map < K,V > type.
- var2: If var1 is of the array < T > type, var2 must be the bigint type must be larger or equal to 0. If var1 is of the map < K,V > type, var2 is of the K type.

Returned value:

- If var1 is of the array < T > type, a value of the T type is returned. If var2 is out of range of array < T > elements, NULL is returned.
- If var1 is of the map < K,V > type, a value of the V type is returned. If no key is var2 in map < K,V >, NULL is returned.

Example:

If var1 is an array, run the following SQL statement:

```
select array('a','b','c')[2] from dual;
-- Returned result:
+-----+
| _c0 |
+-----+
| c   |
+-----+
```

If var1 is of the map type, run the following SQL statement:

```
select str_to_map("test1=1,test2=2")["test1"] from dual;
-- Returned result:
+-----+
| _c0 |
+-----+
| 1   |
+-----+
```

Notice

- To use the SQL statement, remove the index and run var1[var2] directly. Otherwise, a syntax error is returned.
- If Var1 is NULL, NULL is returned.

1.6.7.6.12. MAX_PT

Function declaration:

```
max_pt(table_full_name)
```

Purpose: For partitioned tables, it is used to return the maximum values in the first-level partitions that have data files and sort the values in alphabetic order.

Description:

table_full_name: string type. It specifies a table name (project name required, for example, prj.src). You must have the read permission on the table.

Returned value: maximum value in the primary partition.

Example:

Partitioned table tbl has the following partitions with data files: pt='20170901' and pt='20170902'. In the following statement, the returned value of max_pt is '20170902'. The MaxCompute SQL statement reads data from the '20120902' partition.

```
select * from tbl where pt=max_pt('myproject.tbl');
```

> **Note** If a new partition is added by using alter table, but there is no data file in this partition, then this partition is not returned.

1.6.7.6.13. ORDINAL

Function declaration:

```
ordinal(bigint nth, var1, var2, ...)
```

Purpose: It is used to sort the input variables in ascending order, and return the specified nth value.

Description:

- nth: bigint type. It specifies the position at which the value is to be returned. If it is NULL, NULL is returned.
- var: bigint, double, datetime, or string type.

Returned value:

- The value in nth bit. If the implicit conversion is not needed, return type is the same as input parameter type.
- If type conversion is performed, values of the double, bigint, and string types are converted into values of the double type. Values of the string and datetime types are converted into values of the datetime type. Implicit conversion of other types is not allowed.
- NULL is the least value.

Example:

```
ordinal(3, 1, 3, 2, 5, 2, 4, 6) = 2
```

1.6.7.6.14. LEAST

Function declaration:

```
least(var1, var2, ...)
```

Purpose: It is used to returns the minimum value among the input values.

Description:

var: bigint, double, datetime, or string type. If all values are NULL, NULL is returned.

Returned value:

- The least value in input parameter; If the implicit conversion is not needed, return type is the same as input parameter type.
- If type conversion is performed, values of the double, bigint, and string types are converted into values of the double type. Values of the string and datetime types are converted into values of the datetime type. Implicit conversion of other types is not allowed.

- NULL is interpreted as the minimum value.

1.6.7.6.15. SIZE

Function declaration:

```
size(map<K, V>)
size(array<T>)
```

Purpose: size(map) is used to return the number of key-value pairs in the given map, and size(array) is used to return the number of elements in the given array.

Description:

- map: map type.
- array: array type.

Returned value: int type.

Example:

```
select size(map('a',123,'b',456)) from dual;
-- 2 is returned.
select size(map('a',123,'b',456,'c',789)) from dual;
-- 3 is returned.
select size(array('a','b')) from dual;
-- 2 is returned.
select size(array(123,456,789)) from dual;
-- 3 is returned.
```

1.6.7.6.16. SPLIT

Function declaration:

```
split(str, pat)
```

Purpose: It is used to split a string using the specified separator.

Description:

- str: string type. The string to be separated.
- pat: string type. It indicates the separator and supports regular expressions.

Returned value: array <string >. The returned array contains elements extracted from the string based on the specified separator.

Example:

```
select split("a,b,c",",") from dual;
-- Returned result:
+------+
| _c0 |
+------+
| [a, b, c] |
+------+
```

1.6.7.6.17. STR_TO_MAP

Function declaration:

```
str_to_map(text [, delimiter1 [, delimiter2]])
```

Purpose: It is used to divide 'text' into K-V pairs with 'delimiter1', and to separate each K-V pair with 'delimiter2'.

Description:

ext: string type. It indicates the string to be separated.

delimiter1: string type. It is the delimiter. If it is not specified, the default value ',' is used.

delimiter2: string type. It is the delimiter. If it is not specified, the default value '=' is used.

Returned value: map < string, string >. The elements are the K-V results of the separation of 'text' by the strings 'delimiter1' and 'delimiter2'.

Example:

```
select str_to_map("test1=1,test2=2") from dual;
-- Returned result:
+------------+
| a       |
+------------+
| {Test1: 1, Test2: 2} |
```

1.6.7.6.18. UNIQUE_ID

Function declaration:

```
STRING UNIQUE_ID()
```

Purpose: It is used to return a random but unique ID, for example, 29347a88-1e57-41ae-bb68-a9edbdd94212_1. This function runs more efficiently than UUID.

1.6.7.6.19. UUID

Function declaration:

```
string uuid()
```

Purpose: It returns a random ID, for example, 29347a88-1e57-41ae-bb68-a9edbdd94212.

1.6.7.6.20. SAMPLE

Function declaration:

```
boolean sample(x, y, column_name)
```

Purpose: It is used to sample all values read from the specified column based on the given settings, and filters out the rows that do not meet the sampling condition.

Description:

- x, y: bigint type. It indicates that data is hashed to x portions and the yth portion is taken. y can be omitted. If y is omitted, the first portion is taken and column_name must also be omitted. x and y are constants of the integer type and are greater than 0. If they are of another type or if they are less than or equal to 0, an error is returned. If y is greater than x, an error is returned. If either x or y is NULL, NULL is returned.
- column_name: target column of sampling. column_name can be omitted. If column_name is omitted, random sampling is performed based on values of x and y. It can be of any type, and the column value can be NULL. No implicit conversion is performed. If column_name is the constant NULL, an error is reported.

Returned value: boolean type.

> **Note** To avoid data skew resulting from the NULL value, a uniform hash of x is made for a value of NULL in column_name. If column_name is not added, the output is not necessarily uniform since the data size is smaller. So column_name is suggested to be added to get better output.

Example:

Table tbla contains a column named cola.

```
select * from tbla where sample (4, 1 , cola) = true;
-- The values are hashed to four portions based on cola, and the first portion is used.
select * from tbla where sample (4, 2) = true;
-- The values in each row are randomly hashed to four portions, and the second portion is used.
```

1.6.7.6.21. CASE WHEN expression

MaxCompute provides the following two kinds of CASE WHEN syntax formats:

```
case value
when (_condition1) then result1
when (_condition2) then result2
...
else resultn
end
case
when (_condition1) then result1
when (_condition2) then result2
when (_condition3) then result3
...
else resultn
end
```

CASE WHEN flexibly returns different values based on the calculation result of the expression. Alibaba Cloud StreamCompute supports two types of CASE WHEN expressions:

```
select
case
when shop_name is null then 'default_region'
when shop_name like 'hang%' then 'zj_region'
end as region
From sale_detail;
```

Note

- If there are values of only the bigint and double type in the results, the results are converted into values of the double type.
- If there is a value of the string type in the results, the results are all converted into values of the string type. If the result of a type cannot be converted (for example, boolean type), an error is returned.
- Conversion between other types is not allowed.

1.6.7.6.22. IF

Function declaration:

```
if(testCondition, valueTrue, valueFalseOrNull)
```

Purpose: It is used to determine whether 'testCondition' is true. If it is true, valueTrue is returned. If it is not true, valueFalseOrNull is returned.

Description:

testCondition: boolean type. The expression to be determined true or not.

valueTrue: the value returned when expression 'testCondition' is true.

valueFalseOrNull: the value returned when expression 'testCondition' is false. It can be set to NULL.

Returned value: The type is the same as that of valueTrue or valueFalseOrNull.

Example:

```
select if(1=2,100,200) from dual;
-- Returned result:
+------------+
| _c0      |
+------------+
| 200      |
+------------+
```

1.6.7.6.23. Additional functions

MaxCompute 2.0 provides additional functions.

The functions described in the following topics are new in this version.

1.6.7.6.24. MAP

Function declaration:

```
map(K key1, V value1, K key2, V value2, ...)
```

Purpose: It is used to create a map with the given K-V pairs.

Description:

key/value: The types of all keys are the same and must be of one of the basic types. The types of all values are the same and can be of any type.

Returned value: map type.

Example:

```
select map('a',123,'b',456) from dual;
-- Returned result:
{a:123, b:456}
```

1.6.7.6.25. MAP_KEYS

Function declaration:

```
map_keys(map<K, V> )
```

Purpose: It is used to return all keys in the map parameter as an array.

Description:

map: data of the map type.

Returned value: array type. If the input is NULL, NULL is returned.

Example:

```
select map_keys(map('a',123,'b',456)) from dual;
-- Returned result:
[a, b]
```

1.6.7.6.26. MAP_VALUES

Function declaration:

```
map_values(map<K, V>)
```

Purpose: It is used to return all values in the map parameter as an array.

Description:

map: map type.

Returned value: array type. If the input is NULL, NULL is returned.

Example:

```
select map_keys(map('a',123,'b',456)) from dual;
-- Returned result:
[123, 456]
```

1.6.7.6.27. SORT_ARRAY

Function declaration:

```
sort_array(ARRAY<T>)
```

Purpose: It is used to sort a given array.

Description:

ARRAY: array type. The data in the array is of any type.

Returned value: array type.

Example:

```
select sort_array(array('a','c','f','b')),sort_array(array(4,5,7,2,5,8)),sort_array(array('You','Me','He')) from du
al;
-- Returned result:
[a, b, c, f] [2, 4, 5, 5, 7, 8] [him, you, me]
```

1.6.7.6.28. POSEXPLODE

Command syntax:

```
posexplode(ARRAY<T>)
```

Purpose: It is used to explode the given array. Each value is given a row and each row has two columns corresponding to the subscript (starting from 0) and the array element.

Description:

ARRAY: array type. Data in the array can be of any type.

Returned value: table generation function.

Example:

```
select posexplode(array('a','c','f','b')) from dual;
-- Returned result:
+------------+-----+
| pos        | val |
+------------+-----+
| 0          | a   |
| 1          | c   |
| 2          | f   |
| 3          | b   |
+------------+-----+
```

1.6.7.6.29. STRUCT

Function declaration:

```
struct(value1,value2, ...)
```

Purpose: It is used to create a struct using a given value list.

Description:

value: any type.

Returned value: struct type. The field names of the created struct are col1, col2, and so on.

Example:

```
select struct('a',123,'ture',56.90) from dual;
-- Returned result:
{col1:a, col2:123, col3:true, col4:56.9}
```

1.6.7.6.30. NAMED_STRUCT

Function declaration:

```
named_struct(string name1, T1 value1, string name2, T2 value2, ...)
```

Purpose: It is used to create a struct using a given name-value list.

Description:

- value: any type.
- name: field name of the string type.

Returned value: struct type. The field names of the created struct are name1, name2, and so on.

Example:

```
select named_struct('user_id',10001,'user_name','bob','married','F','weight',63.50) from dual;
-- Returned result:
{user_id:10001, user_name:bob, married:F, weight:63.5}
```

1.6.7.6.31. INLINE

Function declaration:

```
inline(ARRAY<STRUCT<f1:T1, f2:T2, ... >>)
```

Purpose: It is used to expand a struct, with each element corresponding to a row, and each struct element in each row corresponding to a column.

Description:

STRUCT: The values in the array can be of any type.

Returned value: table generation function.

Example:

```
select inline(array(named_struct('user_id',10001,'user_name','bob','married','F','weight',63.50))) from dual;
-- Returned result:
+------------+-----------+---------+------------+
| user_id    | user_name | married | weight     |
+------------+-----------+---------+------------+
| 10001      | bob       | F       | 63.5       |
+------------+-----------+---------+------------+
```

1.6.7.6.32. BETWEEN AND expression

Command syntax:

```
A [NOT] BETWEEN B AND C
```

If A, B, or C is NULL, then the value is NULL. If A is greater than or equal to B, and less than or equal to C, the value is true. Otherwise, the value is false.

Example:

The emp table contains the following data:

```
| empno | ename | job | mgr | hiredate| sal| comm | deptno |
7369,SMITH,CLERK,7902,1980-12-17 00:00:00,800,,20
7499,ALLEN,SALESMAN,7698,1981-02-20 00:00:00,1600,300,30
7521,WARD,SALESMAN,7698,1981-02-22 00:00:00,1250,500,30
7566,JONES,MANAGER,7839,1981-04-02 00:00:00,2975,,20
7654,MARTIN,SALESMAN,7698,1981-09-28 00:00:00,1250,1400,30
7698,BLAKE,MANAGER,7839,1981-05-01 00:00:00,2850,,30
7782,CLARK,MANAGER,7839,1981-06-09 00:00:00,2450,,10
7788,SCOTT,ANALYST,7566,1987-04-19 00:00:00,3000,,20
7839,KING,PRESIDENT,,1981-11-17 00:00:00,5000,,10
7844,TURNER,SALESMAN,7698,1981-09-08 00:00:00,1500,0,30
7876,ADAMS,CLERK,7788,1987-05-23 00:00:00,1100,,20
7900,JAMES,CLERK,7698,1981-12-03 00:00:00,950,,30
7902,FORD,ANALYST,7566,1981-12-03 00:00:00,3000,,20
7934,MILLER,CLERK,7782,1982-01-23 00:00:00,1300,,10
7948,JACCKA,CLERK,7782,1981-04-12 00:00:00,5000,,10
7956,WELAN,CLERK,7649,1982-07-20 00:00:00,2450,,10
7956,TEBAGE,CLERK,7748,1982-12-30 00:00:00,1300,,10
```

Run the following command to query data where sal is greater than or equal to 1,000 and less than or equal to 1,500:

```
select * from emp where sal BETWEEN 1000 and 1500;
-- Returned result:
+-------+-------+-----+------------+------------+------------+------------+------------+
| empno | ename | job | mgr      | hiredate  | sal      | comm      | deptno    |
+-------+-------+-----+------------+------------+------------+------------+------------+
| 7521  | WARD  | SALESMAN | 7698  | 1981-02-22 00:00:00 | 1250.0    | 500.0     | 30 |
| 7654  | MARTIN | SALESMAN | 7698 | 1981-09-28 00:00:00 | 1250.0    | 1400.0    | 30 |
| 7844  | TURNER | SALESMAN | 7698 | 1981-09-08 00:00:00 | 1500.0    | 0.0       | 30 |
| 7876  | ADAMS | CLERK | 7788  | 1987-05-23 00:00:00 | 1100.0    | NULL      | 20  |
| 7934  | MILLER | CLERK | 7782  | 1982-01-23 00:00:00 | 1300.0    | NULL      | 10 |
| 7956  | TEBAGE | CLERK | 7748  | 1982-12-30 00:00:00 | 1300.0    | NULL      | 10 |
+-------+-------+-----+------------+------------+------------+------------+------------+
```

1.6.7.6.33. NVL

Function declaration:

```
nvl(T value, T default_value)
```

Purpose: It is used to return default_value if value is NULL and return value otherwise.

Example:

Table t_data has three columns of c1 string, c2 bigint, and c3 datetime, as well as the following data:

```
+----+------------+------------+
| c1 | c2       | c3       |
+----+------------+------------+
| NULL | 20       | 2017-11-13 05:00:00 |
| ddd | 25       | NULL     |
| bbb | NULL     | 2017-11-12 08:00:00 |
| aaa | 23       | 2017-11-11 00:00:00 |
+----+------------+------------+
```

Use the NVL function to output the NULL values in c1 to 00000, the NULL values in c2 to 0, and the NULL values in c3 to "-".

```
-- Execute the following statement:
SELECT nvl(c1,'00000'),nvl(c2,0) nvl(c3,'-') from nvl_test;
-- Returned result:
+-----+------------+-----+
| _c0 | _c1      | _c2 |
+------------+---------+
| bbb | 0        | 2017-11-12 08:00:00 |
| ddd | 25       | -   |
| 00000 | 20       | 2017-11-13 05:00:00 |
| aaa | 23       | 2017-11-11 00:00:00 |
+-----+------------+-----+
```

1.6.8. UDFs

1.6.8.1. Overview

UDF is short for user defined function. MaxCompute provides a variety of built-in functions. You can also create UDFs based on specific computing requirements. You can use UDFs as using common built-in functions. This topic briefs how to use SQL UDFs. For more information about SQL UDFs, see the official documentation on UDFs.

The following table lists the extended UDFs in MaxCompute.

UDF category

UDF category	Description
UDF	User defined scalar functions are commonly referred to as UDFs. There is a one-to-one mapping between the input and output. Each time a UDF reads a row of data, it writes an output value.
UDTF	User defined table valued functions are commonly referred to as UDTFs. Each time a UDTF is called, it outputs multiple rows of data. UDTFs are the only category that returns multiple fields. A UDF only returns one value each time.
UDAF	User defined aggregation functions are commonly referred to as UDAFs. A UDAF aggregates multiple input records into one output record. There is a many-to-one mapping between input and output. A UDAF can be used together with the GROUP BY clause (SQL) at the same time. For more information about the syntax, see aggregation functions.

Note In general, UDFs refer to all user defined functions: UDFs, UDAFs, and UDTFs. In a narrow sense, UDFs only refer to user defined scalar functions. This term is used interchangeably in this document. You will have to determine the exact meaning based on the context.

1.6.8.2. Types of parameters and returned values

UDFs support the following MaxCompute SQL data types:

- Basic data types: BIGINT, DOUBLE, BOOLEAN, DATETIME, DECIMAL, STRING, TINYINT, SMALLINT, INT, FLOAT, VARCHAR, BINARY, and TIMESTAMP.
- Complex data types: ARRAY, MAP, and STRUCT.

> **Note** In UDFs, you can define the writable attribute of parameters.

The usage of some basic data types (such as TINYINT, SMALLINT, INT, FLOAT, VARCHAR, BINARY, and TIMESTAMP) in Java UDFs is as follows:

- UDAFs and UDTFs use the @Resolve annotation to obtain signatures. Example: `@Resolve("smallint->varchar(10)")`.
- UDFs reflect and analyze the evaluate() method to obtain signatures. In this case, there is a one-to-one mapping between MaxCompute built-in types and Java types.

To use complex data types (ARRAY, MAP, and STRUCT) in Java UDFs, take the following steps:

- UDTFs use the @Resolve annotation to specify signatures. Example: `@Resolve("array<string>,struct<a1:bigint,b1:string>,string->map<string,bigint>,struct<b1:bigint>")`.
- UDFs use the signature of the evaluate() method to map the input and output types. For more information, see the mappings between MaxCompute types and Java types. In the preceding example, ARRAY corresponds to java.util.List, MAP corresponds to java.util.Map, and STRUCT corresponds to com.aliyun.odps.data.Struct.
- UDAFs and UDTFs use the @Resolve annotation to obtain signatures. Example: `@Resolve("smallint->varchar(10)")`.

> **Notice**
>
> - You can use `type,*` to add any number of parameters. Example: @resolve("string,*->array<string>"). Note that you must add a subtype after array.
> - The field name and field type of com.aliyun.odps.data.Struct cannot be reflected. Therefore, the @Resolve annotation is required. If you want to use struct in a UDF, you must add the @Resolve annotation to the UDF class. This annotation only affects the overloads of parameters or returned values that contain com.aliyun.odps.data.Struct.
> - A class supports only one @Resolve annotation. A UDF that contains struct can only reload parameters or returned values once.

The following table lists the mapping between MaxCompute and Java data types.

Data type mapping

MaxCompute type	Java type
TINYINT	java.lang.Byte
SMALLINT	java.lang.Short

MaxCompute type	Java type
INT	java.lang.Integer
BIGINT	java.lang.Long
FLOAT	java.lang.Float
DOUBLE	java.lang.Double
DECIMAL	java.math.BigDecimal
BOOLEAN	java.lang.Boolean
STRING	java.lang.String
VARCHAR	com.aliyun.odps.data.Varchar
BINARY	com.aliyun.odps.data.Binary
DATETIME	java.util.Date
TIMESTAMP	java.sql.Timestamp
ARRAY	java.util.List
MAP	java.util.Map
STRUCT	com.aliyun.odps.data.Struct

> **Note**
>
> - Java data types and the data types of returned values are objects, and must start with a capitalized letter.
> - The NULL value in SQL is represented by a NULL reference in Java. The Java primitive type is not allowed because it cannot represent a NULL value in SQL.
> - The ARRAY type in MaxCompute corresponds to a list, not an array, in Java.

The following table compares the API features of two languages.

API feature comparison

Supported language	UDF	UDAF	UDTF	DATETIME type	Read resource file	Read resource table
Python	Yes	Yes	Yes	Yes	Yes	Yes
Java	Yes	Yes	Yes	Yes	Yes	Yes

1.6.8.3. UDFs

A UDF must inherit the com.aliyun.odps.udf.UDF class and implement the EVALUATE method. The EVALUATE method must be a non-static public method. The types of parameters and returned values of the EVALUATE method are used as the UDF signatures in SQL. This means that users can implement multiple EVALUATE methods in a UDF. When a UDF is called, the framework matches the correct EVALUATE method based on the parameter type called by the UDF.

Example:

```
package org.alidata.odps.udf.examples;
import com.aliyun.odps.udf.UDF;
public final class Lower extends UDF { public String evaluate(String s) { if (s == null) { return null; } return s.to
LowerCase();
}
}
```

Note You can implement `void setup(ExecutionContext ctx)` and `void close()` to implement UDF initialization and termination code, respectively.

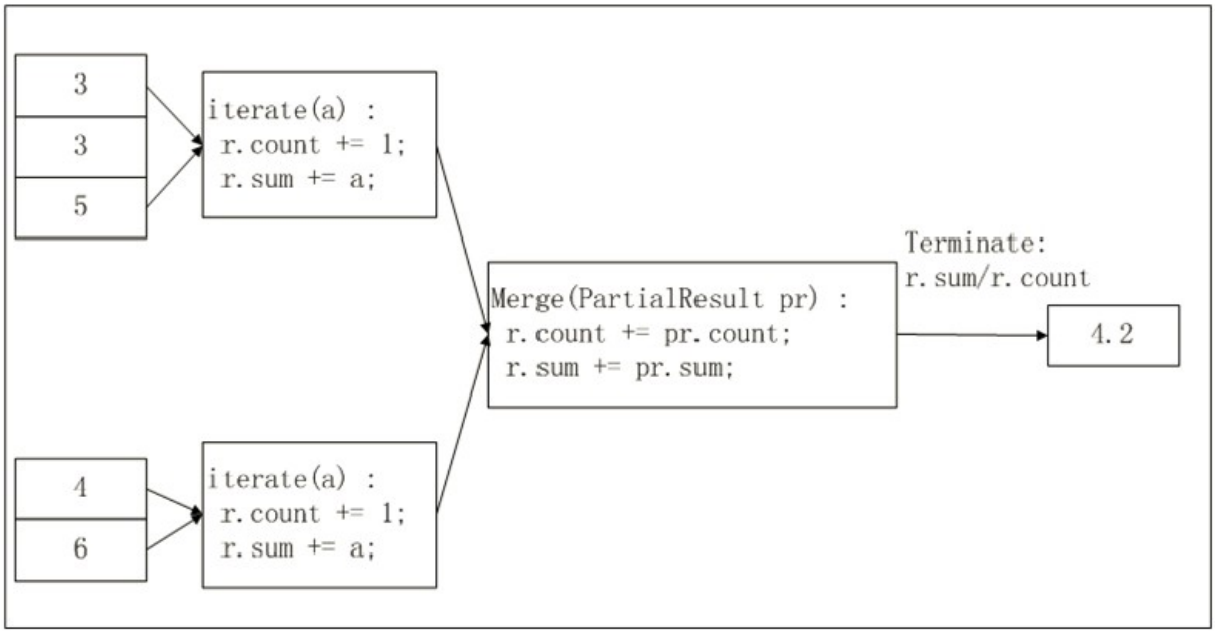
UDFs are used in the same way as built-in functions in MaxCompute SQL. For more information, see Built-in functions.

1.6.8.4. UDAFs

To implement a Java UDAF, you must inherit the com.aliyun.odps.udf.UDAF class and implement the following APIs:

```
public abstract class Aggregator implements ContextFunction {
@Override
public void setup(ExecutionContext ctx) throws UDFException {
}
@Override
public void close() throws UDFException {
}
/**
* Create an aggregate buffer
* @return Writable - Aggregate buffer
*/
abstract public Writable newBuffer();
/**
* @param buffer - Aggregate buffer
* @param args - Parameter specified when SQL calls UDAFs
* @throws UDFException
*/
abstract public void iterate(Writable buffer, Writable[] args) throws UDFException;
/**
* generate final result
* @param buffer
* @return final result of Object UDAF
* @throws UDFException
*/
abstract public Writable terminate(Writable buffer) throws UDFException;
abstract public void merge(Writable buffer, Writable partial) throws UDFException;
}
```

The most important APIs are iterate, merge, and terminate. The primary logic of UDAFs relies on the implementation of these three APIs. In addition, you must implement a custom writable buffer. As an example, the following figure briefly illustrates the implementation logic and computational flow of the avg (average value) MaxCompute UDAF function.



In the preceding figure, the input data is sliced by a certain size (for description of slicing, see MapReduce). The size of each slice is suitable for a worker to complete in an appropriate period of time. You need to manually configure the size of the slices.

The UDAF calculation process is divided into two phases:

- Phase 1: Each Worker counts the number of data rows and the sum of the data in each slice. The user can regard the counted number and sum as an intermediate result.
- Phase 2: The Worker summarizes the information gained from the previous phase within each slice. In the final output, r.sum / r.count is the average of all input data.

The following example shows how to calculate an average by using a UDAF:

```
import java.io.DataInput;
import java.io.DataOutput;
import java.io.IOException;
import com.aliyun.odps.io.DoubleWritable;
import com.aliyun.odps.io.Writable;
import com.aliyun.odps.udf.Aggregator;
import com.aliyun.odps.udf.UDFException;
import com.aliyun.odps.udf.annotation.Resolve;
@Resolve({"double->double"})
public class AggrAvg extends Aggregator {
private static class AvgBuffer implements Writable { private double sum = 0;
private long count = 0;
@Override
public void write(DataOutput out) throws IOException { out.writeDouble(sum);
```

```
out.writeLong(count);
}
@Override
public void readFields(DataInput in) throws IOException { sum = in.readDouble();
count = in.readLong();
}
}
private DoubleWritable ret = new DoubleWritable();
@Override
public Writable newBuffer() { return new AvgBuffer();
}
@Override
public void iterate(Writable buffer, Writable[] args) throws UDFException { DoubleWritable arg = (DoubleWri
table) args[0];
AvgBuffer buf = (AvgBuffer) buffer; if (arg ! = null) {
buf.count += 1; buf.sum += arg.get();
}
}
@Override
public Writable terminate(Writable buffer) throws UDFException { AvgBuffer buf = (AvgBuffer) buffer;
if (buf.count == 0) { ret.set(0);
} else {
ret.set(buf.sum / buf.count);
}
return ret;
}
@Override
public void merge(Writable buffer, Writable partial) throws UDFException { AvgBuffer buf = (AvgBuffer) buffe
r;
AvgBuffer p = (AvgBuffer) partial; buf.sum += p.sum;
buf.count += p.count;
}
}
```

Notice

- The SQL syntax used by UDAFs is the same as that used by common built-in aggregate functions. For more information, see Aggregate functions.
- The way to run UDTFs is the same as that to run UDFs. For more information, see Run UDFs.

1.6.8.5. UDTFs

1.6.8.5.1. Overview

Java UDTFs must inherit the com.aliyun.odps.udf.UDTF class. This class requires the implementation of four APIs. The following table lists the definitions of these APIs.

API definitions

API	Description
public void setup(ExecutionContext ctx) throws UDFException	The initialization method to call the user-defined initialization behavior before a UDTF processes the input data. SETUP is called once first in each worker.
public void process(Object[] args) throws UDFException	This method is called by the framework. Each SQL record calls PROCESS once. The parameters of PROCESS are the specified UDTF input parameters in the SQL statement. The input parameters are passed in as Object[], and the results are output by the FORWARD function. You need to call FORWARD in the PROCESS function to determine the output data.
public void close() throws UDFException	The termination method of UDTF. This method is called by the framework for only once after the last record is processed.
public void forward(Object ...o) throws UDFException	You can call the FORWARD method to output data. Each time FORWARD is called, it outputs one record. The record corresponds to the column specified by the UDTF AS clause in the SQL statement.

UDTF example:

```
package org.alidata.odps.udtf.examples;
import com.aliyun.odps.udf.UDTF;
import com.aliyun.odps.udf.UDTFCollector;
import com.aliyun.odps.udf.annotation.Resolve;
import com.aliyun.odps.udf.UDFException;
// TODO define input and output types, e.g., "string,string->string,bigint".
@Resolve({"string,bigint->string,bigint"}) public class MyUDTF extends UDTF {
@Override public void process(Object[] args) throws UDFException { String a = (String) args[0];
Long b = (Long) args[1];
for (String t: a.split("\\s+")) { forward(t, b);
}
}
}
```

The preceding example shows how to create a UDTF in MaxCompute. If this UDTF is named user_udtf, you can run the following SQL statement to call this UDTF:

```
select user_udtf(col0, col1) as (c0, c1) from my_table;
```

The values in my_table col0 and col1 are as follows:

```
+------+------+
| col0 | col1 |
+------+------+
| A B | 1   |
| C D | 2   |
+------+------+
```

The result of the SELECT statement is as follows:

```
+----+----+
| c0 | c1 |
+----+----+
| A | 1 |
| B | 1 |
| C | 2 |
| D | 2 |
+----+----+
```

1.6.8.5.2. UDTF description

Common uses of UDTFs in SQL:

```
select user_udtf(col0, col1) as (c0, c1) from my_table;
select user_udtf(col0, col1) as (c0, c1) from (select * from my_table distribute by col1 sort by col1) t;
```

Notice

The following limits apply to the use of UDTF.

- No other expressions are allowed in a SELECT clause.

  ```
  select col0, user_udtf(col0, col1) as (c0, c1) from mytable;
  ```

- UDTFs cannot be nested.

  ```
  select user_udtf(mp_udtf(col0,col1)) as (c0,c1)from mytable;
  ```

UDTF examples

The user can use a UDTF to read MaxCompute resources. The following are examples of reading MaxCompute resources by using UDTFs:

1. Write UDTF program. The JAR package (udtfexample1.jar) is exported after compilation.

```
package com.aliyun.odps.examples.udf;
import java.io.BufferedReader;
import java.io.IOException;
import java.io.InputStream;
import java.io.InputStreamReader;
import java.util.Iterator;
import com.aliyun.odps.udf.ExecutionContext;
import com.aliyun.odps.udf.UDFException;
import com.aliyun.odps.udf.UDTF;
import com.aliyun.odps.udf.annotation.Resolve;
/**
* project: example_project
* table: wc_in2
* partitions: p2=1,p1=2
* columns: colc,colb
*/
@Resolve({ "string,string->string,bigint,string" }) public class UDTFResource extends UDTF { ExecutionC
ontext ctx;
long fileResourceLineCount;
long tableResource1RecordCount;
long tableResource2RecordCount;
@Override
public void setup(ExecutionContext ctx) throws UDFException { this.ctx = ctx;
try {
InputStream in = ctx.readResourceFileAsStream("file_resource.txt");
BufferedReader br = new BufferedReader(new InputStreamReader(in));
String line;
fileResourceLineCount = 0;
while ((line = br.readLine()) ! = null) { fileResourceLineCount++;
}
br.close();
Iterator<Object[]> iterator = ctx.readResourceTable("table_resource1").iterator();
tableResource1RecordCount = 0;
while (iterator.hasNext()) { tableResource1RecordCount++; iterator.next();
}
iterator = ctx.readResourceTable("table_resource2").iterator();
tableResource2RecordCount = 0;
```

```
while (iterator.hasNext()) { tableResource2RecordCount++;
iterator.next();
}
} catch (IOException e) { throw new UDFException(e);
}
}
@Override
public void process(Object[] args) throws UDFException { String a = (String) args[0];
long b = args[1] == null ? 0 : ((String) args[1]).length();
forward(a, b, "fileResourceLineCount=" + fileResourceLineCount + "|tableResource1RecordCount=" + ta
bleResource1RecordCount + "|tableResource2RecordCount=" + tableResource2RecordCount);
}
}
```

2. Add resources to MaxCompute.

```
Add file file_resource.txt;
Add jar udtfexample1.jar;
Add table table_resource1 as table_resource1;
Add table table_resource2 as table_resource2;
```

3. Create UDTF function (mp_udtf) in MaxCompute.

```
create function mp_udtf as com.aliyun.odps.examples.udf.UDTFResource using 'udtfexample1.jar, file_
resource.txt, table_resource1, table_resource2';
```

4. Create resource tables 'table_resource1' and 'table_resource2' in MaxCompute, and insert the corresponding data.
5. Run this UDTF.

```
select mp_udtf("10","20") as (a, b, fileResourceLineCount) from table_resource1;
-- Command output:
+-------+------------+-------+
| a | b    | fileResourceLineCount |
+-------+------------+-------+
| 10 | 2 | fileResourceLineCount=3|tableResource1RecordCount=0|tableResource2RecordCount=0 |
| 10   | 2      | fileResourceLineCount=3|tableResource1RecordCount=0|tableResource2RecordCount=0 |
+-------+------------+-------+
```

> **Note** You can also use the same method to obtain resources. For more information, see MapReduce examples.

UDTF examples — Complex data types

The code in the following example defines a UDF with three overloads. The first overload uses array as the parameter; the second uses map as the parameter; and the third uses struct as the parameter. The third overload uses a struct type as the parameter or returned value, the UDF class must be supplemented with a @Resolve annotation to specify the specific type of struct.

```
@Resolve("struct<a:bigint>,string->string")
public class UdfArray extends UDF {
 public String evaluate(List<String> vals, Long len) {
  return vals.get(len.intValue());
 }
 public String evaluate(Map<String,String> map, String key) {
  return map.get(key);
 }
 public String evaluate(Struct struct, String key) {
  return struct.getFieldValue("a") + key;
 }
}
```

You can import a complex data type in the UDF:

```
create function my_index as 'UdfArray' using 'myjar.jar';
select id, my_index(array('red', 'yellow', 'green'), colorOrdinal) as color_name from colors;
```

1.6.8.6. Python UDFs

1.6.8.6.1. Restricted environment

MaxCompute UDF uses Python V2.7. It executes user codes in a sandbox. The following operations are restricted in the sandbox:

- Read and write local files.
- Start subprocesses.
- Start threads.
- Conduct socket communication.
- Call other systems.

Due to these restrictions, user-uploaded code must all be implemented by Python, as C extension modules are disabled.

In addition, not all modules in the Python standard library are available for use. Modules that involve the preceding features are disabled. Description of available modules in the standard library:

1. All modules implemented purely by Python are available.
2. The following C extension modules are available for use.
   - array
   - audioop

- binascii
- _bisect
- cmath
- _codecs_cn
- _codecs_hk
- _codecs_iso2022
- _codecs_jp
- _codecs_kr
- _codecs_tw
- _collections
- cStringIO
- datetime
- _functools
- future_builtins
- _hashlib
- _heapq
- itertools
- _json
- _locale
- _lsprof
- math
- _md5
- _multibytecodec
- operator
- _random
- _sha256
- _sha512
- _sha
- _struct
- strop
- time
- unicodedata
- _weakref
- cPickle

3. Some modules have limited functionality. For example, the sandbox limits the size that user codes can write to the standard output and standard error output. `sys.stdout and sys.stderr` can write up to 20 KB. Any remaining characters are ignored.

1.6.8.6.2. Third-party libraries

Common third-party libraries are installed in the operating environment to supplement the standard library. The supported third-party libraries include NumPy.

> **Warning** The use of third-party libraries is also subject to restrictions. For example, local or remote I/O operations are prohibited. Therefore, the related APIs in the third-party libraries are disabled.

1.6.8.6.3. Types of parameters and returned values

You can run the following command to specify the types of parameters and returned values:

```
@odps.udf.annotate(signature)
```

Python UDFs support the following MaxCompute SQL data types: bigint, string, double, boolean, and datetime. Before you run a SQL statement, you must specify the parameter types and returned value types of all functions. Python is a dynamically-typed language. You need to add decorators to the UDF class to specify the function signature.

The function signature is specified by a string. The syntax is as follows:

```
arg_type_list '->' type_list
arg_type_list: type_list | '*' | ''
type_list: [type_list ','] type
type: 'bigint' | 'string' | 'double' | 'boolean' | 'datetime'
```

> **Note**
>
> - The part to the left of the arrow indicates the type of parameter. The part to the right of the arrow indicates the type of returned value.
> - The returned value of a UDTF can contain multiple columns. The returned value of a UDF or UDAF can contain only one column.
> - * represents a variable argument. If a variable argument is specified, the UDF, UDTF, or UDAF can match any type of parameter.

Examples of valid signature:

```
'bigint,double->string'
-- The parameter is of the bigint or double type, and the returned value is of the string type.
'bigint,boolean->string,datetime'
-- The UDTF parameter is of the bigint or boolean type, and the returned value is of the string or datetime type.
'*->string'
-- Specify a variable argument: The input parameter can be of any type, and the returned value is of the string type.
'->double'
-- The parameter is NULL and the returned value is of the double type.
```

If an invalid signature is found during query parsing, an error is returned and the execution is banned. During execution, the UDF parameter with the type specified by the function signature is transferred to the user. The user returned value must be of the type specified by the function signature. Otherwise, an error is returned. The following table shows the mappings between MaxCompute SQL types and Python types.

Mapping

MaxCompute SQL type	Python type
Bigint	int
String	str
Double	float
Boolean	bool
Datetime	int

> **Note**
>
> - A value of the datetime type is passed to user code as the int type. The value is the number of milliseconds that have elapsed since the epoch time. You can use the datetime module in the Python standard library to process the datetime type.
> - NULL corresponds to none in Python.

In addition, the parameter of odps.udf.int(value[, silent=True]) is modified. Parameter silent is added. If silent is true and the value cannot be converted to the int type, none is returned instead of an error.

1.6.8.6.4. UDFs

Implementing a Python UDF is as easy as defining a new-style class and implementing the evaluate method.

Example:

```
from odps.udf import annotate
@annotate("bigint,bigint->bigint")
class myplus (object ):
  def evaluate (self, arg0, arg1 ):
    If none in (arg0, arg1 ):
      return none
    return arg0 + arg1
```

Notice A Python UDF must have its signature specified through annotate.

1.6.8.6.5. UDAFs

Description:

- class odps.udf.BaseUDAF: inherit this class to implement a Python UDAF.
- BaseUDAF.new_buffer(): implement this method and return the median 'buffer' of the aggregate function. Buffer must be mutable object (such as list and dict). The size of the buffer should not increase with the amount of data. The buffer size should not exceed 2 MB after marshal.
- BaseUDAF.iterate(buffer[, args, ...]): This method aggregates args into the median buffer.
- BaseUDAF.merge(buffer, pbuffer): This method aggregates two median buffers; that is, aggregate pbuffer into buffer.
- BaseUDAF.terminate(buffer): This method converts the median 'buffer' into the MaxCompute SQL basic types.

The following example shows how to calculate an average by using a UDAF:

```
#coding:utf-8
from odps.udf import annotate
from odps.udf import BaseUDAF
@annotate('double->double')

class Average(BaseUDAF):
  def new_buffer(self):
    return [0, 0]
  def iterate(self, buffer, number):
    If number is not None:
      buffer[0] += number
      buffer[1] += 1
  def merge(self, buffer, pbuffer):
    buffer [0] + = pbuffer [0]
    buffer [1] + = pbuffer [1]
  def terminate (self, buffer ):
    If buffer [1] = 0:
      return 0.0
    return buffer[0] / buffer[1]
```

1.6.8.6.6. UDTFs

The parameters are described as follows.

Parameters

Parameter	Description
class odps.udf.BaseUDTF	Base class for a Python UDTF. Users inherit this class and implement methods such as PROCESS and CLOSE.
BaseUDTF.init()	Initialization method. To implement this method for an inherited class, you must call the initialization method super(BaseUDTF, self).init() for the base class at the beginning . The INIT method will only be called once during the entire UDTF life cycle; that is, before the first record is processed. When the UDTF needs to save internal states, all states can be initialized in this method.
BaseUDTF.process([args, ...])	The method is called by the MaxCompute SQL framework. The process method is called for each record passed in from SQL. The parameters passed into the process method are the parameters passed into the UDTF in SQL statements.

Parameter	Description
BaseUDTF.forward([args, ...])	The UDTF output method, which is called by user code. Each time FORWARD is called, one record is output. The parameters of FORWARD are the UDTF output parameters specified in SQL statements.
BaseUDTF.close()	The UDTF termination method. This method is called by the MaxCompute SQL framework.This method is called only once, after the last record is processed.

Example:

```
#coding:utf-8
# explode. py
from odps.udf import annotate

from odps.udf import BaseUDTF
@annotate('string -> string')
class Explode(BaseUDTF):
-- Output string as multiple comma-separated records.
  def process(self, arg):
    props = arg.split(',')
    for p in props:
      self.forward(p)
```

Notice A Python UDTF can also specify the parameter type or returned value type without adding 'annotate'. In this case, the function can match any input parameter in SQL. The type of returned value cannot be deduced, but all output parameters will be considered to be of the string type. Therefore, when FORWARD is called, all output values must be converted into values of the string type.

1.6.8.6.7. Reference resources

You can reference file and table resources in Python UDF through the odps.distcache module.

Syntax for referencing file resources:

```
odps.distcache.get_cache_file(resource_name)
```

Note

- Description: returns the content of the specified resource. resource_name is a string that corresponds to the name of an existing resource in the current project. If the resource name is invalid or does not exist, an error is returned.
- Returned value: returns file-like object. After this object is used, the caller must call the CLOSE method to release the resource file that is opened.

Example:

```
from odps.udf import annotate
from odps.distcache import get_cache_file
@annotate('bigint->string')
class DistCacheExample(object):
def __init__(self):
  cache_file = get_cache_file('test_distcache.txt')
  kv = {}
  for line in cache_file:
    line = line.strip()
    if not line:
      continue
    k, v = line.split()
    kv[int(k)] = v
  cache_file.close()
  self.kv = kv
def evaluate(self, arg):
  return self.kv.get(arg)
```

Command syntax:

```
odps.distcache.get_cache_table(resource_name)
```

Note

- Description: returns the content of the specified resource table. resource_name is a string that corresponds to the name of an existing resource table in the current project. If the resource table name is invalid or does not exist, an error is returned.
- Returned value: returns a value of the generator type. The caller traverses the table to obtain the content. Each time the caller traverses the table, a record is obtained in the form of a tuple.

Example:

```
from odps.udf import annotate
from odps.distcache import get_cache_table
@annotate('->string')
class DistCacheTableExample(object):
  def __init__(self):
    self.records = list(get_cache_table('udf_test'))
    self.counter = 0
    self.ln = len(self.records)
  def evaluate(self):
    if self.counter > self.ln - 1:
      return None
    ret = self.records[self.counter]
    self.counter += 1
    return str(ret)
```

1.6.9. UDTs

1.6.9.1. Overview

User-defined types (UDTs) are introduced in MaxCompute 2.0 for the latest version of the SQL engine. UDTs allow you to reference classes or objects of third-party languages in SQL statements to obtain data or call methods.

UDTs are typically applied in the following scenarios:

- **Scenario 1**: MaxCompute does not have built-in functions to complete tasks that can be easily performed using other languages. For example, there are some tasks that can be performed by calling a single built-in Java class. Performing these tasks with user defined functions (UDFs) is complex.
- **Scenario 2**: You need to call a third-party library in SQL statements to implement the corresponding feature. You want to use a feature provided by a third-party library directly in a SQL statement, instead of wrapping the feature inside a UDF.
- **Scenario 3**: SELECT TRANSFORM allows you to include objects and classes in SQL statements to make these SQL statements easier to read and maintain. For some languages, such as Java, the source code can be only executed after it is compiled. You want to reference objects and classes of these languages in SQL statements.

> **Notice**
>
> - UDTs only support Java.
> - All operators use the semantics of MaxCompute SQL.
> - UDTs cannot be used as shuffle keys in the JOIN, GROUP BY, DISTRIBUTE BY, SORT BY, ORDER BY, and CLUSTER BY clauses.
> - DDL statements do not support UDTs. You cannot create tables that contain UDT objects. The final output cannot be UDT types.

1.6.9.2. Feature summary

UDTs allow you to reference classes or objects of third-party languages in SQL statements to obtain data or call methods.

The UDTs supported in MaxCompute are very different from those in other SQL engines.

UDTs supported by other SQL engines are similar to the struct composite type in MaxCompute. UDTs supported by MaxCompute are similar to the CREATE TYPE statement. A UDT contains both fields and methods. Additionally, MaxCompute does not require that you use Data Definition Language (DDL) statements to define type mappings. MaxCompute allows you to reference types directly in SQL statements.

Example:

```
set odps.sql.type.system.odps2=true;
SELECT Integer.MAX_VALUE;
-- A similar output is displayed:
+------------+
| max_value |
+------------+
| 2147483647 |
+------------+
```

The expression in the preceding SELECT statement is similar to a Java expression and executed in the same manner as it would in Java. The expression specifies a UDT in MaxCompute.

You can use UDFs to implement all features provided by UDTs, but with some complexity. If you use a UDF to implement the same feature, you need to follow these steps:

1. Define a UDF class.

   ```
   package com.aliyun.odps.test;
   public class IntegerMaxValue extends com.aliyun.odps.udf.UDF {
   public Integer evaluate() {
    return Integer.MAX_VALUE;
   }
   }
   ```

2. Compile the UDF as a JAR package. Upload the JAR package and create a function.

   ```
   add jar odps-test.jar;
   create function integer_max_value as 'com.aliyun.odps.test.IntegerMaxValue' using 'odps-test.jar';
   ```

3. Call the function in a SQL statement.

   ```
   select integer_max_value();
   ```

A UDT simplifies this procedure. By using UDTs, you can use features provided by other languages in SQL statements.

1.6.9.3. Feature details

The preceding example shows how to use UDTs to access Java static fields. UTDs can be used to implement a number of functions. The following example shows the UDT execution procedure and its features.

```
-- Sample data
@table1 := select * from values ('10000000000000000000') as t(x);
@table2 := select * from values (100L) as t(y);
-- Logic of the code
@a := select new java.math.BigInteger(x) x from @table1;        -- Create a new object
@b := select java.math.BigInteger.valueOf(y) y from @table2;    -- Call a static method.
select /*+mapjoin(b)*/ x.add(y).toString() from @a a join @b b; -- Call an instance method
```

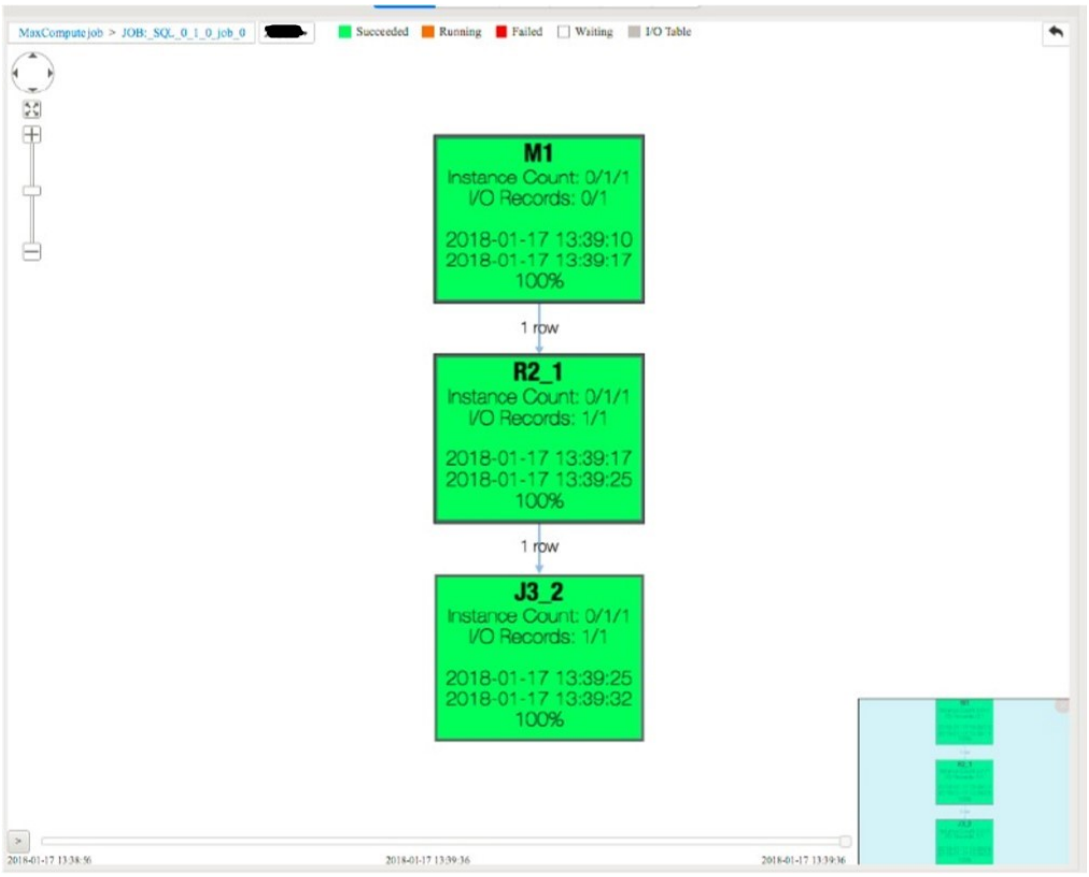
Command output:

```
100000000000000000100
```

Note This example also shows how to use subqueries using UDT columns. This task is difficult to accomplish with UDFs. Variable a is java.math.BigInteger type, but not a built-in type. You can pass the UDT data to another operator and then call its method. You can also use the UDT data in data shuffling.

UDT execution procedure

Example



This figure shows that a UDT has three stages: M1, R2, and J3. Only the *new java.math.BigInteger(x)* method is called in the M1 stage. The *java.math.BigInteger.valueOf(y)* and *x.add(y).toString()* methods are called separately at the J3 stage.

When a JOIN clause is used, data must be reshuffled similar to as it would in MapReduce. Data is processed in multiple stages. Typically, data processing at different stages are performed in different processes or different physical machines. The UDT encapsulates these stages and acts as a JVM.

Detailed features

- UDTs only support Java.
- UDTs also allow you to upload JAR packages and directly reference their contents. UDTs have provided flags.

- **set odps.sql.session.resources**: specifies one or more resources that you need to reference. Separate multiple resources with commas (,). Example: `set odps.sql.session.resources=foo.sh,bar.txt;`. Example:

```
set odps.sql.type.system.odps2=true;
set odps.sql.session.resources=odps-test.jar; -- To reference the JAR package, you must first upload th
e package to the corresponding project and make sure that it is a JAR type resource.
select new com.aliyun.odps.test.IntegerMaxValue().evaluate();
```

> **Notice** This flag is the same as the resource setting flag in SELECT TRANSFORM. Therefore, this flag controls two features.

- **odps.sql.session.java.imports**: specifies one or more default Java packages. Separate multiple Java packages with commas (,). It is similar to the IMPORT statement in Java. You can specify a class path, such as `java.math.BigInteger`, or use `*`. `static import` is not supported. Example:

```
set odps.sql.type.system.odps2=true;
set odps.sql.session.resources=odps-test.jar;
set odps.sql.session.java.imports=com.aliyun.odps.test. -- Specify the default Java package.
select new IntegerMaxValue().evaluate();
```

- UDTs allow you to:
  - Instantiate objects using the new operator.
  - Instantiate arrays using the new operator, including ArrayList initialization. Example: `new Integer[]{1,2,3}`.
  - Call methods, including static methods. You can create objects in the factory pattern.
  - Access fields, including static fields.

> **Notice**
> - Identifiers in UDTs include package names, class names, method names, and field names. All identifiers are case-sensitive.
> - UDTs support SQL syntax type conversion, such as cast (1 as java.lang.Object). UDTs do not support Java syntax type conversion, such as (Object)1.
> - Anonymous classes and lambda expressions are not supported.
> - Functions that do not return values cannot be called in UDTs.
>
> > **Note** This is because UDTs are typically used in expressions and functions that do not return values cannot be called in expressions.

- All Java SDK classes can be referenced by UDTs. The JDK runtime environment is JDK 1.8. Later versions may not be supported.
- All operators use the semantics of MaxCompute SQL. The result of `String.valueOf(1) + String.valueOf(2`

) is 3. The two strings are implicitly converted to double type values and summed. If you use Java string concatenation to merge the strings, the result will be 12.

In addition to the string concatenation methods in MaxCompute and Java, you may also have confusion about the = operator. The = operator in SQL statements is used as a comparison operator. You must call the equals method in Java to compare whether two objects are equivalent. The = operator cannot be used to verify the equivalence of two objects.

- Java data types are mapped to built-in data types. The mapping table can be applied to UDTs.
  - Built-in type data can directly call the method of the Java type to which the built-in type is mapped. Example: `'123'.length()` , `1L.hashCode()` .
  - UDTs can be used in built-in functions and UDFs. For example, in `chr(Long.valueOf('100'))` , `Long.valueOf` returns a `java.lang.Long` type value. Built-in function chr supports the built-in type of BIGINT.
  - Java primitive type data is automatically converted to boxing type data and the preceding two rules can be applied in this situation.

  > **Notice** For certain built-in new data types, you must add the `set odps.sql.type.system.odps2=true;` statement to declare these types. Otherwise, an error occurs.

- UDTs completely support Java generics. For example, the compiler can determine that the value returned by the `java.util.Arrays.asList(new java.math.BigInteger('1'))` method is `java.util.List<java.math.BigInteger>` based on the parameter type.

  > **Notice** You must set the type parameter in a construct function or use java.lang.Object. This is the same as in Java. You must set the type parameter in a construct function or use java.lang.Object. This is the same as in Java. For example, the result of `new java.util.ArrayList(java.util.Arrays.asList('1', '2'))` is `java.util.ArrayList<Object>` . The result of `new java.util.ArrayList<String>(java.util.Arrays.asList('1', '2'))` is `java.util.ArrayList<String>` .

- UDTs do not have a clear definition of **object equality**. This is caused by data reshuffling. The JOIN example shows that objects may be transmitted between different processes or physical machines. During the transmission, an object may be referenced as two different objects. For example, an object may be shuffled to two machines and then reshuffled.

  Therefore, when you use UDTs, you must use the equals method to compare two objects instead of using the = operator.

  > **Note** Objects in the same row or column are guaranteed to be correlated in some way. However, there may not be a correlation between objects in different rows and columns.

- UDTs cannot be used as shuffle keys in the JOIN, GROUP BY, DISTRIBUTE BY, SORT BY, ORDER BY, and CLUSTER BY clauses.

  UDTs can be used in any stages in expressions, but cannot be output as final results. For example, you cannot call the `group by new java.math.BigInteger('123')` method, but can call the `group by new java.math.BigInteger('123').hashCode()` method. This is because the value returned by hashCode is an int.class type, which can be used as a built-in type of INT.

- The following type conversion rules are extended in UDTs:
  - UDT objects can be converted to objects of its base classes by implicit conversion.
  - UDT objects can be forcibly converted to objects of its base classes or subclasses.
  - Data type conversion for two objects without inheritance follows the native conversion rules.

    > **Notice** The conversion may change the data. For example, java.lang.Long type data can be forcibly converted to java.lang.Integer type data. This process converts built-in BIGINT type data to INT type data. This process may cause data changes or even data precision changes.

- UDT objects cannot be saved or added to tables. DDL statements do not support UDTs. You cannot create tables that contain UDT objects unless the data is implicitly converted to one of the built-in types. In addition, the final output cannot be UDT types. However, you can call the toString() method to convert the UDT data to java.lang.String type data because the toString() method supports all Java types. You can use this method to check UDT data during debugging.

  You can also add the `set odps.sql.udt.display.tostring=true;` statement to enable MaxCompute to convert all UDT data to strings when the `java.util.Objects.toString(...)` method is called.

  > **Note** This flag is typically used for debugging because it can only be applied to the print statement. It cannot be applied to the INSERT statement.

  BINARY is a built-in type and supports automatic serialization. You can then save the byte[] arrays. The saved byte[] arrays can be deserialized to BINARY type.

  Some types may have their own serialization and deserialization methods, such as protobuffer. To save UDTs, you must call serialization and deserialization methods to convert the data to BINARY data.

- You can use UDTs to achieve the feature provided by the SCALAR function. With built-in functions COLLECT_LIST and EXPLODE, you can use UDTs to achieve the features provided by aggregate and table functions.

1.6.9.4. More examples

1.6.9.4.1. Example of using Java arrays

Example:

```
set odps.sql.type.system.odps2=true;
set odps.sql.udt.display.tostring=true;
select
  new Integer[10],   -- Create an array that contains 10 elements.
  new Integer[] {c1, c2, c3},  -- Create an array that contains three elements by initializing an ArrayList.
  new Integer[][] { new Integer[] {c1, c2}, new Integer[] {c3, c4} },  -- Create a multidimensional array.
  new Integer[] {c1, c2, c3} [2], -- Access the elements in the array using indexes.
  java.util.Arrays.asList(c1, c2, c3);   -- This is another way to create a built-in array. It creates a List<Integer>
, which can be used as an array<int>.
from values (1,2,3,4) as t(c1, c2, c3, c4);
```

1.6.9.4.2. Example of using JSON

The runtime of UDT carries a GSON dependency (version 2.2.4), which can be directly used in GSON.

Example:

```
set odps.sql.type.system.odps2=true;
set odps.sql.session.java.imports=java.util.*,java,com.google.gson. *; -- To import multiple packages, separ
ate the packages with commas (,).
@a := select new Gson() gson;  -- Create a GSON object.
select
gson.toJson(new ArrayList<Integer>(Arrays.asList(1, 2, 3))), -- Convert an object to a JSON string.
cast(gson.fromJson('["a","b","c"]', List.class) as List<String>) --Deserialize the JSON string. GSON also forci
bly converts the deserialized result from List<Object> type to List<String> type.
from @a;
```

Compared with built-in function **GET_JSON_OBJECT**, this method is simple and improves efficiency by extracting content from the JSON string and deserializing the string to a supported data type.

In addition to GSON dependencies, MaxCompute runtime also carries other dependencies, including commons-logging (1.1.1), commons-lang (2.5), commons-io (2.4), and protobuf-java (2.4.1).

1.6.9.4.3. Example of using composite types

Built-in types of array and map are mapped to java.util.List and java.util.Map, respectively.

- Java objects in classes calling the java.util.List or java.util.Map API can be used in MaxCompute SQL composite type data processing.
- Array and map type data in MaxCompute can directly call the java.util.List or java.util.Map API.

Example:

```
set odps.sql.type.system.odps2=true;
set odps.sql.session.java.imports=java.util.*;
select
  size(new ArrayList<Integer>()),     -- Call built-in function size to obtain the size of the ArrayList.
  array(1,2,3).size(),              -- Call the List method for built-in type array.
  sort_array(new ArrayList<Integer>()), -- Sort the data in the ArrayList.
  al[1],                        -- The Java List method does not support indexing. However, the array type supports i
ndexing.
  Objects.toString(a),     -- With this method, you can convert array type to string type data.
  array(1,2,3).subList(1, 2)         -- Get a sublist.
from (select new ArrayList<Integer>(array(1,2,3)) as al, array(1,2,3) as a) t;
```

1.6.9.4.4. Example of aggregation

To achieve aggregation with UDTs, you must first use built-in function COLLECT_SET or COLLECT_LIST to convert the data to the List type and then call the UDT methods to aggregate the data.

The following example shows how to obtain the median from BigInteger data. You cannot directly call the built-in MEDIAN function because the data is java.math.BigInteger type.

```
set odps.sql.session.java.imports=java.math.*;
@test_data := select * from values (1),(2),(3),(5) as t(value);
@a := select collect_list(new BigInteger(value)) values from @test_data;  -- Aggregate the data to a list.
@b := select sort_array(values) as values, values.size() cnt from @a;  -- To obtain the median, first sort the da
ta.
@c := select if(cnt % 2 == 1, new BigDecimal(values[cnt div 2]), new BigDecimal(values[cnt div 2 - 1].add(value
s[cnt div 2])).divide(new BigDecimal(2))) med from @b;
-- Final output.
select med.toString() from @c;
```

You cannot use the COLLECT_LIST function to implement partial aggregation because it aggregates all data. It is more efficient to use the built-in aggregator or UDAF object. We recommend that you use the built-in aggregator. Aggregating all data in a group increases the risk of data skew.

If the logic of the UDAF object is to aggregate all data in a similar manner to built-in function WM_CONCAT, using the COLLECT_LIST function is more efficient than using the UDAF object.

1.6.9.4.5. Example of using table-valued functions

Table-valued functions allow you to input and output multiple rows and columns. To input or output multiple rows and columns, follow these steps:

1. For more information about how to input multiple rows or columns, see the example of using aggregate functions.
2. To output multiple rows, you can use a UDT to define a Collection type (List or Map), and then call the EXPLODE function to split the collection into multiple rows.
3. A UDT can contain multiple fields. You can retrieve the data from the fields by calling different getter methods. The data is then output in multiple rows.

The following example shows how to split a JSON string and output the result as multiple columns:

```
@a := select '[{"a":"1","b":"2"},{"a":"1","b":"2"}]' str; -- Sample data
@b := select new com.google.gson.Gson().fromJson(str, java.util.List.class) l from @a; -- Deserialize the JSO
N string.
@c := select cast(e as java.util.Map<Object,Object>) m from @b lateral view explode(l) t as e;  -- Call the EXPL
ODE function to split the string.
@d := select m.get('a') as a, m.get('b') as b from @c; -- Output the splitting result in multiple columns.
select a.toString() a, b.toString() b from @d; -- The final output. Columns a and b in variable d are of the Obje
ct type.
```

1.6.9.5. Feature advantages

UDT has the following features:

- Easy to use. You do not need to define any functions.
- To improve the flexibility of SQL, all JDK supported features can be used directly.
- You can directly reference objects and classes of other languages in SQL statements.
- You can directly reference the libraries of other language and reuse code that you have written in other languages.
- You can create object-oriented features.

1.6.9.6. Performance advantages

UDTs and UDFs use similar execution procedures and provide similar performance. However, UDTs have higher performance in certain scenarios where the compute engine has been greatly improved.

- Deserialization is not required for objects in only one process. Deserialization is required only when the objects are transmitted among processes. This means that UDT do not incur any serialization or deserialization overhead when no data reshuffling is performed, such as calling the join or aggregator function.
- UDTs suffer no performance loss from reflection because the runtime of UDTs is based on Codegen, rather than based on reflection.
- Multiple UDTs can be wrapped into a single function call and executed together. In the following example, a single UDT is being called. UDTs focus on small-granularity data processing. This does not incur additional overhead for the API where multiple functions are called.

```
values[x].add(values[y]).divide(java.math.BigInteger.valueOf(2))
```

1.6.9.7. Security advantages

UDTs are restricted in the Java sandbox model similar to UDFs. To perform restricted operations, you must enable sandbox isolation or apply to join the sandbox whitelist.

1.6.10. UDJ

1.6.10.1. Overview

MaxCompute provides multiple JOIN methods natively, including INNER JOIN, RIGHT JOIN, OUTER JOIN, LEFT JOIN, FULL JOIN, SEMIJOIN, and ANTISEMIJOIN methods. You can use these native JOIN methods in most scenarios. However, these methods cannot handle multiple tables.

In most cases, you can build your code framework using UDFs. However, the current UDF, UDTF, and UDAF frameworks only can handle one table at a time. To perform user-defined operations for multiple tables, you have to use native JOIN methods, UDFs, UDTFs, and complex SQL statements. In certain cases when you handle multiple tables, you must use a custom MapReduce framework instead of SQL to complete the required task.

In any situation, these operations require technological expertise and may cause the following problems:

- Calling multiple JOIN methods in SQL statements can lead to computational black box that is complex and difficult to execute with minimal overheads.

- Using MapReduce even make optimal execution of code becomes impossible. Most of the MapReduce code is written in Java. The execution of the MapReduce code is less efficient than the execution of MaxCompute code generated by the LLVM code generator at an optimized native runtime.

With the addition of the MaxCompute 2.0 compute engine, the user defined join (UDJ) API has been added to the user defined function (UDF) framework. This API allows you to handle multiple tables and simplifies operations performed in the underlying MapReduce distributed system.

1.6.10.2. UDJ usage

1.6.10.2.1. Examples

The following example describes how to use UDJ in MaxCompute.

This example uses the payment table and the user_client_log table.

- The payment (user_id string,time datetime,pay_info string) table stores the payment information of a user. Each payment record includes the user ID, payment time, and the payment details.
- The user_client_log (user_id string,time datetime,content string) table stores user client records, including the user ID, operation time, and operation.

Requirements: For each record in the user_client_log table, locate the payment record that has the time closest to the operation time, and join and output the content of both records.

To complete this task by using standard join methods, you would need to join the two tables based on their common user_id fields, and then locate the payment record and operation that most closely match each other's time. The SQL statement may be written as follows:

```
SELECT
 p.user_id,
 p.time,
 merge(p.pay_info, u.content)
FROM
 payment p RIGHT OUTER JOIN user_client_log u
ON p.user_id = u.user_id and abs(p.time - u.time) = min(abs(p.time - u.time))
```

However, when you join two rows in the tables, you must calculate the minimum difference between the p.time and u.time under the same user_id, and the aggregate function cannot be called in the join condition. Because of this, this task cannot be completed by calling the standard JOIN method.

Can we use UDJ to solve this problem? Yes. The following topics describe how to use UDJ to satisfy the preceding requirements.

1.6.10.2.2. Use Java to write the UDJ code

Prerequisites

UDJ is a new feature, so a new SDK is required.

```
<dependency>
 <groupId>com.aliyun.odps</groupId>
 <artifactId>odps-sdk-udf</artifactId>
 <version>0.30.0</version>
 <scope>provided</scope>
</dependency>
```

The SDK contains a new abstract class UDJ. All UDJ features can be implemented through this class.

Sample code

The following sample code is used for reference only.

```
package com.aliyun.odps.udf.example.udj;
import com.aliyun.odps.Column;
import com.aliyun.odps.OdpsType;
import com.aliyun.odps.Yieldable;
import com.aliyun.odps.data.ArrayRecord;
import com.aliyun.odps.data.Record;
import com.aliyun.odps.udf.DataAttributes;
import com.aliyun.odps.udf.ExecutionContext;
import com.aliyun.odps.udf.UDJ;
import com.aliyun.odps.udf.annotation.Resolve;
import java.util.ArrayList;
import java.util.Iterator;
/** For each record of right table, find the nearest record of left table and
 * merge two records.
 */
@Resolve("->string,bigint,string")
public class PayUserLogMergeJoin extends UDJ {
 private Record outputRecord;
 /** Will be called prior to the data processing phase. User could implement
  * this method to do initialization work.
  */
 @Override
 public void setup(ExecutionContext executionContext, DataAttributes dataAttributes) {
  //
  outputRecord = new ArrayRecord(new Column[]{
    new Column("user_id", OdpsType.STRING),
    new Column("time", OdpsType.BIGINT),
    new Column("content", OdpsType.STRING)
  });
```

```
}
/** Override this method to implement join logic.
 * @param key Current join key
 * @param left Group of records of left table corresponding to the current key
 * @param right Group of records of right table corresponding to the current key
 * @param output Used to output the result of UDJ
 */
@Override
public void join(Record key, Iterator<Record> left, Iterator<Record> right, Yieldable<Record> output) {
 outputRecord.setString(0, key.getString(0));
 if (! right.hasNext()) {
  // Empty right group, do nothing.
  return;
 } else if (! left.hasNext()) {
  // Empty left group. Output all records of right group without merge.
  while (right.hasNext()) {
   Record logRecord = right.next();
   outputRecord.setBigint(1, logRecord.getDatetime(0).getTime());
   outputRecord.setString(2, logRecord.getString(1));
   output.yield(outputRecord);
  }
  return;
 }
 ArrayList<Record> pays = new ArrayList<>();
 // The left group of records will be iterated from the start to the end
 // for each record of right group, but the iterator cannot be reset.
 // So we save every records of left to an ArrayList.
 left.forEachRemaining(pay -> pays.add(pay.clone()));
 while (right.hasNext()) {
  Record log = right.next();
  long logTime = log.getDatetime(0).getTime();
  long minDelta = Long.MAX_VALUE;
  Record nearestPay = null;
  // Iterate through all records of left, and find the pay record that has
  // the minimal difference in terms of time.
  for (Record pay: pays) {
   long delta = Math.abs(logTime - pay.getDatetime(0).getTime());
   if (delta < minDelta) {
    minDelta = delta;
    nearestPay = pay;
   }
```

```
    }
    // Merge the log record with nearest pay record and output to the result.
    outputRecord.setBigint(1, log.getDatetime(0).getTime());
    outputRecord.setString(2, mergeLog(nearestPay.getString(1), log.getString(1)));
    output.yield(outputRecord);
   }
  }
  String mergeLog(String payInfo, String logContent) {
   return logContent + ", pay " + payInfo;
  }
  @Override
  public void close() {
  }
}
```

Notice In this example, the NULL values in the entries are not processed. To simplify the data processing procedure, assume that no NULL values are contained in the tables.

Each time you call this JOIN method of UDJ, records that match the same key in the two tables are returned. Therefore, UDJ searches all records in the payment table to locate the record with the time closest to each record in the user_client_log table.

Assume that the user only has a few payment records. In this case, you can load the data in the payment table to the memory. Typically, there is sufficient memory to store the user payment data generated each day. What if this assumption is invalid? How can we resolve this issue? This issue will be discussed in **Pre-sorting**.

1.6.10.2.3. Create a UDJ function in MaxCompute

After you have written the UDJ code in Java, upload the code to MaxCompute SQL as a plug-in. You must have registered the code with MaxCompute first.

Assume that the code is compressed into JAR package odps-udj-example.jar. Use the Add JAR command to upload the JAR package to MaxCompute.

```
add jar odps-udj-example.jar;
```

Execute the CREATE FUNCTION statement to create UDJ function *pay_user_log_merge_join*, using JAR package odps-udj-example.jar and Java class *com.aliyun.odps.udf.example.udj.PayUserLogMergeJoin*.

```
create function pay_user_log_merge_join
 as 'com.aliyun.odps.udf.example.udj.PayUserLogMergeJoin'
 using 'odps-udj-example.jar';
```

1.6.10.2.4. Use UDJ in MaxCompute SQL

After you have registered UDJ in the database, UDJ can be used in MaxCompute SQL.

1. Create a sample source table.

```
create table payment (user_id string,time datetime,pay_info string);
create table user_client_log(user_id string,time datetime,content string);
```

2. Create sample data.

> **Notice** The data in this example is only used for reference. You may need to create different data in actual operations.

```
-- Create data in the payment table
INSERT OVERWRITE TABLE payment VALUES
('1335656', datetime '2018-02-13 19:54:00', 'PEqMSHyktn'),
('2656199', datetime '2018-02-13 12:21:00', 'pYvotuLDIT'),
('2656199', datetime '2018-02-13 20:50:00', 'PEqMSHyktn'),
('2656199', datetime '2018-02-13 22:30:00', 'gZhvdySOQb'),
('8881237', datetime '2018-02-13 08:30:00', 'pYvotuLDIT'),
('8881237', datetime '2018-02-13 10:32:00', 'KBuMzRpsko'),
('9890100', datetime '2018-02-13 16:01:00', 'gZhvdySOQb'),
('9890100', datetime '2018-02-13 16:26:00', 'MxONdLckwa')
;
-- Create data in the user_client_log table
INSERT OVERWRITE TABLE user_client_log VALUES
('1000235', datetime '2018-02-13 00:25:36', 'click FNOXAibRjkIaQPB'),
('1000235', datetime '2018-02-13 22:30:00', 'click GczrYaxvkiPultZ'),
('1335656', datetime '2018-02-13 18:30:00', 'click MxONdLckpAFUHRS'),
('1335656', datetime '2018-02-13 19:54:00', 'click mKRPGOciFDyzTgM'),
('2656199', datetime '2018-02-13 08:30:00', 'click CZwafHsbJOPNitL'),
('2656199', datetime '2018-02-13 09:14:00', 'click nYHJqIpjevkKToy'),
('2656199', datetime '2018-02-13 21:05:00', 'click gbAfPCwrGXvEjpI'),
('2656199', datetime '2018-02-13 21:08:00', 'click dhpZyWMuGjBOTJP'),
('2656199', datetime '2018-02-13 22:29:00', 'click bAsxnUdDhvfqaBr'),
('2656199', datetime '2018-02-13 22:30:00', 'click XIhZdLaOocQRmrY'),
('4356142', datetime '2018-02-13 18:30:00', 'click DYqShmGbIoWKier'),
('4356142', datetime '2018-02-13 19:54:00', 'click DYqShmGbIoWKier'),
('8881237', datetime '2018-02-13 00:30:00', 'click MpkvilgWSmhUuPn'),
('8881237', datetime '2018-02-13 06:14:00', 'click OkTYNUHMqZzlDyL'),
('8881237', datetime '2018-02-13 10:30:00', 'click OkTYNUHMqZzlDyL'),
('9890100', datetime '2018-02-13 16:01:00', 'click vOTQfBFjcgXisYU'),
('9890100', datetime '2018-02-13 16:20:00', 'click WxaLgOCcVEvhiFJ')
;
```

3. In MaxCompute SQL, use the UDJ function you have created:

```
SELECT r.user_id, from_unixtime(time/1000) as time, content FROM (
SELECT user_id, time as time, pay_info FROM payment
) p JOIN (
SELECT user_id, time as time, content FROM user_client_log
) u
ON p.user_id = u.user_id
USING pay_user_log_merge_join(p.time, p.pay_info, u.time, u.content)
r
AS (user_id, time, content)
;
```

> **Note** The syntax of UDJ is similar to that of the standard JOIN statement. The only difference is that the USING clause is added to UDJ.

Description:

- **pay_user_log_merge_join** is the name of the UDJ function in SQL.
- **(p.time, p.pay_info, u.time, u.content)** are the columns used in these two tables.
- **r** is the alias of the result returned by the UDJ function. You can reference this alias in other SQL statements.
- **(user_id, time, content)** are the columns returned by the UDJ function.

4. Execute this SQL statement. A similar output is displayed:

```
+---------+------------+---------+
| user_id | time       | content |
+---------+------------+---------+
| 1000235 | 2018-02-13 00:25:36 | click FNOXAibRjkIaQPB |
| 1000235 | 2018-02-13 22:30:00 | click GczrYaxvkiPultZ |
| 1335656 | 2018-02-13 18:30:00 | click MxONdLckpAFUHRS, pay PEqMSHyktn |
| 1335656 | 2018-02-13 19:54:00 | click mKRPGOciFDyzTgM, pay PEqMSHyktn |
| 2656199 | 2018-02-13 08:30:00 | click CZwafHsbJOPNitL, pay pYvotuLDIT |
| 2656199 | 2018-02-13 09:14:00 | click nYHJqIpjevkKToy, pay pYvotuLDIT |
| 2656199 | 2018-02-13 21:05:00 | click gbAfPCwrGXvEjpI, pay PEqMSHyktn |
| 2656199 | 2018-02-13 21:08:00 | click dhpZyWMuGjBOTJP, pay PEqMSHyktn |
| 2656199 | 2018-02-13 22:29:00 | click bAsxnUdDhvfqaBr, pay gZhvdySOQb |
| 2656199 | 2018-02-13 22:30:00 | click XIhZdLaOocQRmrY, pay gZhvdySOQb |
| 4356142 | 2018-02-13 18:30:00 | click DYqShmGbIoWKier |
| 4356142 | 2018-02-13 19:54:00 | click DYqShmGbIoWKier |
| 8881237 | 2018-02-13 00:30:00 | click MpkvilgWSmhUuPn, pay pYvotuLDIT |
| 8881237 | 2018-02-13 06:14:00 | click OkTYNUHMqZzlDyL, pay pYvotuLDIT |
| 8881237 | 2018-02-13 10:30:00 | click OkTYNUHMqZzlDyL, pay KBuMzRpsko |
| 9890100 | 2018-02-13 16:01:00 | click vOTQfBFjcgXisYU, pay gZhvdySOQb |
| 9890100 | 2018-02-13 16:20:00 | click WxaLgOCcVEvhiFJ, pay MxONdLckwa |
+---------+------------+---------+
```

As shown in the preceding code, the task that could not be performed by calling native JOIN methods has been completed by using UDJ.

1.6.10.2.5. Pre-sorting

An iterator is used to search all records in the payment table and locate payment records that match the query. To perform this task, you must load all payment records with the same user_id to an ArrayList. This method can be applied when the number of payment records is small. Due to RAM size limits, you must find another method to load the data if a large number of payment records have been generated.

This topic describes how to address this issue using the SORT BY clause. When the size of the payment data is too large to be stored in the memory, it would be easier to address this issue if all data in the table has already been sorted by time. You then only need to compare the first element in these two lists. UDJ code in Java:

```
@Override
public void join(Record key, Iterator<Record> left, Iterator<Record> right, Yieldable<Record> output) {
 outputRecord.setString(0, key.getString(0));
 if (! right.hasNext()) {
  return;
 } else if (! left.hasNext()) {
  while (right.hasNext()) {
```

```
    Record logRecord = right.next();
    outputRecord.setBigint(1, logRecord.getDatetime(0).getTime());
    outputRecord.setString(2, logRecord.getString(1));
    output.yield(outputRecord);
   }
   return;
  }
  long prevDelta = Long.MAX_VALUE;
  Record logRecord = right.next();
  Record payRecord = left.next();
  Record lastPayRecord = payRecord.clone();
  while (true) {
   long delta = logRecord.getDatetime(0).getTime() - payRecord.getDatetime(0).getTime();
   if (left.hasNext() && delta > 0) {
    // The delta of time between two records is decreasing, we can still
    // explore the left group to try to gain a smaller delta.
    lastPayRecord = payRecord.clone();
    prevDelta = delta;
    payRecord = left.next();
   } else {
    // Hit to the point of minimal delta. Check with the last pay record,
    // output the merge result and prepare to process the next record of
    // right group.
    Record nearestPay = Math.abs(delta) < prevDelta ? payRecord : lastPayRecord;
    outputRecord.setBigint(1, logRecord.getDatetime(0).getTime());
    String mergedString = mergeLog(nearestPay.getString(1), logRecord.getString(1));
    outputRecord.setString(2, mergedString);
    output.yield(outputRecord);
    if (right.hasNext()) {
     logRecord = right.next();
     prevDelta = Math.abs(
      logRecord.getDatetime(0).getTime() - lastPayRecord.getDatetime(0).getTime()
     );
    } else {
     break;
    }
   }
  }
}
```

> **Notice** After you have modified the UDJ code, you must update the corresponding JAR package.

When the created UDJ function is used in MaxCompute SQL, you must modify the command as follows:

```
SELECT r.user_id, from_unixtime(time/1000) as time, content FROM (
 SELECT user_id, time as time, pay_info FROM payment
) p JOIN (
 SELECT user_id, time as time, content FROM user_client_log
) u
ON p.user_id = u.user_id
USING pay_user_log_merge_join(p.time, p.pay_info, u.time, u.content)
r
AS (user_id, time, content)
SORT BY p.time, u.time
;
```

In the native SQL language, you must make a few modifications, add a SORT BY clause to the end of the UDJ clause, and then sort the data in both tables by time.

The execution result is the same as the result before the code is modified.

This method uses the SORT BY clause to pre-sort the data. To achieve the same result, only a maximum of three records need to be cached.

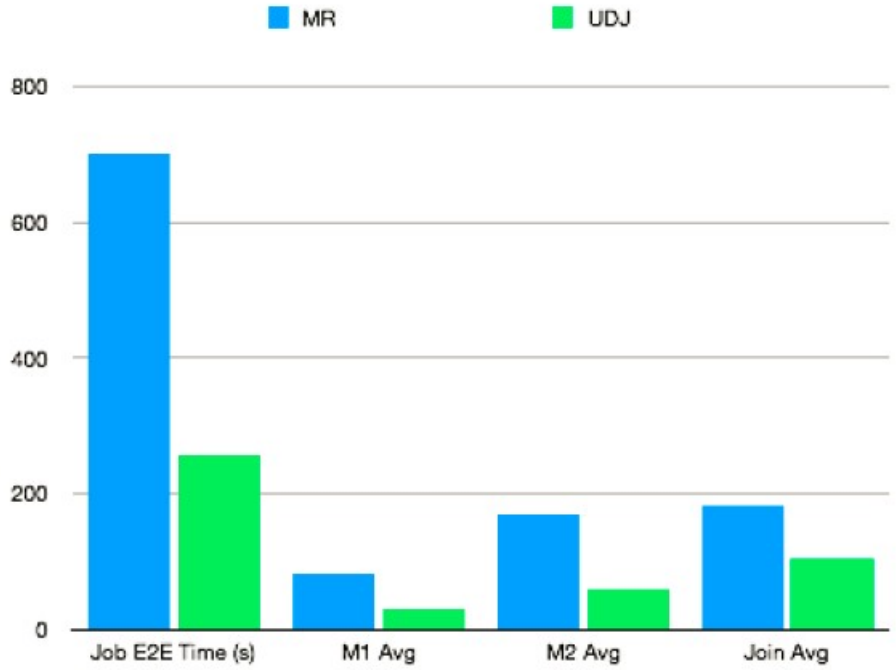
1.6.10.3. Performance advantages

Without UDJ, you must use MapReduce to handle complex cross-table computing tasks in a distributed system.

The following example uses an online MapReduce job to test the UDJ performance. This MapReduce job uses a complex algorithm to join two tables. This example uses UDJ to rewrite the SQL statements of the MapReduce job and checks the execution results.

Under the same programming concurrency, the comparison of performance is as follows.

Performance comparison



As shown in the figure, UDJ helps describe the complex logic of handling multiple tables, and greatly improves the query performance.

> **Note** The code is only executed inside UDJ. The entire logic of the code is executed by the high-performance MaxCompute native runtime.

UDJ optimizes the MaxCompute runtime engine and the data exchange between interfaces. The join logic of UDJ is more efficient than that of the reduce stage.

1.6.11. MaxCompute SQL limits

The following table lists all the limits of MaxCompute SQL statements.

Limits

Item	Maximum value/Limit	Category	Description
Table name length	128 bytes	Length	A table name or column name cannot contain special characters. It can contain only lowercase and uppercase letters, digits, and underscores (_) and must start with a letter.
Comment length	1,024 bytes	Length	A comment can be up to 1,024 bytes in length.
Column definitions in a table	1,200	Quantity	A table can contain a maximum of 1,200 column definitions.
Partitions in a table	60,000	Quantity	A table can contain a maximum of 60,000 partitions.

Item	Maximum value/Limit	Category	Description
Partition levels of a table	6	Quantity	A table can contain a maximum of six levels of partitions.
Statistical definitions of a table	100	Quantity	A table can contain a maximum of 100 statistical definitions.
Statistical definition length of a table	64,000	Length	The length of statistical definitions in a table cannot exceed 64,000.
Screen display	10,000 rows	Quantity	A SELECT statement can generate a maximum of 10,000 rows.
INSERT targets	256	Quantity	A MULTIINS operation can insert a maximum of 256 data tables at a time.
UNION ALL	256 tables	Quantity	A UNION ALL operation can be performed on a maximum of 256 tables.
JOIN sources	128	Quantity	The JOIN operation can be performed on a maximum of 128 source tables.
MAPJOIN memory	512 MB	Quantity	The memory size for all small tables on which the MAPJOIN operation is performed cannot exceed 512 MB.
Window functions	5	Quantity	A SELECT statement can contain a maximum of five window functions.
PTINSUBQ	1,000 rows	Quantity	A PT IN SUBQUERY statement can generate a maximum of 1,000 rows.
Length of an SQL statement	2 MB	Length	The maximum length of an SQL statement is 2 MB.
Conditions of a WHERE clause	256	Quantity	A WHERE clause can contain a maximum of 256 conditions.
Length of a column record	8 MB	Length	The maximum length of a column record in a table is 8 MB.
IN parameters	1,024	Quantity	This item specifies the maximum number of parameters in an IN clause, such as in(1,2,3,...,1024). Excess parameters can slow down the compilation process. We recommend that you use no more than 1,024 parameters, but this is not a fixed upper limit.

Item	Maximum value/Limit	Category	Description
jobconf.json	1 MB	Length	The maximum size of the jobconf.json file is 1 MB. If a table contains a large number of partitions, the size of jobconf.json may exceed 1 MB.
View	Not writable	Operation	A view is not writable and does not support the INSERT operation.
Data type and position of a column	Unmodifiable	Operation	The data type and position of a column are unmodifiable.
Java UDFs	Cannot be abstract or static	Operation	Java UDFs cannot be abstract or static.
Partitions to query	10,000	Quantity	A maximum of 10,000 partitions can be queried.

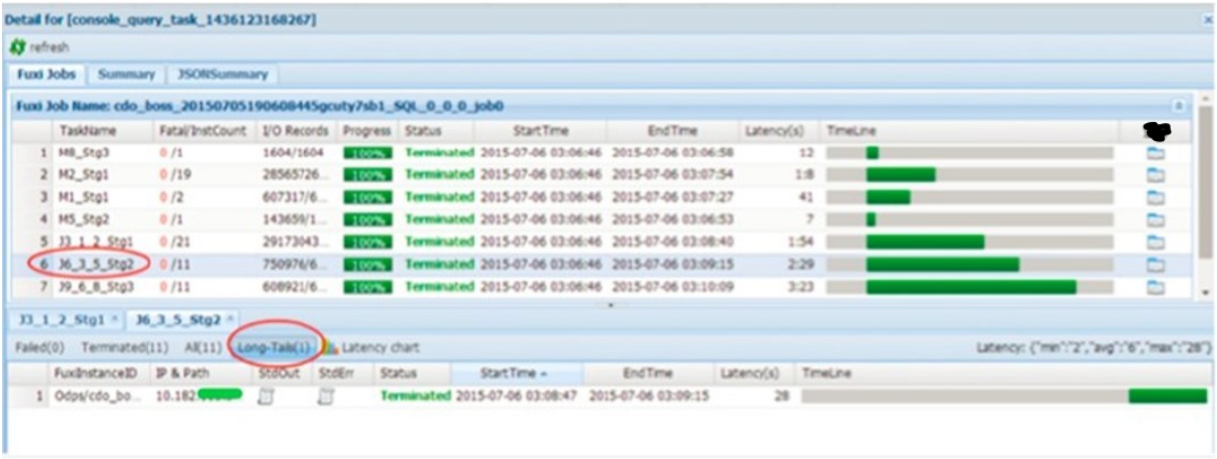
Notice The preceding MaxCompute SQL limits cannot be modified manually.

1.6.12. Common MaxCompute SQL errors and solutions

1.6.12.1. Data skew

1.6.12.1.1. Overview

For a running job instance where the min, max, and avg values for the parameters time, input records, and output records are imbalanced (for example, max is much greater than avg), a data skew problem may have occurred. You can check the log view to locate the data skew problem, as shown in the following figure.



The Long Tails tab of each task shows the instance where the data skew occurred. The root cause of data skew is that the amounts of data processed by some instances are much higher than that processed by other instances, causing the running time of these instances to exceed the average time of other instances. As a result, the entire job slows down.

You can reduce the data skew of different SQL data types using different methods.

1.6.12.1.2. GROUP BY skew

Possible cause: The unbalanced distribution of GROUP BY keys causes data skew in the Reduce step.

Solution: Enable the group skew prevention parameter before running SQL statements:

```
set odps.sql.groupby.skewindata=true
```

> **Note** If this parameter is set to true, the system adds random factors to the shuffle hash algorithm and adds a new task to prevent data skew.

1.6.12.1.3. DISTRIBUTE BY skew

Possible cause: Using constants for full-table sorting in DISTRIBUTE BY mode will result in data skew at the Reduce end.

Solution: Avoid the preceding operation.

1.6.12.1.4. JOIN skew

Possible cause: The unbalanced distribution of join on keys (such as a large number of repeated keys in multiple JOIN tables) causes surging Cartesian product data in some JOIN instances, which results in data skew.

Solution: The solutions to different scenarios are as follows:

- If there are small tables on both sides of 'join', perform 'map join' instead of 'join'.
- The skewed key can be dealt with by using individual logic. For example, a large amount of NULL data in keys on both sides of a table results in skew. In this case, you need to filter out the NULL data before performing the JOIN operation or replacing NULL values with random values by using the CASE WHEN clause, and then do JOIN operation.
- If you do not want to change SQL statements, set the following parameters to enable automatic optimization on MaxCompute:

```
set odps.sql.skewinfo=tab1:(col1, col2)[(v1, v2), (v3, v4), ...]
set odps.sql.skewjoin=true;
```

1.6.12.1.5. MULTI-DISTINCT skew

Possible cause: Multiple DISTINCT keywords aggravate the GROUP BY skew problem.

Solution: You can use a two-layer GROUP BY to smooth the skew.

1.6.12.1.6. Data skew caused by misuse of dynamic partitioning

Possible cause: If dynamic partitioning is enabled, and there are K map instances and N target partitions, a number of small files (K * N) may be generated. A large amount of small files can greatly increase the management workload of the file system. Therefore, the following configuration takes effect by default:

```
set odps.sql.reshuffle.dynamicpt=true;
```

It introduces an additional level of ReduceTask to allow one or more reduce instances to write data to the same target partition. This prevents too many small files from being generated. However, dynamic partition shuffle may cause data skew.

Solution: If there are only a few target partitions, the system will not generate many small files. In this case, you can run the following command to disable the preceding function, or disable dynamic partitioning:

```
set odps.sql.reshuffle.dynamicpt=false;
```

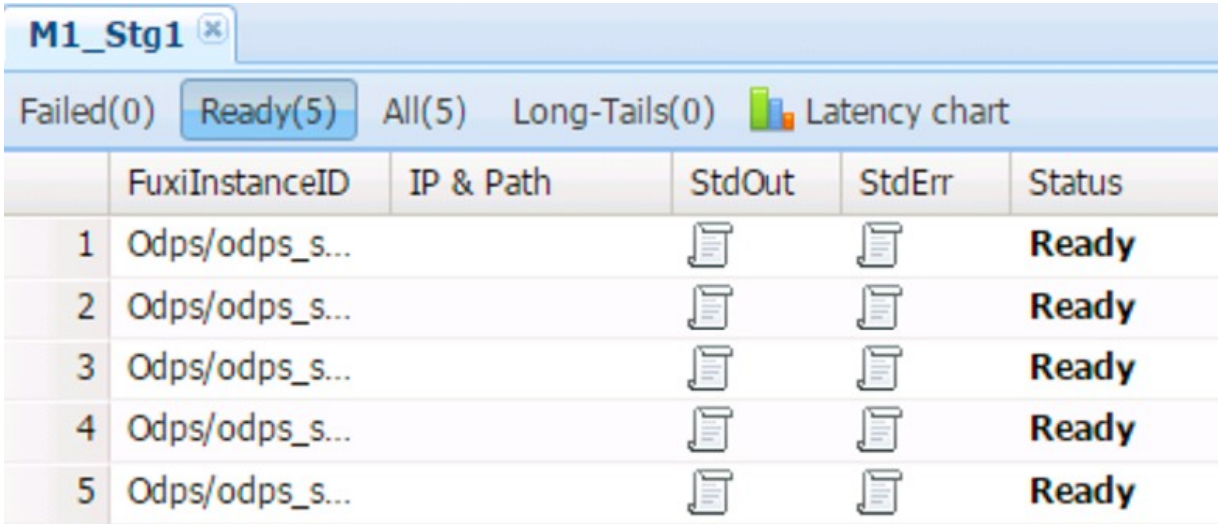
1.6.12.2. Quota and resource usage

Computing resources in MaxCompute may be insufficient sometimes because of improper planning and use of cluster resources.

In general, tasks lacking computing resources have two characteristics, one of which is that the task gets stuck with the output remained at a certain stage. For example, in the following figure, the progress of the M1_Stg1 task has stayed at 0% (because R2_1_Stg1 depends on M1_Stg1, it stays at 0% until M1_Stg1 ends).

```
2016-01-29 13:52:09 M1_Stg1_job0:0/0/5[0%]      R2_1_Stg1_job0:0/0/1[0%]
2016-01-29 13:52:14 M1_Stg1_job0:0/0/5[0%]      R2_1_Stg1_job0:0/0/1[0%]
2016-01-29 13:52:19 M1_Stg1_job0:0/0/5[0%]      R2_1_Stg1_job0:0/0/1[0%]
2016-01-29 13:52:24 M1_Stg1_job0:0/0/5[0%]      R2_1_Stg1_job0:0/0/1[0%]
2016-01-29 13:52:29 M1_Stg1_job0:0/0/5[0%]      R2_1_Stg1_job0:0/0/1[0%]
2016-01-29 13:52:34 M1_Stg1_job0:0/0/5[0%]      R2_1_Stg1_job0:0/0/1[0%]
2016-01-29 13:52:39 M1_Stg1_job0:0/0/5[0%]      R2_1_Stg1_job0:0/0/1[0%]
2016-01-29 13:52:44 M1_Stg1_job0:0/0/5[0%]      R2_1_Stg1_job0:0/0/1[0%]
2016-01-29 13:52:49 M1_Stg1_job0:0/0/5[0%]      R2_1_Stg1_job0:0/0/1[0%]
2016-01-29 13:52:54 M1_Stg1_job0:0/0/5[0%]      R2_1_Stg1_job0:0/0/1[0%]
2016-01-29 13:52:59 M1_Stg1_job0:0/0/5[0%]      R2_1_Stg1_job0:0/0/1[0%]
2016-01-29 13:53:04 M1_Stg1_job0:0/0/5[0%]      R2_1_Stg1_job0:0/0/1[0%]
2016-01-29 13:53:09 M1_Stg1_job0:0/0/5[0%]      R2_1_Stg1_job0:0/0/1[0%]
2016-01-29 13:53:15 M1_Stg1_job0:0/0/5[0%]      R2_1_Stg1_job0:0/0/1[0%]
2016-01-29 13:53:20 M1_Stg1_job0:0/0/5[0%]      R2_1_Stg1_job0:0/0/1[0%]
2016-01-29 13:53:25 M1_Stg1_job0:0/0/5[0%]      R2_1_Stg1_job0:0/0/1[0%]
2016-01-29 13:53:30 M1_Stg1_job0:0/0/5[0%]      R2_1_Stg1_job0:0/0/1[0%]
2016-01-29 13:53:35 M1_Stg1_job0:0/0/5[0%]      R2_1_Stg1_job0:0/0/1[0%]
2016-01-29 13:53:40 M1_Stg1_job0:0/0/5[0%]      R2_1_Stg1_job0:0/0/1[0%]
2016-01-29 13:53:45 M1_Stg1_job0:0/0/5[0%]      R2_1_Stg1_job0:0/0/1[0%]
2016-01-29 13:53:50 M1_Stg1_job0:0/0/5[0%]      R2_1_Stg1_job0:0/0/1[0%]
2016-01-29 13:53:55 M1_Stg1_job0:0/0/5[0%]      R2_1_Stg1_job0:0/0/1[0%]
```

The other characteristic is that the task remains in "Ready" state in the Logview (as shown in the following figure) (a "Ready" task is awaiting allocation of resources; a "Waiting" task is waiting for completion of the dependent task). The "Ready" state indicates that the resources for running these stand-by task instances are insufficient. Once the instances obtain the necessary resources, they resume operating and change to "Running" state.



Each task is split into subtasks based on the execution plan and shown in a DAG, and each subtask invokes multiple instances to execute the computation concurrently. In general, the resources required for invoking an instance are a 1-core CPU and 2 GB of memory. A quota group is assigned to each project for reasonable resource allocation. The quota group determines the maximum amount of resources (CPU and memory) that can be used by all jobs in the project concurrently. Once the resource usage for simultaneously running tasks reaches the limit of the quota group, the tasks are stuck due to insufficient resources.

There are two methods to solve this problem:

- Run the tasks in idle periods.
- Increase the quota group for the project (handled by OAM personnel).

1.6.12.3. MaxCompute storage optimization tips

Partition tables reasonably

MaxCompute supports the concept of partitioning in a table. A partition refers to the specified partition space in the creation of a table; that is, a few fields in the specified table as the partition columns. In most cases, you can consider a partition as a directory in a file system. MaxCompute divides each value of the partition column into a partition (directory). Users can specify multi-level partitions (use multiple fields of the table as partition columns). Multi-level partitions are like multi-level directories. If you specify the name of the partition that you want to access when using the data, then only the corresponding partition are read, avoiding a full table scan. This improves the processing efficiency and reduces costs.

Example of a partitioning statement: `create table src (key string, value bigint) partitioned by (pt string);` . In this example, `select * from src where pt='20160901';` specifies the partitioning format. MaxCompute takes only the data in the "20160901" partition as the input when generating a query plan.

Example of a non-partitioning statement: `select * from src where key = 'MaxCompute';` scans the entire table.

Partitioning is usually based on date or geographical region. You may also set partitions based on your business requirements. Example:

```
create table if not exists sale_detail(
shop_name string,
customer_id string,
total_price double)
partitioned by (sale_date string,region string);
-- Create a two-level partitioned table, in which sale_date is level-1 partition, and region level-2 partition.
```

Set table lifecycle reasonably

Storage space on MaxCompute is precious. You can set the life cycle of a table according to data usage. MaxCompute will delete expired data to save storage space.

Example: Run the `create table test3 (key boolean) partitioned by (pt string, ds string) lifecycle 100;` command to create a table with a lifecycle of 100. If the latest modification time of this table or partition was more than 100 days ago, the table or partition will be deleted.

> **Notice** The lifecycle takes a partition as the smallest unit, so for a partitioned table, if some partitions reach the lifecycle threshold, they will be deleted directly. Partitions that have not reached the lifecycle threshold are not be affected.

Run the `alter table table_name set lifecycle days;` command to modify the lifecycle of an existing table.

Archive cold data

Some data need to be preserved either permanently or for a long period of time, but the frequency of access decreases over time. When the use frequency is very low, you can archive the data. The archive function saves data with RAID. Data is not simply stored as three copies. By using the Cauchy Reed-Solomon algorithm, data is stored as six copies of the original data plus three parity blocks. This improves the effective storage ratio from 1:3 to 1:1.5. In addition, MaxCompute uses the bzip2 algorithm to archive tables with a higher compression ratio than other algorithms. Combining the two algorithms reduces storage usage by more than 70%.

Archiving command format is as below:

```
ALTER TABLE table_name [PARTITION(partition_name='partition_value')] ARCHIVE;
```

Example:

```
alter table my_log partition(ds='20140101') archive;
```

Merge small files

In the reduce calculation or real-time tunnel data collection, a large number of small files are generated. Too many small files may cause the following problems:

- Many instances are occupied because a single instance can process only a small number of files. This results in a waste of resources, affecting the overall execution performance.
- The file system becomes larger, while the use ratio of disk space becomes smaller.

Currently, there are two alternative ways to merge small files: ALTER merge mode and SQL merge mode:

- The ALTER merge mode merges files through 'console' command. The command format is as follows:

  ```
  ALTER TABLE tablename [PARTITION] MERGE SMALLFILES;
  ```

- Set control parameters after SQL execution is complete. Run `odps.task.merge.enabled=true;` to determine whether it is necessary to merge small files. If so, start FuxiJob to merge these files.

1.6.12.4. UDF OOM error

Some jobs will report the OOM error during running. The error message is as follows:

```
FAILED: ODPS-0123144: Fuxi job failed - WorkerRestart errCode:9,errMsg:SigKill(OOM), usually caused by OOM(out of memory)
```

This problem can be solved by setting the UDF runtime parameters:

```
odps.sql.mapper.memory=3072;
set odps.sql.udf.jvm.memory=2048;
set odps.sql.udf.python.memory=1536;
```

1.6.13. Common MaxCompute SQL parameter settings

1.6.13.1. MAP configurations

```
set odps.sql.mapper.cpu=100
```

Purpose: It is used to set the number of CPUs for each instance in a Map task. Default value: 100. Value range: 50 to 800.

```
set odps.sql.mapper.memory=1024
```

Purpose: It is used to set the memory size for each instance in a Map task. Default value: 1024 MB. Value range: 256 MB to 12,288 MB.

```
set odps.sql.mapper.merge.limit.size=64
```

Purpose: It is used to set the maximum size of control files to be merged. Default value: 64 MB. You can set this variable to control the inputs of mappers. Value range: 0 to Integer.MAX_VALUE.

```
set odps.sql.mapper.split.size=256
```

Purpose: It is used to set the maximum data input volume for a map. Default value: 256 MB. You can set this variable to control the inputs of mappers. Value range: 1 to Integer.MAX_VALUE.

1.6.13.2. JOIN configurations

```
set odps.sql.joiner.instances=-1
```

Purpose: It is used to set the number of instances in a JOIN task. Default value: 1. Value range: 0 to 2,000.

```
set odps.sql.joiner.cpu=100
```

Purpose: It is used to set the number of CPUs for each instance in a JOIN task. Default value: 100. Value range: 50 to 800.

```
set odps.sql.joiner.memory=1024
```

Purpose: It is used to set the memory size for each instance in a JOIN task. Default value: 1,024 MB. Value range: 256 MB to 12,288 MB.

1.6.13.3. Reduce configurations

```
set odps.sql.reducer.instances=-1
```

Purpose: It is used to set the number of instances in a Reduce task. Default value: 1. Value range: 0 to 2,000.

```
set odps.sql.reducer.cpu=100
```

Purpose: It is used to set the number of CPUs for each instance in a Reduce task. Default value: 100. Value range: 50 to 800.

```
set odps.sql.reducer.memory=1024
```

Purpose: It is used to set the memory size for each instance in a Reduce task. Default value: 1,024 MB. Value range: 256 to 12,288 MB.

1.6.13.4. UDF configurations

```
set odps.sql.udf.jvm.memory=1024
```

Purpose: It is used to set the maximum memory size for a UDF JVM heap. Default value: 1,024 MB. Value range: 256 to 12,288 MB.

```
set odps.sql.udf.timeout=600
```

Purpose: It is used to set the timeout value of a UDF. Default value: 600 seconds. Value range: 0 to 3,600 seconds.

```
set odps.sql.udf.python.memory=256
```

Purpose: It is used to set the maximum memory size for UDF python. Default value: 256 MB. Value range: 64 to 3,072 MB.

```
set odps.sql.udf.optimize.reuse=true/false
```

Purpose: after start-up, each UDF function expression can only be calculated once, improving performance. The default is true.

```
set odps.sql.udf.strict.mode=false/true
```

Purpose: It is used to control functions regarding whether to return NULL or error if dirty data is

encountered. If it is true, an error is returned. If it is false, NULL is returned.

1.6.13.5. MAPJOIN configurations

```
set odps.sql.mapjoin.memory.max=512
```

Purpose: It is used to set the maximum memory of a small table in MAPJOIN. Default vlaue 512 MB. Value range: 128 to 2,048 MB.

```
set odps.sql.reshuffle.dynamicpt=true/false
```

Purpose:

- Some scenarios of dynamic partitioning are time-consuming. Shutting them down can speed up SQL.
- If the dynamic partition value is very small, disabling dynamic partition can avoid data skew.

1.6.13.6. Configure data skew

```
set odps.sql.groupby.skewindata=true/false
```

Effect: enables the group by optimization.

```
set odps.sql.skewjoin=true/false
```

Effect: enables the join optimization. It takes effect only when odps.sql.skewinfo is configured.

```
set odps.sql.skewinfo
```

Purpose: It is used to set detailed information of join optimization. The command syntax is as follows:

```
set odps.sql.skewinfo=skewed_src:(skewed_key)[("skewed_value")]
```

Example:

The following command is used to set a single skewed data value in a single field:

```
set odps.sql.skewinfo=src_skewjoin1:(key)[("0")]
-- Command output: explain select a.key c1, a.value c2, b.key c3, b.value c4 from src a join src_skewjoin1 b on a.key = b.key;
```

The following command is used to set multiple skewed data values in a single field:

```
set odps.sql.skewinfo=src_skewjoin1:(key)[("0")("1")]
-- Command output: explain select a.key c1, a.value c2, b.key c3, b.value c4 from src a join src_skewjoin1 b on a.key = b.key;
```

1.6.14. MapReduce-to-SQL conversion for execution

1.6.14.1. Overview

MaxCompute provides a series of Java APIs for MapReduce to process data.

In MaxCompute 2.0, MapReduce programs are automatically converted to SQL for execution. After the conversion, you can use the compiler, cost-based optimizer, and vectorized execution engine released with MaxCompute 2.0 to process the MapReduce programs. The new features of the SQL engine can also be used in MaxCompute 2.0. The features, performance, and stability of the SQL engine are optimized.

> **Notice**
>
> - Changes to the original APIs and job logic are not required.
> - Only MapReduce jobs of the OpenMR job type, which are written with MapReduce APIs, can be converted to SQL.

1.6.14.2. Local running settings

1. Download the latest MaxCompute client package to the local PC and make proper configurations.
2. Set the execution mode.

   You can change the execution mode to better suit your business needs. The default execution mode is the lot mode. In the lot mode, jobs are executed by MapReduce. The MaxCompute 2.0 compiler, optimizer, and execution engine are not utilized.

   You can enable the conversion flag by changing *odps.mr.run.mode*. Valid values: **lot**, **sql**, **and hybrid**.

   - The first method is to enable the conversion flag at the project level. Because this method affects all jobs, it requires a project administrator to apply for it. Set the value of *odps.mr.run.mode* to **hybrid** or **sql**. In the hybrid mode, if SQL execution fails, the job will be executed by MapReduce. In the SQL mode, when SQL execution fails, an error is returned.
   - The second method is to enable the conversion flag at the session level and is only valid for the current job. The following two ways can be used:
     - Add the SET statement. Example: `set odps.mr.run.mode=hybrid` .
     - Configure the job parameter as follows:

       ```
       JobConf job = new JobConf();
       job.set("odps.mr.run.mode","hybrid")
       ```

   The conversion flag will be enabled at the project level later by MaxCompute O&M personnel.

1.6.14.3. Operation settings in DataWorks

Jobs running in DataWorks are updated by the O&M personnel of MaxCompute and DataWorks. You do not need to update the client manually.

1. Enable the conversion for a single job.

   You can add the SET statement before a MapReduce job or configure the job parameter for it. These methods take effect at the session level and apply only to the current job.

   The following examples demonstrate how to use these methods:

   - Add the SET statement, such as `set odps.mr.run.mode=hybrid`.
   - Configure the job parameter as follows:

     ```
     JobConf job = new JobConf();
     job.set("odps.mr.run.mode","hybrid")
     ```

2. Enable the conversion at the project level by setting *odps.mr.run.mode* for a project.

1.6.14.4. View running details

You can use Logview and MaxCompute Studio to view MapReduce-to-SQL conversion results and running details of SQL jobs.

1. LogView XML.

   Open Logview and click the LOT node in the center of the page. The SQL jobs that are converted from MapReduce jobs are included in the XML information of the node. Example:

```
create temporary function mr2sql_mapper_152955927079392291755 as  'com.aliyun.odps.mapred.bridge.LotMapperUDTF' using ;
create temporary function mr2sql_reducer_152955927079392291755 as 'com.aliyun.odps.mapred.bridge.LotReducerUDTF' using ;
 @sub_query_mapper :=
 SELECT k_id,v_gmt_create,v_gmt_modified,v_product_id,v_admin_seq,v_sku_attr,v_sku_price,v_sku_stock,v_sku_code,v_sku_image,v_delivery_time,v_sku_bulk_order,v_sku_bulk_discount,v_sku_image_version,v_currency_code
FROM(
SELECT mr2sql_mapper_152955927079392291755(id,gmt_create,gmt_modified,product_id,admin_seq,sku_attr,sku_price,sku_stock,sku_code,sku_image,delivery_time,sku_bulk_order,sku_bulk_discount,sku_image_version,currency_code ) as (k_id,v_gmt_create,v_gmt_modified,v_product_id,v_admin_seq,v_sku_attr,v_sku_price,v_sku_stock,v_sku_code,v_sku_image,v_delivery_time,v_sku_bulk_order,v_sku_bulk_discount,v_sku_image_version,v_currency_code)
FROM ae_antispam.product_sku_tt_inc
WHERE ds = "20180615"  AND hh = "21"
UNION ALL
SELECT mr2sql_mapper_152955927079392291755(id,gmt_create,gmt_modified,product_id,admin_seq,sku_attr,sku_price,sku_stock,sku_code,sku_image,delivery_time,sku_bulk_order,sku_bulk_discount,sku_image_version,currency_code ) as (k_id,v_gmt_create,v_gmt_modified,v_product_id,v_admin_seq,v_sku_attr,v_sku_price,v_sku_stock,v_sku_code,v_sku_image,v_delivery_time,v_sku_bulk_order,v_sku_bulk_discount,v_sku_image_version,v_currency_code)
FROM ae_antispam.product_sku
) open_mr_alias1
 DISTRIBUTE BY k_id SORT BY k_id ASC;
@sub_query_reducer :=
SELECT mr2sql_reducer_152955927079392291755(k_id,v_gmt_create,v_gmt_modified,v_product_id,v_admin_seq,v_sku_attr,v_sku_price,v_sku_stock,v_sku_code,v_sku_image,v_delivery_time,v_sku_bulk_order,v_sku_bulk_discount,v_sku_image_version,v_currency_code) as (id,gmt_create,gmt_modified,product_id,admin_seq,sku_attr,sku_price,sku_stock,sku_code,sku_image,delivery_time,sku_bulk_order,sku_bulk_discount,sku_image_version,currency_code)
FROM @sub_query_mapper;
FROM @sub_query_reducer
INSERT OVERWRITE TABLE ae_antispam.product_sku
SELECT id,gmt_create,gmt_modified,product_id,admin_seq,sku_attr,sku_price,sku_stock,sku_code,sku_image,delivery_time,sku_bulk_order,sku_bulk_discount,sku_image_version,currency_code ;
```

2. LogView detail or summary.

   You can see that the new execution engine is used to execute jobs.

```
Job run mode: fuxi job
Job run engine: execution engine
```

3. LogView detail or JSON summary.

   The JSON summary information in MapReduce only contains the input and output information of Map and Reduce. However, the JSON summary information in SQL allows you to view details about each stage of SQL execution, such as all execution parameters, logical execution plans, physical execution plans, and execution details. Example:

```
"midlots" :
[
"LogicalTableSink(table=[[odps_flighting.flt_20180621104445_step1_ad_quality_tech_qp_algo_antifake_wordbag_filter_bag_change_result_lv2_20, auctionid,word,match_word(3) {0, 1, 2}]])
OdpsLogicalProject(auctionid=[$0], word=[$1], match_word=[$2])
OdpsLogicalProject(auctionid=[$0], word=[$1], match_word=[$2])
OdpsLogicalProject(auctionid=[$0], word=[$1], match_word=[$2])
OdpsLogicalProject(auctionid=[$2], word=[$3], match_word=[$4])
OdpsLogicalTableFunctionScan(invocation=[[MR2SQL_MAPPER_15295529411881306373 2($0, $1)]()], rowType=[RecordType(VARCHAR(2147483647) item_id, VARCHAR(2147483647) text, VARCHAR(2147483647) __tf_0_0, VARCHAR(2147483647) __tf_0_1, VARCHAR(2147483647) __tf_0_2)])
OdpsLogicalTableScan(table=[[ad_quality_tech.qp_algo_antifake_wordbag_filter_bag_change_lv2_20, item_id,text(2) {0, 1}]])
]
```

1.6.14.5. Perform operations on the distributed file system

Procedure

1. Specify volume files.

   You can use either of the following methods to specify volume files:

   - Use a utility class to specify the input and output files:

     ```
     com.aliyun. ODPS .mapred.utils.InputUtils.addVolume( new VolumeInfo([project,]inVolume,inPartition, "inLabel"), new JobConf());
     com.aliyun. ODPS .mapred.utils.OutputUtils.addVolume( new VolumeInfo([project,]outVolume, outPartition, "outLabel"), new JobConf());
     ```

     In the preceding commands, project and label are optional, and the current project and default label are used by default. If multiple input and output files are used, labels are used to distinguish the files from each other. Authorization is required before you access the volume files of other projects.

   - Configure parameters to specify the volume and partition of the input and output files. If

multiple input or output files are used, separate the parameters with commas (,).

```
set odps.sql.volume.input[/output].desc = [<project>.]<table>.<partition>[:<label>];
```

2. Call the following method by using a context object in the map and reduce steps to write data to the distributed file system or write data stream input and output files:

```
context.getOutputVolumeFileSystem();
```

1.6.15. Appendix

1.6.15.1. Escape character

String constants in MaxCompute SQL can be enclosed in single or double quotation marks, in double quotation marks enclosed in single quotation marks, or in single quotation marks enclosed in double quotation marks. Otherwise, they must be expressed with an escape character. Examples of correct expressions: "I'm a happy coder!" and 'I\'m a happy coder!'.

In MaxCompute SQL, the backslash (\) is an escape character, which expresses the special character in a string or interprets the character that follows as the character itself. When a string constant is read, if the backslash is followed by three valid octal digits in the range from 001 to 177, the system converts the ASCII values into the corresponding characters. The following table lists the mappings between escape sequences and represented characters.

Escape sequences

Escape sequence	Represented character
\b	Backspace
\t	Tab
\n	Newline
\r	Carriage return
\'	Single quote
\"	Double quote
**\ **	Backslash
\;	Semicolon
\Z	Control-Z
\0 or \00	Terminator

Example:

```
select length('a\tb') from dual;
-- The result is 3, indicating that the string contains three characters, with "\t" regarded as one character. An
y character following the escape sequence is interpreted as the character itself.
```

```
select 'a\ab',length('a\ab') from dual;
-- The result is 'aab', with a length of 3. "\a" is interpreted as an ordinary "a".
```

1.6.15.2. LIKE matching

In LIKE matching, "%" indicates matching any number of characters; "_" indicates matching a single character. If the character "%" or "_" needs to be matched, escape conversion is required. "\%" indicates matching "%", and "_" indicates matching "_".

> **Note** For the character set of strings, MaxCompute SQL currently supports the UTF-8 character set. Data that is encoded in a different format may result in incorrect calculations.

1.6.15.3. Regular expressions

MaxCompute SQL adopts the PCRE library for regular expressions. Matching is performed character by character. The supported metacharacters are as follows:

- ^: the beginning of a row
- $: the end of a row
- .: any character
- *: matches zero or multiple times.
- +: matches once or multiple times.
- ?: matches a modifier. If this character follows any one of other delimiters (*, +, ?, {n}, {n,}, or {n,m}), the match is lazy. In the lazy mode, as few strings as possible are matched. In the default greedy mode, as many searched strings as possible are matched zero times or once.
- A|B: A or B
- (abc)*: matches the abc sequence zero or multiple times.
- {n} or {m,n}: the number of matches
- [ab]: matches any character in the brackets.
- [^ab]: ^ represents NOT. This metacharacter matches any character that is neither a nor b.
- \: the escape sequence
- \n: n represents digit 1 to 9. This metacharacter specifies backward reference.
- \d: digit
- \D: non-digit
- [::]: POSIX character set
  - [[:alnum:]]: letter or digit in the range of [a-zA-Z0-9]
  - [[:alpha:]]: letter in the range of [a-zA-Z]
  - [[:ascii:]]: ASCII character in the range of [\x00-\x7F]
  - [[:blank:]]: space and tab in the range of [\t]

- [[:cntrl:]]: control character in the range of [\x00-\x1F\x7F]
- [[:digit:]]: digit in the range of [0-9]
- [[:graph:]]: any character except space in the range of [\x21-\x7E]
- [[:space:]]: space in the range of [\t\r\n\v\f]
- [[:print:]]: [:graph:] and [:space:] in the range of [\x20-\x7E]
- [[:lower:]]: lowercase letter in the range of [a-z]
- [[:punct:]]: punctuation in the range of [][!"#$%&()*+,./:;<=>? @\^_`{|}~-]
- [[:upper:]]: uppercase letter in the range of [A-Z]
- [[:xdigit:]]: hexadecimal character in the range of [A-Fa-f0-9]

The system uses a backslash (\) as the escape character, so a backslash (\) in a regular expression indicates second escape. For example, the string to be matched by the regular expression is "a+b". The plus sign (+) is a special character in regex, and must be escaped to obtain the string "a+b". However, the system needs to escape the first backslash (escape character) before it can be read by regex. Hence, the expression to match "a+b" is "a\\+b".

The following example assumes that there is a table named test_dual:

```
select 'a+b' rlike 'a\\+b' from test_dual;
+------+
_c1 |
+------+
true |
+------+
```

In extreme cases, to match the character "\", which is a special character in the regular engine, the expression must be "\\". The system must perform an escape on the expression, so it is expressed as "\\\".

```
select 'a\\b', 'a\\b' rlike 'a\\\\b' from test_dual;
+-----+------+
_c0 | _c1 |
+-----+------+
a\b | true |
+-----+------+
```

Note

- If a MaxCompute SQL statement contains "a\b", 'a\b' is displayed in the output because MaxCompute escapes the expression.
- If a string contains a tab or tab character, the system reads '\t' and stores it as one character. Therefore, it is a common character in the regular expression mode.

```
select 'a\tb', 'a\tb' rlike 'a\tb' from test_dual;
+---------+------+
_c0 | _c1 |
+---------+------+
a b | true |
+---------+------+
```

1.6.15.4. Reserved words

The following are all reserved words in MaxCompute SQL. Do not use these words to name tables, columns, or partitions. Otherwise, an error is returned. Reserved words are case-insensitive.

```
% & && ( ) * +. / ; < <= <> = > >= ? ADD AFTER ALL ALTER ANALYZE AND ARCHIVE ARRAY AS ASC BEFORE BETWEE
N BIGINT BINARY BLOB BOOLEAN BOTH BUCKET BUCKETS BY CASCADE CASE CAST CFILE CHANGE CLUSTER CL
USTERED CLUSTERSTATUS COLLECTION COLUMN COLUMNS COMMENT COMPUTE CONCATENATE CONTINUE
CREATE CROSS CURRENT CURSOR DATA DATABASE DATABASES DATE DATETIME DBPROPERTIES DEFERRED D
ELETE DELIMITED DESC DESCRIBE DIRECTORY DISABLE DISTINCT DISTRIBUTE DOUBLE DROP ELSE ENABLE EN
D ESCAPED EXCLUSIVE EXISTS EXPLAIN EXPORT EXTENDED EXTERNAL FALSE FETCH FIELDS FILEFORMAT FIRS
T FLOAT FOLLOWING FORMAT FORMATTED FROM FULL FUNCTION FUNCTIONS GRANT GROUP HAVING HOLD
_DDLTIME IDXPROPERTIES IF IMPORT IN INDEX INDEXES INPATH INPUTDRIVER INPUTFORMAT INSERT INT INTE
RSECT INTO IS ITEMS JOIN KEYS LATERAL LEFT LIFECYCLE LIKE LIMIT LINES LOAD LOCAL LOCATION LOCK LO
CKS LONG MAP MAPJOIN MATERIALIZED MINUS MSCK NOT NO_DROP NULL OF OFFLINE ON OPTION OR ORDE
R OUT OUTER OUTPUTDRIVER OUTPUTFORMAT OVER OVERWRITE PARTITION PARTITIONED PARTITIONPROP
ERTIES PARTITIONS PERCENT PLUS PRECEDING PRESERVE PROCEDURE PURGE RANGE RCFILE READ READONL
Y READS REBUILD RECORDREADER RECORDWRITER REDUCE REGEXP RENAME REPAIR REPLACE RESTRICT REVO
KE RIGHT RLIKE ROW ROWS SCHEMA SCHEMAS SELECT SEMI SEQUENCEFILE SERDE SERDEPROPERTIES SET S
HARED SHOW SHOW_DATABASE SMALLINT SORT SORTED SSL STATISTICS STORED STREAMTABLE STRING S
TRUCT TABLE TABLES TABLESAMPLE TBLPROPERTIES TEMPORARY TERMINATED TEXTFILE THEN TIMESTAMP
TINYINT TO TOUCH TRANSFORM TRIGGER TRUE UNARCHIVE UNBOUNDED UNDO UNION UNIONTYPE UNIQUEJ
OIN UNLOCK UNSIGNED UPDATE USE USING UTC UTC_TMESTAMP VIEW WHEN WHERE WHILE
```

1.7. MaxCompute Tunnel

1.7.1. Overview

MaxCompute provides two data upload and download channels:

- **DataHub**: provides real-time data upload and download services. It includes the OGG, Flume, Logstash, and Fluentd plug-ins.
- **Tunnel**: provides batch data upload and download services. It includes the MaxCompute client, DataWorks, DTS, Sqoop, Kettle plug-in, and MMA migration tool.

DataHub and Tunnel provide their own SDKs. The data upload and download tools derived from these SDKs can meet the requirements of most common cloud migration scenarios and allow you to upload or download data in a variety of scenarios.

Limits

- Limits on data upload by using Tunnel:
  - You cannot run Tunnel commands to upload or download data of the ARRAY, MAP, and STRUCT types.
  - There is no limit on the upload speed. The upload speed depends on the network bandwidth and server performance.
  - There is a limit on the number of retries. When the number of retries exceeds the limit, the next block is uploaded. After data upload is completed, you can execute the select count(*) from table_name statement to check whether any data is lost.
  - A project supports a maximum of 2,000 concurrent Tunnel connections by default.
  - On the server, the lifecycle for each session spans 24 hours after it is created. A session can be shared among processes and threads on the server, but you must make sure that each block ID is unique.
  - MaxCompute guarantees the validity of concurrent writes based on atomicity, consistency, isolation, durability (ACID).
- Limits on data upload by using DataHub:
  - The size of each field cannot exceed its upper limit.

    > **Note** The size of a STRING-type field cannot exceed 8 MB.

  - During the upload, multiple data entries are packaged.
- Limits on TableTunnel SDK interfaces:
  - The value of a block ID must be greater than or equal to 0 and less than 20000. The size of data to be uploaded in a block cannot exceed 100 GB.
  - The lifecycle of a session is 24 hours. If you want to transfer large volumes of data, we recommend that you transfer your data in multiple sessions.
  - The lifecycle of an HTTP request corresponding to a RecordWriter is 120 seconds. If no data flows over an HTTP connection within 120 seconds, the server closes the connection.

1.7.2. Tunnel service connections

DataHub and Tunnel use different endpoints in different network environments. You must also select different endpoints when connecting to the service.

1.7.3. Selection of cloud data migration tools

MaxCompute provides a variety of data upload and download tools, which can be used in different cloud data migration scenarios. This topic describes the selection of data transmission tools in three typical scenarios.

Hadoop data migration

You can use Sqoop and DataWorks to migrate Hadoop data.

- When you use DataWorks, DataX is required.
- When you use Sqoop, a MapReduce job is executed on the original Hadoop cluster for distributed data transmission to MaxCompute.

Synchronization of data in a database

To synchronize data from a database to MaxCompute, you must select a tool based on the database type and synchronization policy.

- Use DataWorks for offline batch synchronization. DataWorks supports a wide range of database types, including MySQL, SQL Server, and PostgreSQL.
- Use the OGG plug-in for real-time synchronization of data in an Oracle database.
- Use DTS for real-time synchronization of data in an ApsaraDB for RDS database.

Log collection

You can use tools such as Flume, Fluentd, and Logstash to collect logs.

1.7.4. Introduction to the tools

MaxCompute supports a wide range of data upload and download tools. The source code for most of the tools can be found and maintained on the open-source community GitHub. You can select the appropriate tools to upload and download data based on the application scenario.

Alibaba Cloud DTplus products

- Data Integration of DataWorks (Tunnel)

  Data Integration of DataWorks is a stable, efficient, and scalable data synchronization platform provided by Alibaba Cloud. It is designed to provide full offline and incremental real-time data synchronization, integration, and exchange services for the heterogeneous data storage systems on Alibaba Cloud.

  Data synchronization tasks support the following data source types: MaxCompute, ApsaraDB for RDS (MySQL, SQL Server, and PostgreSQL), Oracle, FTP, AnalyticDB (ADS), OSS, ApsaraDB for Memcache, and DRDS.

- MaxCompute client (Tunnel)

  Based on the batch data tunnel SDK, the client provides built-in Tunnel commands for data upload and download.

- DTS (Tunnel)

  Data Transmission (DTS) is an Alibaba Cloud data service that supports data exchange between multiple data sources, such as Relational Database Management System (RDBMS), NoSQL, and Online Analytical Processing (OLAP) databases. It provides data transmission features, such as data migration, real-time data subscription, and real-time data synchronization.

DTS supports data synchronization from ApsaraDB for RDS and MySQL instances to MaxCompute tables. Other data source types are not supported.

Open-source products

The projects corresponding to each product are open-sourced. You can visit aliyun-maxcompute-data-collectors to view details.

- Sqoop (Tunnel)

  Sqoop 1.4.6 on the community is further developed to provide enhanced MaxCompute support. It can import data from relational databases such as MySQL and data from HDFS or Hive to MaxCompute tables. It can also export data from MaxCompute tables to relational databases such as MySQL.

- Kettle (Tunnel)

  Kettle is an open-source ETL tool that is developed in Java. It can run on Windows, Unix, or Linux. It provides graphic interfaces for you to define data transmission topology by using drag-and-drop components.

- Flume (DataHub)
  - Apache Flume is a distributed and reliable system. It collects large volumes of log data from different data sources and then aggregates and stores the data in a centralized data storage.
  - The DataHub Sink plug-in of Apache Flume allows you to upload log data to DataHub in real time and archive the data in MaxCompute tables.

- Fluentd (DataHub)
  - Fluentd is an open-source software product. It collects logs, such as application logs, system logs, and access logs, from various sources. It allows you to use plug-ins to filter log data and store the data in different data processors, including MySQL, Oracle, MongoDB, Hadoop, and Treasure Data.
  - The DataHub plug-in of Fluentd allows you to upload log data to DataHub in real time and archive the data in MaxCompute tables.

- Logstash (DataHub)
  - Logstash is an open-source log collection and processing framework. The logstash-output-datahub plug-in allows you to import data to DataHub. This tool can be easily configured to collect and transmit data. It can be used together with MaxCompute or StreamCompute to easily create an all-in-one streaming data solution from data collection to analysis.
  - The DataHub plug-in of Logstash allows you to upload log data to DataHub in real time and archive the data in MaxCompute tables.

- OGG (DataHub)

  The DataHub plug-in of OGG allows you to incrementally synchronize data in the Oracle database to DataHub in real time and archive the data in MaxCompute tables.

1.7.5. Tunnel SDK overview

1.7.5.1. Overview

Data upload and download tools provided by MaxCompute are compiled based on the Tunnel SDK. This topic describes the major APIs of the Tunnel SDK.

The usage of the SDK varies according to the version. For specific information, see SDK Java Doc.

Major APIs

API	Description
TableTunnel	An entry class of the MaxCompute Tunnel service.
TableTunnel.UploadSession	A session that uploads data to a MaxCompute table.
TableTunnel.DownloadSession	A session that downloads data from a MaxCompute table.
InstanceTunnel	An entry class of the MaxCompute Tunnel service.
InstanceTunnel.DownloadSession	A session that downloads data from a MaxCompute instance. This session applies only to SQL instances that start with the SELECT keyword and are used to query data.

Note The tunnel endpoint supports automatic routing based on the MaxCompute endpoint settings.

1.7.5.2. TableTunnel

This topic describes the TableTunnel API.

Definition

Definition:

```
public class TableTunnel {
public DownloadSession createDownloadSession(String projectName, String tableName);
public DownloadSession createDownloadSession(String projectName, String tableName, PartitionSpec partitionSpe c);
public UploadSession createUploadSession(String projectName, String tableName);
public UploadSession createUploadSession(String projectName, String tableName, PartitionSpec partitionSpec);
public DownloadSession getDownloadSession(String projectName, String tableName, PartitionSpec partitionSpec, String id);
public DownloadSession getDownloadSession(String projectName, String tableName, String id);
public UploadSession getUploadSession(String projectName, String tableName, PartitionSpec partitionSpec, String id);
public UploadSession getUploadSession(String projectName, String tableName, String id); public void setEndpoint(String endpoint);
}
```

Description:

- **Lifecycle**: the duration from the creation of the TableTunnel instance to the end of the program.
- TableTunnel provides a method to create UploadSession and DownloadSession objects. TableTunnel.UploadSession is used to upload data, and TableTunnel.DownloadSession is used to download data.
- A session refers to the process of uploading or downloading a table or partition. A session consists of one or more HTTP requests to Tunnel RESTful APIs.
- Upload sessions of TableTunnel use the INSERT INTO semantics. Multiple upload sessions of the same table or partition does not affect each other, and the data uploaded in each session is stored in an independent directory.
- In an upload session, each RecordWriter is matched with an HTTP request and is identified by a unique block ID. The block ID is the name of the file corresponding to the RecordWriter.
- If you use the same block ID to enable a RecordWriter multiple times in the same session, the data uploaded by the RecordWriter that calls the close() function last will overwrite all previous data. This feature can be used to retransmit data of a block when data upload fails.

API implementation process

1. The RecordWriter.write() function uploads your data as files to a temporary directory.
2. The RecordWriter.close() function moves the files from the temporary directory to the Data directory.
3. The session.commit() function moves each file in the Data directory to the directory where the corresponding table is located and updates the table metadata. This way, data moved into a table by the current task will be visible to the other MaxCompute tasks such as SQL and MapReduce.

API limits

- The value of a block ID must be greater than or equal to 0 and less than 20000. The size of data to be uploaded in a block cannot exceed 100 GB.
- A session is uniquely identified by its session ID. The lifecycle of a session is 24 hours. If your session times out due to the transfer of large volumes of data, you must transfer your data in multiple sessions.
- The lifecycle of an HTTP request corresponding to a RecordWriter is 120 seconds. If no data flows over an HTTP connection within 120 seconds, the server closes the connection.

  > **Note** HTTP has an 8 KB buffer. When you call the RecordWriter.write() function, your data may be saved to the buffer and no inbound traffic flows over the corresponding HTTP connection. In this case, you can call the TunnelRecordWriter.flush() function to forcibly flush data from the buffer.

- When you use a RecordWriter to write logs to MaxCompute, the RecordWriter may time out due to unexpected traffic fluctuations. Therefore, we recommend that you:
  - Do not use a RecordWriter for each data record. Otherwise, a large number of small files are generated, because each RecordWriter corresponds to a file. This affects the performance of MaxCompute.
- Do not use a RecordWriter to write data until the size of cached code reaches 64 MB.
- The lifecycle of a RecordReader is 300 seconds.

1.7.5.3. InstanceTunnel

This topic describes the InstanceTunnel API.

Definition:

```
public class InstanceTunnel{
 public DownloadSession createDownloadSession(String projectName, String instanceID);
 public DownloadSession createDownloadSession(String projectName, String instanceID, boolean limitEnab
led);
 public DownloadSession getDownloadSession(String projectName, String id);
 }
```

Parameter description:

- **projectName**: the name of a project.
- **instanceID**: the ID of an instance.

Limits: Although InstanceTunnel provides an easy way to obtain instance execution results, it is subject to the following permission limits to ensure data security:

- If the number of records does not exceed 10,000, all users who have the read permission on the specified instance can use InstanceTunnel to download the data. This is also applicable to the scenario of calling a Restful API to query data.
- If the number of records exceeds 10,000, only users who have the permission to read all the source tables from which the specified instance queries data can use InstanceTunnel to download the data.

1.7.5.4. UploadSession

This topic describes the UploadSession API.

API definition:

```
public class UploadSession {
UploadSession(Configuration conf, String projectName, String tableName, String partitionSpec) throws Tu
nnelException;
UploadSession(Configuration conf, String projectName, String tableName, String partitionSpec, String uplo
adId) throws TunnelException;
public void commit(Long[] blocks); public Long[] getBlockList();
public String getId();
public TableSchema getSchema();
public UploadSession.Status getStatus(); public Record newRecord();
public RecordWriter openRecordWriter(long blockId);
public RecordWriter openRecordWriter(long blockId, boolean compress);
}
```

UploadSession API description.

UploadSession API

Item	Description
Lifecycle	From the upload instance creation to the end of the uploading.
Purpose	Creates an upload instance by calling a constructor method or by using the TableTunnel class. • Request mode: synchronous. • The server creates an upload session and generates a unique upload ID. You can get the upload ID by running getId on the console.
Upload data	• Request mode: asynchronous. • Call openRecordWriter to generate a RecordWriter instance. The blockId parameter identifies the data to upload this time and the position of the data in the table. The value range is [0, 20000]. In case the uploading fails, the data is re-uploaded based on the block ID.
Check uploading	• Request mode: synchronous. • Call getStatus to get the uploading status. • Call getBlockList to get a list of the block IDs of successful uploading instances, check the block ID list, and re-upload data for failed uploading instances.
Stop uploading	• Request mode: synchronous. • Call commit(Long[] blocks). The blocks parameter indicates the list of block IDs of successful uploading instances. The server will verify the block ID list. • The verification improves data correctness. If the provided block list is different from the block list on the server, an error is reported.
Status	• UNKNOWN: Initial value set while server just creates a session. • NORMAL: An UPLOAD object is created successfully. • CLOSING: The server sets the upload session to CLOSING status before calling the COMPLETE method (to complete uploading). • CLOSED: The uploading is completed (data has been moved to the directory where the result table is). • EXPIRED: The upload session is timed out. • CRITICAL: An error occurs.

Notice

- blockId in the same UploadSession API must be unique. That is, after a block ID is used to start RecordWriter in an upload session, data is written, and the session is closed and committed, this block ID cannot be used to start another RecordWriter.
- The maximum size of a block is 100 GB. We strongly recommend that 64 MB or more data is written into each block. Otherwise, the computing performance will seriously degrade.
- Each session has a 24-hour life cycle on the server.
- You are advised to have data prepared before calling openRecordWriter. A network action is triggered every time the Writer writes 8 KB data. If no network action is triggered in the last 120 seconds, the server closes the connection and the Writer becomes unavailable. You have to start a new Writer.

1.7.5.5. DownloadSession

This topic describes the DownloadSession class.

API definition:

```
public class DownloadSession {
DownloadSession(Configuration conf, String projectName, String tableName, String partitionSpec) throws
TunnelException
DownloadSession(Configuration conf, String projectName, String tableName, String partitionSpec, String d
ownloadId) throws TunnelException
public String getId()
public long getRecordCount() public TableSchema getSchema()
public DownloadSession.Status getStatus()
public RecordReader openRecordReader(long start, long count)
public RecordReader openRecordReader(long start, long count, boolean compress)
}
```

DownloadSession API description.

DownloadSession API

Parameter	Description
Lifecycle	From the creation of the Download instance to the end of the download process.

Parameter	Description
Purpose	Creates a Download instance by calling a constructor method or using TableTunnel. • Request mode: Synchronous. • The server creates a session for this Download and generates a unique download ID to mark the Download. The console can get data with a get ID. The operation has a high overhead. The server creates indexes for the data files. If many data files exist, the operation takes a long time. Then the server returns the total number of records, and starts concurrent downloads according to the number of records.
Download data	• Request mode: Asynchronous. • Call openRecordReader to generate a RecordReader instance. The Start parameter marks the start position of record for this download. The value of Start is equivalent to or greater than 0. The Count parameter marks the number of records for this download. The value of Count is greater than 0.
View the download process	• Request mode: Synchronous. • Call getStatus to get the download status.
Status	• UNKNOWN: the initial value that is set when the server creates a session. • NORMAL: The download object is successfully created. • CLOSED: The download session is completed. • EXPIRED: The download session times out.

1.7.5.6. TunnelBufferedWriter

This topic describes the TunnelBufferedWriter interface.

The upload process is complex due to limits on block management and connection timeout on the server. The Tunnel SDK provides an enhanced RecordWriter, TunnelBufferWriter, to simplify the upload process.

The TunnelBufferedWriter interface is defined as follows:

```
public class TunnelBufferedWriter implements RecordWriter {
  public TunnelBufferedWriter(TableTunnel.UploadSession session, CompressOption option) throws IOExc
eption;
  public long getTotalBytes();
  public void setBufferSize(long bufferSize);
  public void setRetryStrategy(RetryStrategy strategy);
  public void write(Record r) throws IOException;
  public void close() throws IOException;
}
```

A TunnelBufferedWriter object is described as follows:

- **Lifecycle**: the duration from the time RecordWriter is created to the time the data upload ends.
- **TunnelBufferedWriter instance**: You can call the openBufferedWriter interface of UploadSession to create a TunnelBufferedWriter instance
- **Data upload**: When you call the Write interface, data is first written to the local cache. After the cache is full, the data is submitted to the server in batches to avoid connection timeout. In addition, if the upload fails, the system automatically retries the upload operation.
- **End upload**: Call the Close interface and then call the Commit interface of UploadSession to end the upload process.
- **Buffer control**: You can use the setBufferSize interface to modify the memory occupied by the buffer (in bytes), preferably 64 MB or more to prevent the server from generating too many small files, which may affect performance. The valid range is 1 MB to 1000 MB. The default value is 64 MB, which is recommended in most cases.
- **Retry policy settings**: You have three retry avoidance policies to choose from: EXPONENTIAL_BACKOFF, LINEAR_BACKOFF, and CONSTANT_BACKOFF. For example, the following code segment sets the Write retry count to 6. To avoid unnecessary retries, each retry is performed only after exponentially ascending intervals of 4s, 8s, 16s, 32s, 64s, and 128s by default.

```
RetryStrategy retry
 = new RetryStrategy(6, 4, RetryStrategy.BackoffStrategy.EXPONENTIAL_BACKOFF)
writer = (TunnelBufferedWriter) uploadSession.openBufferedWriter();
writer.setRetryStrategy(retry);
```

> **Note** We recommend that you do not adjust the preceding settings.

1.7.6. Tunnel SDK example

1.7.6.1. Simple upload example

This topic provides a simple upload example of Tunnel SDK.

Example:

```
import java.io.IOException;
import java.util.Date;
import com.aliyun.odps.Column;
import com.aliyun.odps.Odps;
import com.aliyun.odps.PartitionSpec;
import com.aliyun.odps.TableSchema;
import com.aliyun.odps.account.Account;
import com.aliyun.odps.account.AliyunAccount;
import com.aliyun.odps.data.Record;
import com.aliyun.odps.data.RecordWriter;
import com.aliyun.odps.tunnel.TableTunnel;
import com.aliyun.odps.tunnel.TunnelException;
```

```
import com.aliyun.odps.tunnel.TableTunnel.UploadSession;
public class UploadSample {
 private static String accessId = "<your access id>";
 private static String accessKey = "<your access Key>";
 private static String tunnelUrl = "<your tunnel endpoint>";
 private static String odpsUrl = "<your odps endpoint>";
 private static String project = "<your project>";
 private static String table = "<your table name>";
 private static String partition = "<your partition spec>";
 public static void main(String args[]) {
  Account account = new AliyunAccount(accessId, accessKey);
  Odps odps = new Odps(account);
  odps.setEndpoint(odpsUrl);
  odps.setDefaultProject(project);
  try {
   TableTunnel tunnel = new TableTunnel(odps);
   tunnel.setEndpoint(tunnelUrl);
   PartitionSpec partitionSpec = new PartitionSpec(partition);
   UploadSession uploadSession = tunnel.createUploadSession(project,
     table, partitionSpec);
   System.out.println("Session Status is : "
     + uploadSession.getStatus().toString());
   TableSchema schema = uploadSession.getSchema();
   // After data is prepared, run the Writer command to start writing data. The prepared data is written to a
block.
   // Writing a small volume of data to each block can result in a large number of small files.This greatly reduc
es computing performance. We strongly recommend that you write at least 64 MB (and up to 100 GB) of data
to each block.
   // You can estimate the total data volume based on the average data volume and record count. For examp
le, 64 MB < Average data volume x Record count < 100 GB.
   RecordWriter recordWriter = uploadSession.openRecordWriter(0);
   Record record = uploadSession.newRecord();
   for (int i = 0; i < schema.getColumns().size(); i++) {
    Column column = schema.getColumn(i);
    switch (column.getType()) {
     case BIGINT:
      record.setBigint(i, 1L);
      break;
     case BOOLEAN:
      record.setBoolean(i, true);
      break;
```

```
        break;
       case DATETIME:
        record.setDatetime(i, new Date());
        break;
       case DOUBLE:
        record.setDouble(i, 0.0);
        break;
       case STRING:
        record.setString(i, "sample");
        break;
       default:
        throw new RuntimeException("Unknown column type: "
          + column.getType());
      }
    }
    for (int i = 0; i < 10; i++) {
     // Write data to the server. A network transmission process is triggered each time 8 KB of data is written.
     // If no data is transmitted for 120 seconds, the connection times out. The Writer command becomes una
vailable, and you must write data again.
      recordWriter.write(record);
    }
    recordWriter.close();
    uploadSession.commit(new Long[]{0L});
    System.out.println("upload success!");
   } catch (TunnelException e) {
    e.printStackTrace();
   } catch (IOException e) {
    e.printStackTrace();
   }
 }
}
```

1.7.6.2. Simple download example

This topic provides an example for the simple download function of Tunnel SDK.

Example:

```
import java.io.IOException; import java.util.Date;
import com.aliyun.odps.Column; import com.aliyun.odps.Odps;
import com.aliyun.odps.PartitionSpec; import com.aliyun.odps.TableSchema; import com.aliyun.odps.acco
unt.Account;
```

```
import com.aliyun.odps.account.AliyunAccount; import com.aliyun.odps.data.Record;
import com.aliyun.odps.data.RecordReader; import com.aliyun.odps.tunnel.TableTunnel;
import com.aliyun.odps.tunnel.TableTunnel.DownloadSession; import com.aliyun.odps.tunnel.TunnelExce
ption;
public class DownloadSample {
private static String accessId = "<your access id>"; private static String accessKey = "<your access Key>";
private static String tunnelUrl = "<your tunnel endpoint>";
private static String odpsUrl = "<your odps endpoint>";
private static String project = "<your project>"; private static String table = "<your table name>";
private static String partition = "<your partition spec>";
public static void main(String args[]) {
Account account = new AliyunAccount(accessId, accessKey); Odps odps = new Odps(account); odps.setEndp
oint(odpsUrl);
odps.setDefaultProject(project);
TableTunnel tunnel = new TableTunnel(odps); tunnel.setEndpoint(tunnelUrl);
PartitionSpec partitionSpec = new PartitionSpec(partition); try {
DownloadSession downloadSession = tunnel.createDownloadSession(project, table, partitionSpec);
System.out.println("Session Status is : "
+ downloadSession.getStatus().toString());
long count = downloadSession.getRecordCount(); System.out.println("RecordCount is: " + count);
RecordReader recordReader = downloadSession.openRecordReader(0, count);
Record record;
while ((record = recordReader.read()) ! = null) { consumeRecord(record, downloadSession.getSchema());
}
recordReader.close();
} catch (TunnelException e) { e.printStackTrace();
} catch (IOException e1) { e1.printStackTrace();
}
}
private static void consumeRecord(Record record, TableSchema schema) { for (int i = 0; i < schema.getColum
ns().size(); i++) {
Column column = schema.getColumn(i); String colValue = null;
switch (column.getType()) { case BIGINT: {
Long v = record.getBigint(i);
colValue = v == null ? null : v.toString(); break;
}
case BOOLEAN: {
Boolean v = record.getBoolean(i); colValue = v == null ? null : v.toString(); break;
}
case DATETIME: {
Date v = record.getDatetime(i); colValue = v == null ? null : v.toString(); break;
```

```
}
case DOUBLE: {
Double v = record.getDouble(i); colValue = v == null ? null : v.toString(); break;
}
case STRING: {
String v = record.getString(i);
colValue = v == null ? null : v.toString(); break;
}
default:
throw new RuntimeException("Unknown column type: "
+ column.getType());
}
System.out.print(colValue == null ? "null" : colValue); if (i ! = schema.getColumns().size())
System.out.print("\t");
}
System.out.println();
}
}
```

1.7.6.3. Multithread upload example

This topic provides a multithread upload example of Tunnel SDK.

Example:

```
import java.io.IOException;
import java.util.ArrayList;
import java.util.Date;
import java.util.concurrent.Callable;
import java.util.concurrent.ExecutorService;
import java.util.concurrent.Executors;
import com.aliyun.odps.Column;
import com.aliyun.odps.Odps;
import com.aliyun.odps.PartitionSpec;
import com.aliyun.odps.TableSchema;
import com.aliyun.odps.account.Account;
import com.aliyun.odps.account.AliyunAccount;
import com.aliyun.odps.data.Record;
import com.aliyun.odps.data.RecordWriter;
import com.aliyun.odps.tunnel.TableTunnel;
import com.aliyun.odps.tunnel.TunnelException;
import com.aliyun.odps.tunnel.TableTunnel.UploadSession;
```

```
class UploadThread implements Callable<Boolean> {
 private long id;
 private RecordWriter recordWriter;
 private Record record;
 private TableSchema tableSchema;
 public UploadThread(long id, RecordWriter recordWriter, Record record, TableSchema tableSchema) {
  this.id = id;
  this.recordWriter = recordWriter;
  this.record = record;
  this.tableSchema = tableSchema;
 }
 @Override
 public Boolean call() {
  for (int i = 0; i < tableSchema.getColumns().size(); i++) {
   Column column = tableSchema.getColumn(i);
   switch (column.getType()) {
    case BIGINT:
     record.setBigint(i, 1L);
     break;
    case BOOLEAN:
     record.setBoolean(i, true);
     break;
    case DATETIME:
     record.setDatetime(i, new Date());
     break;
    case DOUBLE:
     record.setDouble(i, 0.0);
     break;
    case STRING:
     record.setString(i, "sample");
     break;
    default:
     throw new RuntimeException("Unknown column type: "
       + column.getType());
   }
  }
  try {
   for (int i = 0; i < 10; i++) {
   // Write data to the server. A network transmission process is triggered each time 8 KB of data is written.
    // If no data is transmitted for 120 seconds, the connection times out. The Writer command becomes una
```

```
vailable and you must write data again.
      recordWriter.write(record);
    }
    recordWriter.close();
   } catch (IOException e) {
    e.printStackTrace();
    return false;
   }
   return true;
 }
}
public class UploadThreadSample {
 private static String accessId = "<your access id>";
 private static String accessKey = "<your access Key>";
 private static String tunnelUrl = "<your tunnel endpoint>";
 private static String odpsUrl = "<your odps endpoint>";
 private static String project = "<your project>";
 private static String table = "<your table name>";
 private static String partition = "<your partition spec>";
 private static int threadNum = 10;:
 public static void main(String args[]) {
  Account account = new AliyunAccount(accessId, accessKey);
  Odps odps = new Odps(account);
  odps.setEndpoint(odpsUrl);
  odps.setDefaultProject(project);
  try {
   TableTunnel tunnel = new TableTunnel(odps);
   tunnel.setEndpoint(tunnelUrl);
   PartitionSpec partitionSpec = new PartitionSpec(partition);
   UploadSession uploadSession = tunnel.createUploadSession(project,
     table, partitionSpec);
   System.out.println("Session Status is : "
     + uploadSession.getStatus().toString());
   ExecutorService pool = Executors.newFixedThreadPool(threadNum);
   ArrayList<Callable<Boolean>> callers = new ArrayList<Callable<Boolean>>();
   // After the data is prepared, open a writer to start multithread data writing.
   // Writing a small volume of data to each block can result in a large number of small files. This greatly affec
ts computing performance. We recommend that you write at least 64 MB (and up to 100 GB) of data to each b
lock.
   // You can estimate the total data volume based on the average data volume and record count. For examp
le, 64 MB < Average data volume x Record count < 100 GB.
```

```
    for (int i = 0; i < threadNum; i++) {
     RecordWriter recordWriter = uploadSession.openRecordWriter(i);
     Record record = uploadSession.newRecord();
     callers.add(new UploadThread(i, recordWriter, record, uploadSession.getSchema()));
    }
    pool.invokeAll(callers);
    pool.shutdown();
    Long[] blockList = new Long[threadNum];
    for (int i = 0; i < threadNum; i++)
     blockList[i] = Long.valueOf(i);
    uploadSession.commit(blockList);
    System.out.println("upload success!");
   } catch (TunnelException e) {
    e.printStackTrace();
   } catch (IOException e) {
    e.printStackTrace();
   } catch (InterruptedException e) {
    e.printStackTrace();
   }
  }
}
```

1.7.6.4. Multithread download example

This topic provides a multithread download example of Tunnel SDK.

Example:

```
import java.io.IOException;
import java.util.ArrayList; import java.util.Date; import java.util.List;
import java.util.concurrent.Callable;
import java.util.concurrent.ExecutionException; import java.util.concurrent.ExecutorService; import java.ut
il.concurrent.Executors;
import java.util.concurrent.Future;
import com.aliyun.odps.Column; import com.aliyun.odps.Odps;
import com.aliyun.odps.PartitionSpec; import com.aliyun.odps.TableSchema; import com.aliyun.odps.acco
unt.Account;
import com.aliyun.odps.account.AliyunAccount; import com.aliyun.odps.data.Record;
import com.aliyun.odps.data.RecordReader; import com.aliyun.odps.tunnel.TableTunnel;
import com.aliyun.odps.tunnel.TableTunnel.DownloadSession; import com.aliyun.odps.tunnel.TunnelExce
ption;
class DownloadThread implements Callable<Long> { private long id;
```

```
private RecordReader recordReader; private TableSchema tableSchema;
public DownloadThread(int id,
RecordReader recordReader, TableSchema tableSchema) { this.id = id;
this.recordReader = recordReader; this.tableSchema = tableSchema;
}
@Override
public Long call() {
Long recordNum = 0L; try {
Record record;
while ((record = recordReader.read()) ! = null) { recordNum++;
System.out.print("Thread " + id + "\t"); consumeRecord(record, tableSchema);
}
recordReader.close();
} catch (IOException e) { e.printStackTrace();
}
return recordNum;
}
private static void consumeRecord(Record record, TableSchema schema) { for (int i = 0; i < schema.getColum
ns().size(); i++) {
Column column = schema.getColumn(i); String colValue = null;
switch (column.getType()) { case BIGINT: {
Long v = record.getBigint(i);
colValue = v == null ? null : v.toString(); break;
}
case BOOLEAN: {
Boolean v = record.getBoolean(i); colValue = v == null ? null : v.toString(); break;
}
case DATETIME: {
Date v = record.getDatetime(i); colValue = v == null ? null : v.toString(); break;
}
case DOUBLE: {
Double v = record.getDouble(i); colValue = v == null ? null : v.toString(); break;
}
case STRING: {
String v = record.getString(i);
colValue = v == null ? null : v.toString(); break;
}
default:
throw new RuntimeException("Unknown column type: "
+ column.getType());
```

```
}
System.out.print(colValue == null ? "null" : colValue); if (i ! = schema.getColumns().size())
System.out.print("\t");
}
System.out.println();
}
}
public class DownloadThreadSample {
private static String accessId = "<your access id>"; private static String accessKey = "<your access Key>";
private static String tunnelUrl = "<your tunnel endpoint>";
private static String odpsUrl = "<your odps endpoint>";
private static String project = "<your project>"; private static String table = "<your table name>";
private static String partition = "<your partition spec>";
private static int threadNum = 10; public static void main(String args[]) {
Account account = new AliyunAccount(accessId, accessKey);
Odps odps = new Odps(account); odps.setEndpoint(odpsUrl); odps.setDefaultProject(project);
TableTunnel tunnel = new TableTunnel(odps); tunnel.setEndpoint(tunnelUrl);
PartitionSpec partitionSpec = new PartitionSpec(partition); DownloadSession downloadSession;
try {
downloadSession = tunnel.createDownloadSession(project, table, partitionSpec);
System.out.println("Session Status is : "
+ downloadSession.getStatus().toString());
long count = downloadSession.getRecordCount(); System.out.println("RecordCount is: " + count);
ExecutorService pool = Executors.newFixedThreadPool(threadNum); ArrayList<Callable<Long>> callers = ne
w ArrayList<Callable<Long>>();
long start = 0;
long step = count / threadNum;
for (int i = 0; i < threadNum - 1; i++) {
RecordReader recordReader = downloadSession.openRecordReader( step * i, step);
callers.add(new DownloadThread( i, recordReader, downloadSession.getSchema()));
}
RecordReader recordReader = downloadSession.openRecordReader(step * (threadNum - 1), count
+ ((threadNum - 1) * step));
callers.add(new DownloadThread( threadNum - 1, recordReader, downloadSession.getSchema()));
Long downloadNum = 0L;
List<Future<Long>> recordNum = pool.invokeAll(callers); for (Future<Long> num : recordNum)
downloadNum += num.get(); System.out.println("Record Count is: " + downloadNum); pool.shutdown();
} catch (TunnelException e) { e.printStackTrace();
} catch (IOException e) { e.printStackTrace();
} catch (InterruptedException e) { e.printStackTrace();
} catch (ExecutionException e) { e.printStackTrace();
```

```
}
}
}
```

1.7.6.5. Example of uploading data by using BufferedWriter

This topic provides an example on how to upload data by using BufferedWriter of the Tunnel SDK.

Example:

```
//Initialize the code of MaxCompute and Tunnel.
RecordWriter writer = null;
TableTunnel.UploadSession uploadSession = tunnel.createUploadSession(projectName, tableName);
try {
 int i = 0;
 //Generate a TunnelBufferedWriter instance.
 writer = uploadSession.openBufferedWriter();
 Record product = uploadSession.newRecord();
 for (String item : items) {
  product.setString("name", item);
  product.setBigint("id", i);
  //Call the Write interface to write data.
  writer.write(product);
  i += 1;
 }
} finally {
 if (writer ! = null) {
  //Disable TunnelBufferedWriter.
  writer.close();
 }
}
//Commit the upload session to end the upload.
uploadSession.commit();
```

1.7.6.6. Example of uploading data by using BufferedWriter in multi-threaded mode

This topic provides an example on how to upload data by using BufferedWriter of the Tunnel SDK in multi-threaded mode.

Example:

```
class UploadThread extends Thread {
 private UploadSession session;
 private static int RECORD_COUNT = 1200;
 public UploadThread(UploadSession session) {
  this.session = session;
 }
 @Override
 public void run() {
  RecordWriter writer = up.openBufferedWriter();
  Record r = up.newRecord();
  for (int i = 0; i < RECORD_COUNT; i++) {
   r.setBigint(0, i);
   writer.write(r);
  }
  writer.close();
 }
};
public class Example {
 public static void main(String args[]) {
  //Initialize the code of MaxCompute and Tunnel.
  TableTunnel.UploadSession uploadSession = tunnel.createUploadSession(projectName, tableName);
  UploadThread t1 = new UploadThread(up);
  UploadThread t2 = new UploadThread(up);
  t1.start();
  t2.start();
  t1.join();
  t2.join();
  uploadSession.commit();
}
```

1.7.6.7. Examples of uploading and downloading complex data

This topic provides examples of uploading and downloading complex data by using the Tunnel SDK.

Upload complex data

Example:

```
RecordWriter recordWriter = uploadSession.openRecordWriter(0);
ArrayRecord record = (ArrayRecord) uploadSession.newRecord();
//Prepare data.
List arrayData = Arrays.asList(1, 2, 3);
Map<String, Long> mapData = new HashMap<String, Long>();
mapData.put("a", 1L);
mapData.put("c", 2L);
List<Object> structData = new ArrayList<Object>();
structData.add("Lily");
structData.add(18);
//Import data to a record.
record.setArray(0, arrayData);
record.setMap(1, mapData);
record.setStruct(2, new SimpleStruct((StructTypeInfo) schema.getColumn(2).getTypeInfo(), structData));
//Write the record.
recordWriter.write(record);
```

Download complex data

Example:

```
RecordReader recordReader = downloadSession.openRecordReader(0, 1);
//Read a record.
ArrayRecord record1 = (ArrayRecord)recordReader.read();
//Obtain data of the ARRAY type.
List field0 = record1.getArray(0);
List<Long> longField0 = record1.getArray(Long.class, 0);
//Obtain data of the MAP type.
Map field1 = record1.getMap(1);
Map<String, Long> typedField1 = record1.getMap(String.class, Long.class, 1);
//Obtain data of the STRUCT type.
Struct field2 = record1.getStruct(2);
```

Example of upload and download

Example:

```
import java.io.IOException;
import java.util.ArrayList;
import java.util.Arrays;
import java.util.HashMap;
import java.util.List;
```

```
import java.util.Map;
import com.aliyun.odps.Odps;
import com.aliyun.odps.PartitionSpec;
import com.aliyun.odps.TableSchema;
import com.aliyun.odps.account.Account;
import com.aliyun.odps.account.AliyunAccount;
import com.aliyun.odps.data.ArrayRecord;
import com.aliyun.odps.data.RecordReader;
import com.aliyun.odps.data.RecordWriter;
import com.aliyun.odps.data.SimpleStruct;
import com.aliyun.odps.data.Struct;
import com.aliyun.odps.tunnel.TableTunnel;
import com.aliyun.odps.tunnel.TableTunnel.UploadSession;
import com.aliyun.odps.tunnel.TableTunnel.DownloadSession;
import com.aliyun.odps.tunnel.TunnelException;
import com.aliyun.odps.type.StructTypeInfo;
public class TunnelComplexTypeSample {
 private static String accessId = "<your access id>";
 private static String accessKey = "<your access Key>";
 private static String odpsUrl = "<your odps endpoint>";
 private static String project = "<your project>";
 private static String table = "<your table name>";
 //Partitions in a partitioned table, such as "pt=\'1\',ds=\'2\'".
 //If the table is not a partitioned table, you do not need to execute the following statement.
 private static String partition = "<your partition spec>";
 public static void main(String args[]) {
  Account account = new AliyunAccount(accessId, accessKey);
  Odps odps = new Odps(account);
  odps.setEndpoint(odpsUrl);
  odps.setDefaultProject(project);
  try {
   TableTunnel tunnel = new TableTunnel(odps);
   PartitionSpec partitionSpec = new PartitionSpec(partition);
   //---------- Upload data ----------
   //Create an upload session for the table.
   //The table schema is {"col0": ARRAY<BIGINT>, "col1": MAP<STRING, BIGINT>, "col2": STRUCT<name:STRIN
G,age:BIGINT>}.
   UploadSession uploadSession = tunnel.createUploadSession(project, table, partitionSpec);
   //Obtain the table schema.
   TableSchema schema = uploadSession.getSchema();
   //Enable the RecordWriter.
```

```
    RecordWriter recordWriter = uploadSession.openRecordWriter(0);
    ArrayRecord record = (ArrayRecord) uploadSession.newRecord();
    //Prepare data.
    List arrayData = Arrays.asList(1, 2, 3);
    Map<String, Long> mapData = new HashMap<String, Long>();
    mapData.put("a", 1L);
    mapData.put("c", 2L);
    List<Object> structData = new ArrayList<Object>();
    structData.add("Lily");
    structData.add(18);
    //Import data to a record.
    record.setArray(0, arrayData);
    record.setMap(1, mapData);
    record.setStruct(2, new SimpleStruct((StructTypeInfo) schema.getColumn(2).getTypeInfo(), structData))
;
    //Write the record.
    recordWriter.write(record);
    //Disable the writer.
    recordWriter.close();
    //Commit the upload session to end the upload.
    uploadSession.commit(new Long[]{0L});
    System.out.println("upload success!") ;
    //---------- Download data ----------
    //Create a download session for the table.
    //The table schema is {"col0": ARRAY<BIGINT>, "col1": MAP<STRING, BIGINT>, "col2": STRUCT<name:STRIN
G, age:BIGINT>}.
    DownloadSession downloadSession = tunnel.createDownloadSession(project, table, partitionSpec);
    schema = downloadSession.getSchema();
    //Enable the record reader. In the example, one record is read.
    RecordReader recordReader = downloadSession.openRecordReader(0, 1);
    //Read a record.
    ArrayRecord record1 = (ArrayRecord)recordReader.read();
    //Obtain data of the ARRAY type.
    List field0 = record1.getArray(0);
    List<Long> longField0 = record1.getArray(Long.class, 0);
    //Obtain data of the MAP type.
    Map field1 = record1.getMap(1);
    Map<String, Long> typedField1 = record1.getMap(String.class, Long.class, 1);
    //Obtain data of the STRUCT type.
    Struct field2 = record1.getStruct(2);
    System.out.println("download success!") ;
```

```
    System.out.println("download success.");
  } catch (TunnelException e) {
    e.printStackTrace();
  } catch (IOException e) {
    e.printStackTrace();
  }
 }
}
```

1.7.7. Appendix

1.7.7.1. Tunnel upload/download FAQ

This topic describes frequently asked questions (FAQs) about tunnel upload and download.

What is MaxCompute Tunnel?

Tunnel is data channel of MaxCompute, you are available to upload or download data through Tunnel to or from MaxCompute. You can upload and download only table data (excluding view data) with MaxCompute Tunnel.

Can block IDs be repeated?

Each block ID in an Upload session must be unique. After a block ID is used to start RecordWriter in an upload session, data is written, and the session is closed and committed, this block ID cannot be used to start another RecordWriter. A maximum of 20,000 blocks are supported, with the block IDs ranging from 0 to 19999.

Is there a limit on block size?

The maximum size of a block is 100 GB. We strongly recommend that 64 MB or more data is written into each block. Each block is a file. A file smaller than 64 MB is a small file. Excessive small files will affect the computing performance.

Can a session be shared? Does a session have a life cycle?

Each session has a 24-hour life cycle on the server. It can be used within 24 hours after being created, and can be shared among processes or threads. The block ID of each session must be unique. The procedure for distributed uploading is as follows: **Create a session > Evaluate data volume > Assign blocks (for example, thread 1 uses blocks 0-100 and thread 2 uses blocks 100-200) > Prepare data > Upload data > Commit all blocks with data written.**

How to process write/read timeout or I/O exceptions?

During data uploading, a network action is triggered every time the Writer writes 8 KB data. If no network action is triggered within 120 seconds, the server closes the connection and the Writer becomes unavailable. You have to start a new Writer.

The Reader in data downloading works in a similar way. If no network I/O occurs for a period of time, the connection is closed. We suggest that you run Read without inserting any interfaces from other systems.

Which languages of SDK are available for MaxCompute Tunnel?

MaxCompute Tunnel provides the Java and C++ editions of SDK.

Does MaxCompute Tunnel allow multiple consoles to upload the same table at the same time?

Yes.

Is MaxCompute Tunnel suitable for batch uploading or stream uploading?

MaxCompute Tunnel is more suitable for batch uploading.

Are partitions required for data uploading through MaxCompute Tunnel?

Yes, MaxCompute Tunnel does not automatically build partitions.

What is the relationship between Dship and MaxCompute Tunnel?

Dship is a tool that uploads and downloads data through MaxCompute Tunnel.

Does data uploaded with MaxCompute Tunnel append to the existing file or overwrite the data?

The uploaded data appends to the file.

What is the routing function of MaxCompute Tunnel?

The routing function allows the Tunnel SDK to get the tunnel endpoint by setting MaxCompute. That is, you can run the Tunnel SDK properly by setting the endpoint of MaxCompute.

What is the preferred size of a block when data is uploaded with MaxCompute Tunnel?

The block size depends on factors such as the network situation, real-time performance requirement, data usage, and number of small files in a cluster. If a large volume of data is uploaded continuously, the preferred block size is 64–256 MB. If the data is uploaded in a batch once every day, the block size can be 1 GB.

Why is the timeout error often reported during data downloading with MaxCompute Tunnel?

This may have occurred due to an endpoint error. Check the endpoint configuration. A simple method is to run telnet to check the network connectivity to the endpoint.

Why does the following error occur during data downloading with MaxCompute Tunnel?

```
You have NO privilege 'odps:Select' on {acs:odps:*:projects/XXX/tables/XXX}. project 'XXX' is protected
```

The data protection function has been enabled for the project. Only the project owner has the right to transfer data from one project to another if the project data is protected.

Why does the following error occur during data uploading with MaxCompute Tunnel?

```
ErrorCode=FlowExceeded, ErrorMessage=Your flow quota is exceeded. **
```

The maximum number of concurrent requests is exceeded. By default, MaxCompute Tunnel allows a maximum of 2,000 concurrent upload and download requests (quota). Each request, once it is sent, occupies one quota unit until it ends. Try the following solutions:

- Put the system to sleep, and try again after it awakes.
- Change the concurrency quota to a greater number for the project after obtaining the forecast flow pressure from the administrator.
- Report the problem to the project owner to check and control the top requests occupying a large quota.

1.7.7.2. Common tunnel error codes

This topic describes common tunnel error codes.

Common tunnel error codes are as follows.

Common error codes

Error code	Error	Processing recommendations
NoSuchPartition	The partition does not exist.	Tunnel doesn't create partitions, you need to create partitions and then upload or download.
InvalidProjectTable	Invalid project name or table name.	Check related names.
NoSuchProject	The project does not exist.	Check related names.
NoSuchTable	The table does not exist.	Check related names.
StatusConflict	The session expires or has been committed.	Re-create the session and upload it.
MalformedDataStream	Data format error.	Normally created because network is disconnected, or Schema and Table are different.
InvalidPartitionSpec	Invalid partition information.	Check partition information. An example of a correct value is pt='1',ct='2017'.
InvalidRowRange	Invalid designated row range, normally it exceeds the max. size or it is 0.	Check related parameters.

Error code	Error	Processing recommendations
Unauthorized	Account information error.	Normally it is wrong AccessId or AccessKey, or local device time has a 15-minute gap with server.
DataStoreError	Storage error.	Contact the administrator.
NoPermission	No permission normally because no related permission or IP whitelist has been set.	Check whether permission is correct.
MissingPartitionSpec	Missing partition information, partition table operation must carry partition information.	Add partition information.
TableModified	Data in the table is modified by other tasks while upload or download.	Re-create the session and re-try.
FlowExceeded	Exceed concurrency quota limit.	Check and control volume of concurrency. If it is needed to add concurrency, please contact the project owner or administrator to evaluate flow pressure.
InvalidResourceSpec	Normally because the project, table or partition information is different from the session.	Check related information and re-try.
MethodNotAllowed	Method is not allowed, normally try to export the view.	Exporting the view is not supported currently.
InvalidColumnSpec	Invalid column information.	Normally it is column name error while download designated column.
DataVersionConflict	It is cross-cluster coping.	Re-try later.
InternalServerError	Internal error.	Re-try or contact the administrator.

1.8. MaxCompute MapReduce

1.8.1. Overview

1.8.1.1. MapReduce

MaxCompute provides a MapReduce programming API. You can use the API to write MapReduce programs to process MaxCompute data.

MapReduce is a distributed data processing model initially proposed by Google. It later gained extensive attention in the industry and was widely used in a variety of business scenarios.

A MapReduce program processes data in two stages: the Map stage and the Reduce stage. It executes the Map stage first and then the Reduce stage. Although you can define the processing logics of Map and Reduce, they need to follow the conventions of the MapReduce framework.

The following is a detailed procedure of how MapReduce processes data:

1. Before you formally start Map, ensure that partition is set for input data. The input data is divided into equal-sized blocks, which are partitions. Each partition is processed as the input of a single Map worker so that multiple Map workers can work together.
2. After partitioning, multiple Map Workers start working simultaneously. Each Map Worker reads its respective shard, computes the shard, and works out the result to Reduce.

   > **Note** During data output, each Map worker needs to specify one key for each output data. The key decides the Reduce worker for which the data is targeted. Multiple keys may correspond to a single Reduce worker. Data of the same key is sent to the same Reduce worker, and a single Reduce worker may receive data with different keys.

3. Before entering the Reduce stage, the MapReduce framework will sort the data Key values to make data with the same Key values adjacent. If you specify Combiner, the framework will call Combiner and aggregate data with the same Key.

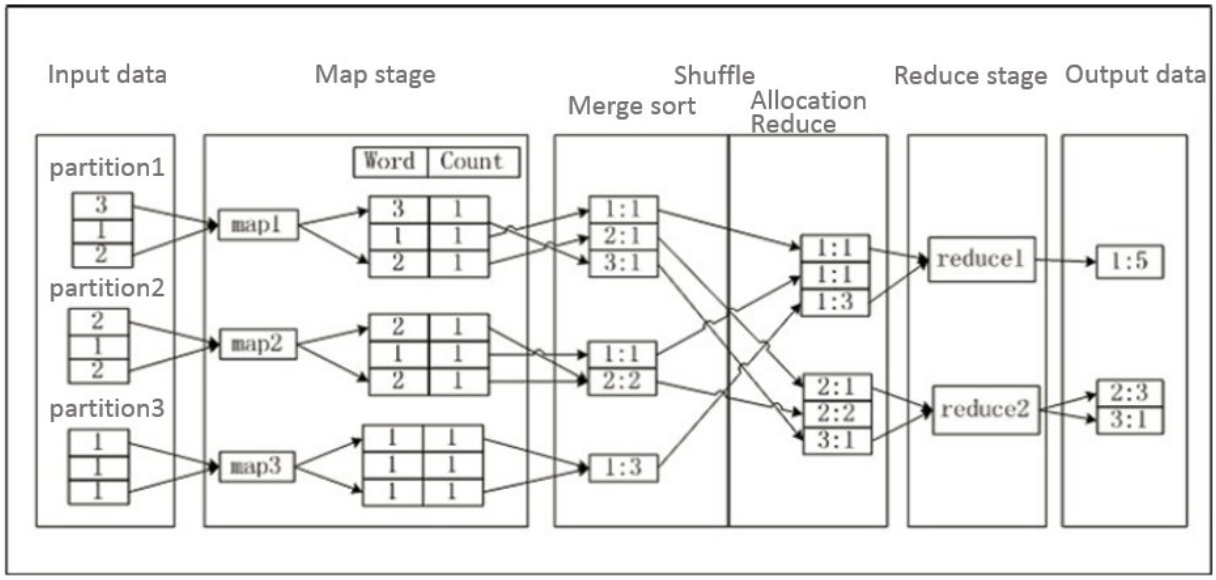
   > **Note** You can customize the Combiner logic. Unlike the typical MapReduce framework protocol, Unlike the typical MapReduce framework protocol, MaxCompute requires the input and output parameters be consistent with those of Reduce. This process is generally called Shuffle.

4. When entering the Reduce stage, data with same Key will be in the same Reduce Worker. A single Reduce Worker may receive data from multiple Map Workers. Each Reduce worker performs the Reduce operation on multiple values with the same key. Finally, the multiple data entries with 1 Key will become 1 Value after the Reduce operation.

> **Note** The preceding section is only a brief introduction to MapReduce. For more details, see related documentation.

The following uses WordCount as an example to explain the related concepts of MaxCompute MapReduce in different stages.

Assume there is a file a.txt, and in each line in the text is a digit. You need to count the number of times each digit appears. Each number is called a Word, and the number of its occurrences is called the Count. To use MaxCompute MapReduce for this purpose, perform the steps shown in the following figure.



1. Partition a.txt data and use data in each partition as input of a single Map worker.
2. For the Map processing input, the Count parameter is set to 1 for each obtained number. The Word|Count pair is output as a Word data key.
3. At the start of the Shuffle stage, the output of each Map worker is sorted by key value (Word value). MapReduce performs the COMBINER operation on the sorted outputs, combining data of the same key (Word value) to form a new Word|Count pair. The process is called combine sorting.
4. Later in the Shuffle stage, data is sent to the Reduce side. The Reduce Worker sorts the received data again depending on Key value.
5. During the Reduce stage, each Reduce Worker uses the same logic as Combiner while processing data, and adds the Count with the same Key value (Word value) to obtain the output result.

Note Because all the MaxCompute data is saved in the table, the input and output of MaxCompute MapReduce can only be a table. Customizing the output format is not permitted, and similar file system APIs are not provided.

1.8.1.2. Extended MapReduce

In a traditional MapReduce model, data must be stored in a distributed file system (such as an HDFS or a MaxCompute table) after each round of MapReduce operations. A typical MapReduce application is composed of multiple MapReduce jobs. Data is written to a disk after each job is completed. Subsequent map tasks usually only read data once to prepare for the following Shuffle stage. This results in redundant I/O operations.

The computing scheduling logic of MaxCompute supports more complicated programming models. In the preceding case, a reduce operation can be followed by the next reduce operation without having a map operation in between. An extended MapReduce model is provided. This model supports any number of reduce operations after map, such as Map-Reduce-Reduce.

Hadoop Chain Mapper and Chain Reducer also support similar serialized map or reduce operations. However, they are essentially different from the extended MapReduce (MR2) model. Chain Mapper and Chain Reducer are based on the traditional MapReduce model. They support one or more mapper operations, not reducer operations, after the original mapper or reduce operation. One benefit is that you can reuse the preceding mapper business logic by splitting a map or reduce operation into multiple mapper stages. This, however, does not change the underlying scheduling or I/O model.

1.8.1.3. Open-source compatibility with MapReduce

MaxCompute offers a set of native MapReduce programming models and interfaces. The inputs and outputs for these interfaces are MaxCompute tables, and the data is organized to be processed in the record format.

However, MaxCompute MapReduce APIs differ from Hadoop MapReduce APIs. Traditionally, to migrate your Hadoop MapReduce jobs to MaxCompute, you need to rewrite the MapReduce code, compile and debug the code by using MaxCompute APIs, compress the final code into a JAR package, and upload the package to the MaxCompute platform. This process is tedious and labor-intensive for development and testing. It was expected that the original Hadoop MapReduce code can be used on the MaxCompute platform with little or no modification at all.

To achieve this purpose, the MaxCompute platform provides a plug-in to adapt Hadoop MapReduce to MaxCompute MapReduce. With this plug-in, Hadoop MapReduce jobs are compatible with MaxCompute at the binary level to a certain extent. You can specify some configurations without modifying the code and then run the original Hadoop MapReduce JAR packages on MaxCompute. Click here to download the plug-in. This plug-in is in the testing stage and does not support custom comparators or key types.

In the following section, a WordCount program is used as an example to introduce the basic usage of this plug-in.

> **Note**
> - For more information about open-source compatibility, see Compatibility with Hadoop MapReduce.
> - For more information about the Hadoop MapReduce SDK, see the MapReduce official documentation.
> - The code in the example is for reference only. You need to modify it based on your business needs.

Download the plug-in

Click here to download the plug-in. The package name is openmr_hadoop2openmr-1.0.jar.

> **Note** This JAR package contains the dependencies with Hadoop 2.7.2. To avoid version conflicts, you must not include Hadoop dependencies in the JAR packages of your jobs.

Prepare a JAR package

Compile and export the WordCount JAR package (wordcount_test.jar). The source code of the WordCount program is as follows:

```
package com.aliyun.odps.mapred.example.hadoop;
import org.apache.hadoop.conf.Configuration;
```

```
import org.apache.hadoop.fs.Path;
import org.apache.hadoop.io.IntWritable;
import org.apache.hadoop.io.Text;
import org.apache.hadoop.mapreduce.Job;
import org.apache.hadoop.mapreduce.Mapper;
import org.apache.hadoop.mapreduce.Reducer;
import org.apache.hadoop.mapreduce.lib.input.FileInputFormat;
import org.apache.hadoop.mapreduce.lib.output.FileOutputFormat;
import java.io.IOException;
import java.util.StringTokenizer;
public class WordCount {
  public static class TokenizerMapper
    extends Mapper<Object, Text, Text, IntWritable>{
    private final static IntWritable one = new IntWritable(1);
    private Text word = new Text();
    public void map(Object key, Text value, Context context
    ) throws IOException, InterruptedException {
      StringTokenizer itr = new StringTokenizer(value.toString());
      while (itr.hasMoreTokens()) {
        word.set(itr.nextToken());
        context.write(word, one);
      }
    }
  }
  public static class IntSumReducer
    extends Reducer<Text,IntWritable,Text,IntWritable> {
    private IntWritable result = new IntWritable();
    public void reduce(Text key, Iterable<IntWritable> values,
      Context context
    ) throws IOException, InterruptedException {
      int sum = 0;
      for (IntWritable val : values) {
        sum += val.get();
      }
      result.set(sum);
      context.write(key, result);
    }
  }
  public static void main(String[] args) throws Exception {
    Configuration conf = new Configuration();
    Job job = Job.getInstance(conf, "word count");
```

```
    job.setJarByClass(WordCount.class);
    job.setMapperClass(TokenizerMapper.class);
    job.setCombinerClass(IntSumReducer.class);
    job.setReducerClass(IntSumReducer.class);
    job.setOutputKeyClass(Text.class);
    job.setOutputValueClass(IntWritable.class);
    FileInputFormat.addInputPath(job, new Path(args[0]));
    FileOutputFormat.setOutputPath(job, new Path(args[1]));
    System.exit(job.waitForCompletion(true) ? 0 : 1);
  }
}
```

Prepare test data

1. Create input and output tables.

   ```
   create table if not exists wc_in(line string);
   create table if not exists wc_out(key string, cnt bigint);
   ```

2. Use Tunnel to import data to the input table.

   The following content in the data.txt file needs to be imported:

   ```
   hello maxcompute
   hello mapreduce
   ```

3. You can run the following command on the MaxCompute client to import data from data.txt to wc_in:

   ```
   tunnel upload data.txt wc_in;
   ```

Configure the mapping between HDFS file paths and MaxCompute tables

The configuration file is named wordcount-table-res.conf.

```
{
 "file:/foo": {
  "resolver": {
   "resolver": "com.aliyun.odps.mapred.hadoop2openmr.resolver.TextFileResolver",
   "properties": {
     "text.resolver.columns.combine.enable": "true",
     "text.resolver.seperator": "\t"
   }
  },
  "tableInfos": [
   {
    "tblName": "wc_in",
    "partSpec": {},
    "label": "__default__"
   }
  ],
  "matchMode": "exact"
 },
 "file:/bar": {
  "resolver": {
   "resolver": "com.aliyun.odps.mapred.hadoop2openmr.resolver.BinaryFileResolver",
   "properties": {
     "binary.resolver.input.key.class" : "org.apache.hadoop.io.Text",
     "binary.resolver.input.value.class" : "org.apache.hadoop.io.LongWritable"
   }
  },
  "tableInfos": [
   {
    "tblName": "wc_out",
    "partSpec": {},
    "label": "__default__"
   }
  ],
  "matchMode": "fuzzy"
 }
}
```

The preceding configuration is a JSON file that describes the mapping between HDFS file paths and MaxCompute tables. You need to configure both the input and output. Each HDFS file path matches three configuration items: resolver, tableInfos, and matchMode. The configuration items are described as follows:

- **resolver**: specifies how to process data in files. Currently, the following two built-in resolvers are available: com.aliyun.odps.mapred.hadoop2openmr.resolver.TextFileResolver and com.aliyun.odps.mapred.hadoop2openmr.resolver.BinaryFileResolver. After you specify the resolver name, you must configure properties for the resolver to support data parsing.
  - **TextFileResolver**: regards the input or output as plaintext if the data is of plaintext type. When you configure an input resolver, you must configure the text.resolver.columns.combine.enable and text.resolver.seperator properties. When text.resolver.columns.combine.enable is set to true, all columns in the input table are combined into a single string based on the delimiter specified by text.resolver.seperator. Otherwise, the first two columns in the input table are used as the key and value fields.
  - **BinaryFileResolver**: converts binary data into a data type that is supported by MaxCompute, such as BIGINT, BOOLEAN, and DOUBLE. When you configure an output resolver, you must configure the binary.resolver.input.key.class and binary.resolver.input.value.class properties. binary.resolver.input.key.class defines the key type of the intermediate result, and binary.resolver.input.value.class defines the value type.
- **tableInfos**: specifies the MaxCompute table that corresponds to HDFS. At present, only the tblName parameter is configurable. The partSpec and label parameters must be set to the values the same as those in the preceding example.
- **matchMode**: specifies the path matching mode. It can be set to exact or fuzzy. You can use a regular expression in fuzzy mode to match the HDFS input path.

Submit a job

Use the MaxCompute command line tool odpscmd to submit the job. Run the following command in odpscmd:

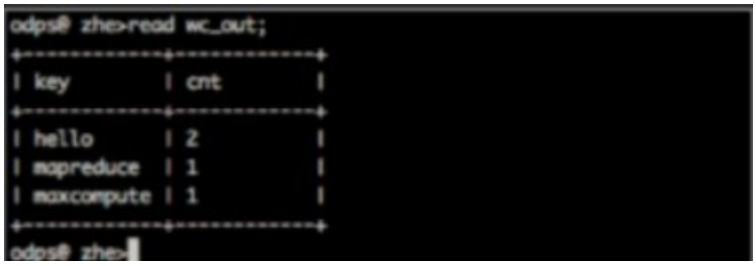
```
jar -DODPS_HADOOPMR_TABLE_RES_CONF=./wordcount-table-res.conf -classpath hadoop2openmr-1.0.jar,
wordcount_test.jar com.aliyun.odps.mapred.example.hadoop.WordCount /foo/bar;
```

Note

- **wordcount-table-res.conf**: the mapped configuration file configured with /foo/bar.
- **wordcount_test.jar**: the JAR package of your Hadoop MapReduce program.
- **com.aliyun.odps.mapred.example.hadoop.WordCount**: the class name of the job that you want to run.
- **/foo/bar**: the path on HDFS, which is mapped to wc_in and wc_out in the JSON configuration file.
- After you configure the mapping, you must import the Hadoop HDFS input file to wc_in for MapReduce computing by using the data integration function of DataX or DataWorks, and export the result table wc_out to your HDFS output directory */bar*.
- Before you run the preceding command, make sure that hadoop2openmr-1.0.jar, wordcount_test.jar, and wordcount-table-res.conf have been stored in the current directory of odpscmd. Otherwise, you must make the relevant changes when you specify the configuration and -classpath.

The following figure shows the running process.

After the job running process is complete, you can view the result table wc_out to check whether the job is successful and whether the results meet expectations.



1.8.2. Features

1.8.2.1. Run command

The MaxCompute client provides a jar command for running MapReduce jobs.

Command syntax:

```
Usage: jar [<GENERIC_OPTIONS>] <MAIN_CLASS> [ARGS]
-conf <configuration_file> Specify an application configuration file
-classpath <local_file_list> classpaths used to run mainClass
-D <name>=<value> Property value pair, which will be used to run mainClass
-local Run job in local mode
-resources <resource_name_list> file/table resources used in mapper or reducer, separate by comma
```

The following table describes the parameters.

Parameters

Parameter	Description
-conf <configuration file>	Indicates a JobConf file.
-classpath <local_file_list>	Indicates the classpath for local execution. It specifies the local paths (including relative path and absolute path) of the jar packet where the main function is located.
-D <prop_name>=<prop_value>	Indicates the java attribute of <mainClass> in local execution. You can define multiple attributes.
-local	Indicates that the MapReduce job is run locally. It is mainly used for program debugging.
-resources <resource_name_list>	Declares the resources used by a MapReduce job. Typically, you must specify the name of the resource where the Map or Reduce function is located in resource_name_list. **Notice** If the Map or Reduce function reads from other MaxCompute resources, you must add the names of these resource to resource_name_list. Multiple resources are separated by commas. If you want to use resources in another project, you must append PROJECT_NAME/resources/ before the resource name, such as -resources otherproject/resources/resfile.

Note The preceding optional parameters are included in <GENERIC_OPTIONS>.

You can use the -conf option to specify the JobConf file. This file can affect the settings of JobConf in the SDK. For more information about JobConf, see the introduction of MapReduce core interfaces. The following is an example of a JobConf file.

Example:

```
<configuration>
<property>
<name>import.filename</name>
<value>resource.txt</value>
</property>
</configuration>
```

In the preceding example, the JobConf file is used to define a variable named import.filename. The value of this variable is resource.txt. You can use the JobConf API in MapReduce to obtain the value of this variable. You can also use the JobConf API in the SDK for the same purpose.

Example:

```
jar -resources mapreduce-examples.jar -classpath mapreduce-examples.jar
org.alidata.odps.mr.examples.WordCount wc_in wc_out
add file data/src.txt
jar -resources src.txt,mapreduce-examples.jar -classpath mapreduce-examples.jar org.alidata.odps.mr.exam
ples.WordCount wc_in wc_out
add file data/a.txt
add table wc_in as test_table add jar work.jar
jar -conf odps-mapred.xml -resources a.txt,test_table,work.jar
-classpath work.jar:otherlib.jar
-D import.filename=resource.txt org.alidata.odps.mr.examples.WordCount args
```

1.8.2.2. Concepts

1.8.2.2.1. MapReduce

Map and Reduce functions support setup and cleanup methods for their corresponding map() and reduce() methods. A setup method is called prior to the Map() or Reduce() method. Each worker calls it once. A cleanup method is called after the Map() or Reduce() method. Each worker calls it once.

> **Note** For more information about the usage example, see Example program.

1.8.2.2.2. Sorting

Columns in the key records output by map can be set as sort columns. Custom comparators are not supported. You can select a few sort columns as group columns. Custom group comparators are not supported. Sort columns are generally used to sort user data, while group columns are used for secondary sorting.

> **Note** For detailed examples, see Secondary sorting source code.

1.8.2.2.3. Partition

MaxCompute supports partition columns and custom partitioners. Partition columns take precedence over custom partitioners. Partitioners are used to allocate Map output data to different Reduce workers based on the partition logic.

1.8.2.2.4. Combiner

The Combiner function combines adjacent records in the Shuffle stage. You can choose to use the Combiner function based on your business logic. The Combiner function is an optimized MapReduce computing framework. The Combiner logic is the same as the Reduce logic. After map outputs data, the framework merges data with the same key value on the map side locally.

1.8.2.2.5. Submit a job

This topic describes how to use the MaxCompute client to run and submit a MapReduce job.

The MaxCompute client provides a JAR command for running MapReduce jobs. Syntax:

```
jar [<GENERIC_OPTIONS>] <MAIN_CLASS> [ARGS];
    -conf <configuration_file>       Specify an application configuration file
    -resources <resource_name_list>  file\table resources used in mapper or reducer, seperate by comma
    -classpath <local_file_list>     classpaths used to run mainClass
    -D <name>=<value>                Property value pair, which will be used to run mainClass
    -l                               Run job in local mode
```

Example:

```
jar -conf \home\admin\myconf -resources a.txt,example.jar -classpath ..\lib\example.jar:.\other_lib.jar -D jav
a.library.path=.\native;
```

<GENERIC_OPTIONS> includes the following options, which are all optional:

- **-conf <configuration file>**: specifies the JobConf file. This file can affect the settings of JobConf in the SDK.
- **-resources <resource_name_list>**: declares the resources used for running the MapReduce job. You must specify the names of the resources in which the Map or Reduce function is located in resource_name_list.

  > **Note** If the Map or Reduce function reads from other MaxCompute resources, you must add the names of these resources to resource_name_list. Separate multiple resources with commas (,). If you want to use resources in another project, you must append PROJECT/resources/ to the beginning of the resource name, such as -resources otherproject/resources/resfile.

- **-classpath <local_file_list>**: specifies the classpath for local execution. It is used to specify the local paths (including relative and absolute paths) of the JAR package where the main function is located. Package names are separated with default file delimiters of the system. In most cases, semicolons (;) are used in Windows, and commas (,) are used in Linux. If you run a MapReduce job on a cloud server, separate package names with commas (,).

  > **Note** The main function and Map/Reduce function are usually written in the same package. In this case, the -resources and -classpath options both contain information such as mapreduce-examples.jar. However, -resources references the Map or Reduce function and is executed in a distributed environment, while -classpath references the main function and is executed locally with the specified JAR package saved in a local directory.

- **-D <name>=<value>**: specifies the Java attribute of <mainClass> during local execution. You can define multiple attributes.
- **-l** specifies that the MapReduce job is run locally. It is mainly used for program debugging.

The following code is an example of the JobConf file:

```
<configuration>
    <property>
      <name>import.filename</name>
      <value>resource.txt</value>
    </property>
  </configuration>
```

In the preceding example, the JobConf file is used to define a variable named import.filename. The value of this variable is resource.txt. You can use the JobConf API in MapReduce to obtain the value of this variable. You can also use the JobConf API in the SDK for the same purpose.

Example:

```
add jar data\mapreduce-examples.jar;
  jar -resources mapreduce-examples.jar -classpath data\mapreduce-examples.jar
    org.alidata.odps.mr.examples.WordCount wc_in wc_out;
  add file data\src.txt;
  add jar data\mapreduce-examples.jar;
  jar -resources src.txt,mapreduce-examples.jar -classpath data\mapreduce-examples.jar
    org.alidata.odps.mr.examples.WordCount wc_in wc_out;
  add file data\a.txt;
  add table wc_in as test_table;
  add jar data\work.jar;
  jar -conf odps-mapred.xml -resources a.txt,test_table,work.jar
    -classpath data\work.jar:otherlib.jar
    -D import.filename=resource.txt org.alidata.odps.mr.examples.WordCount args;
```

1.8.2.2.6. Input and output

- MaxCompute MapReduce supports the following build-in data types: Bigint, Double, String, Datetime, Boolean, Decimal, Tinyint, Smallint, Int, Float, Varchar, Timestamp, Binary, Array, Map, and Struct. MapReduce does not support custom data types.
- MapReduce supports input from multiple tables with different schemas. You can use the map function to obtain the table information corresponding to the current record.
- MapReduce supports NULL as input, but does not support views as input.
- Reduce can write output to different tables or different partitions of a table. The target tables can have different schemas. Each output is identified by a label. An output is not labeled by default. At least one output is generated.

> **Note** For examples, see Example programs.

1.8.2.2.7. Read data from resources

You can use the Map or Reduce function to read data from MaxCompute resources. Any Map or Reduce worker loads resources to the memory for you to write code.

> **Note** For a detailed example, see Resource utilization example.

1.8.2.2.8. Run MapReduce tasks locally

You can specify the -local parameter in the jar command to enable local debugging by simulating the running of a local MapReduce instance. During local running, the client downloads from MaxCompute the metadata and data of the input table, required resources, and the metadata of the output table needed for local debugging. The client saves the data to a local directory named warehouse. When MapReduce running is complete, MapReduce saves the computing results to a file in the warehouse directory. If the input table and required resources are already downloaded to the local warehouse directory, MapReduce directly references the data and files in the warehouse directory the next time it runs, instead of downloading the data again.

A MapReduce instance that is running locally may start multiple map or reduce processes, which run serially rather than concurrently. The simulated running process is different from an actual distributed running process in the following aspects:

- Input table row count: Up to 100 rows of data can be downloaded.
- Resource usage: In a distributed environment, MaxCompute limits the size of referenced resources. For more information, see Application limits. During local running, the size of resources is unlimited.
- Security limits: MaxCompute MapReduce and UDF programs running in a distributed environment are subject to Java sandbox restrictions. There is no such restrictions during local running.

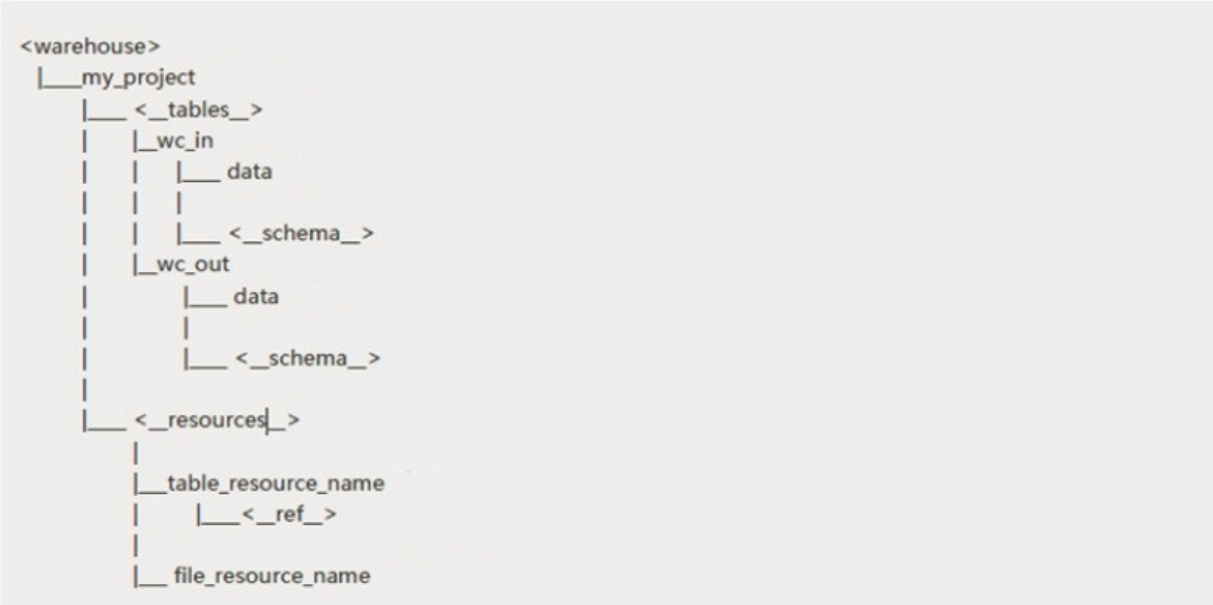
The following is a simple local running example.

Example:

```
odps@my_project> jar -l com.aliyun.odps.mapred.example.WordCount wc_in wc_out;
 Summary:
counters: 10
map-reduce framework combine_input_groups=2 combine_output_records=2 map_input_bytes=4 map_in
put_records=1 map_output_records=2 map_output_[wc_out]_bytes=0 map_output_[wc_out]_records=0 r
educe_input_groups=2 reduce_output_[wc_out]_bytes=8 reduce_output_[wc_out]_records=2
OK
```

> **Note** For a WordCount example, see WordCount example.

If you run the local debugging command for the first time, a directory named warehouse is created in the current path after the command is complete. The following figure shows the directory structure of warehouse.



Directories of the same level as my_project are projects. wc_in and wc_out are data tables. The table file data that you read or write using the jar command is downloaded to directories of this level. The schema file contains the metadata of a table in the following format:

```
project=local_project_name
table=local_table_name
columns=col1_name:col1_type,col2_name:col2_type
partitions=p1:STRING,p2:BIGINT
-- This field is not required in this example.
```

Note Separate the name and type of a column with a colon (:), and separate columns with commas (,). You need to declare the project name and table name at the top of the schema files as projectname.tablename. Separate the declaration from column definition with a comma (,). The data file stores table data. The number of columns and data values must match the definition in the schema file. Separate columns with commas (,).

Example of wc_in schema file:

```
my_project.wc_in,key:STRING,value:STRING
```

Example of the corresponding data file:

```
0,2
```

> **Note** The client downloads the metadata and part of the data of a table from MaxCompute, and saves the data to the preceding files. The next time you run this example, the client directly uses the data in the wc_in directory, instead of downloading it again. Note that you can download data from MaxCompute only when running MapReduce locally. If you use the Eclipse plugin for local debugging, you cannot download data from MaxCompute.

Example of wc_out schema file:

```
my_project.wc_out,key:STRING,cnt:BIGINT
```

Example of the corresponding data file:

```
0,1
2,1
```

> **Note** The client downloads the metadata of we_out from MaxCompute, and saves the data to the schema file. The data file is generated to store the local running results. You can also compile schema and data files, and save them in the corresponding table directory. Then, when you run MapReduce locally, the client detects these files in the table directory, and will not download data from MaxCompute. The local table directory does not have to correspond to an actual table in MaxCompute.

The following table compares the features of Hadoop MapReduce with MaxCompute MapReduce.

Feature comparison

Feature	Hadoop MapReduce	MaxCompute MapReduce
Task progress report	The map stage calculates the read data volume. The Reduce step monitors the progress of various phases. Based on this information, the overall task progress can be estimated. The client can obtain real-time task progress. Task progress is not controlled by users.	Real-time task progress reporting is supported in a different way.
Statistics	Custom statistics, real-time summary, and real-time updates are supported. Real-time statistics updates are not controlled by users.	Real-time statistics updates are not supported during runtime. Calculation and summary are performed after a task is completed.
File compression	Users have an option to specify compressed storage.	File compression is not supported. Users cannot directly store files.
Speculative execution	/	Speculative execution is enabled by default, and cannot be configured by users.

Feature	Hadoop MapReduce	MaxCompute MapReduce
End of task notification	The server notifies the client of task completion.	No notifications are provided. When using the SDK to submit tasks, users must poll task status constantly until the tasks are completed.

1.8.3. SDK introduction

1.8.3.1. Major API overview

Major APIs

API	Description
MapperBase	User-defined Map functions must inherit this class. It converts the record objects in the input table into key-value pairs, and outputs them to the Reduce stage or directly to the result table by skipping the Reduce stage. The jobs that skip the Reduce stage and directly output calculation results are also called Map-Only jobs.
ReducerBase	User-defined Reduce functions must inherit this class. It reduces a set of values associated with a key.
TaskContext	One of the input parameters of multiple member functions of MapperBase and ReducerBase. It contains the contextual information of task execution.
JobClient	It is used to submit and manage jobs, including the blocking mode (synchronous) and non-blocking mode (asynchronous).
RunningJob	Job runtime objects for tracking running MapReduce job instances.
JobConf	Describes the configuration of a MapReduce task. The JobConf object is generally defined in the main program (main function). Then, JobClient submits the job to MaxCompute.

1.8.3.2. API description

1.8.3.2.1. MapperBase

The following table lists the major function APIs.

Major APIs

API	Description
void cleanup(TaskContext context)	The Map method is called after the map stage ends.
void map(long key, Record record, TaskContext context)	Map method for processing records in the input table.
void setup(TaskContext context)	The Map method is called before the map stage begins.

1.8.3.2.2. ReducerBase

The following table lists the major function APIs.

Major APIs

API	Description
void cleanup(TaskContext context)	The Reduce method is called after the reduce stage ends.
void reduce(Record key, Iterator<Record > values, TaskContext context)	Reduce method, processing records in input table.
void setup(TaskContext context)	The Reduce method is called before the reduce stage begins.

1.8.3.2.3. TaskContext

The following table lists the major function APIs.

Major APIs

API	Description
TableInfo[] getOutputTableInfo()	Get output table information.
Record createOutputRecord()	Create record object of default output table.
Record createOutputRecord(String label)	Create record object of given label output table.
Record createMapOutputKeyRecord()	Create record object of Map output Key.
Record createMapOutputValueRecord()	Create record object of Map output Value.
void write(Record record)	Write record to default output for writing data at Reduce end. Can be called multiple times at Reduce end.
void write(Record record, String label)	Write record to given label output for writing data at Reduce end. Can be called multiple times at Reduce end.
void write(Record key, Record value)	Write record to intermediate result for writing data at Map end. Can be called multiple times at Map end.
BufferedInputStream readResourceFileAsStream(String resourceName)	Read file type resource.
Iterator<Record > readResourceTable(String resourceName)	Reads table type resources.

API	Description
Counter getCounter(Enum<? > name)	Get Counter object of given name.
Counter getCounter(String group, String name)	Get Counter object of given group name and name.
void progress()	Report heartbeat information to the MapReduce framework. If the processing time of your method is extended, and you have not called the framework during the current process, call it to avoid a task timeout period. 600 seconds is set as the timeout period by default.

Note TaskContext API has a progress function which prevents it from being forced out due to time-out if a worker runs for a long time. This API sends heartbeats to the framework rather than reporting the Worker progress. The default worker timeout period for MaxCompute MapReduce is 10 minutes (which cannot be modified by the user). If the worker does not send a heartbeat (calling the progress API) in 10 minutes, the framework terminates the worker and the MapReudce task fails. We recommend that you let the worker call the progress API periodically in the Mapper/Reducer function to prevent the framework from terminating the task unexpectedly.

1.8.3.2.4. JobConf

The following table lists the major function APIs.

Major APIs

API	Description
void setResources(String resourceNames)	Declare resources this job uses. Only declared resources are available to be read through TaskContext object while run Mapper/Reducer.
void setMapOutputKeySchema(Column[] schema)	Set attribute of Key output from Mapper to Reducer.
void setMapOutputValueSchema(Column[] schema)	Set attribute of Value output from Mapper to Reducer.
void setOutputKeySortColumns(String[] cols)	Set sorting columns of Key output from Mapper to Reducer.
void setOutputGroupingColumns(String[] cols)	Set Key grouping columns.
void setMapperClass(Class<? extends Mapper > > > theClass)	Set Mapper function of job.
void setPartitionColumns(String[] cols)	Set partition columns designated by job. It is all the columns of Mapper output Key by default.

API	Description
void setReducerClass(Class<? extends Reducer > theClass)	Set the job reducer.
void setCombinerClass(Class<? extends Reducer > theClass)	Set job combiner. When run at Map side, the function is similar to a single Map and local Key value of the local Reduce.
void setSplitSize(long size)	Set input split size, unit: MB, default value: 640.
void setNumReduceTasks(int n)	Set number of Reducer task, it is 1/4 number of Mapper task by default.
void setMemoryForMapTask(int mem)	Set memory size of single Worker in Mapper tasks, unit: MB, default value: 2048.
void setMemoryForReduceTask(int mem)	Set memory size of single Worker in Reduce tasks, unit: MB, default value: 2048.
void setOutputSchema(Column[] schema, String label)	Set output attribute of designated label. While multiplexed output, each output corresponds to 1 label.

Note

- Normally, GroupingColumns is included in KeySortColumns, and KeySortColumns is included in Key.
- At the Map side, the Record output from Mapper calculates Hash value and then, based on the set PartitionColumns, determines which Reducer to distribute to for sorting Records based on KeySortColumns.
- At the Reduce side, after sorting input Records based on KeySortColumns, Records are grouped based on columns designated by GroupingColumns, and are input in traversal sequence. The use of the same Records in columns designated by GroupingColumns as 1 input called by reduce function.

1.8.3.2.5. JobClient

The following table lists the major function APIs.

Major APIs

API	Description
static RunningJob runJob(JobConf job)	Use blocking (synchronous) mode to submit MapReduce jobs and return immediately.
static RunningJob submitJob(JobConf job)	Use non-blocking (asynchronous) mode to submit MapReduce jobs and return immediately.

1.8.3.2.6. RunningJob

The following table lists the major function APIs.

Major APIs

API	Description
String getInstanceID()	Get instance ID for checking run log and job management.
boolean isComplete()	Check whether job is complete.
boolean isSuccessful()	Check whether job instance is successful.
void waitForCompletion()	Wait until job instance is complete. It is typically is used for jobs submitted is asynchronous mode.
JobStatus getJobStatus()	Check job instance status.
void killJob()	End the job.
Counters getCounters()	Get Counter information.

1.8.3.2.7. InputUtils

The following table lists the major function APIs.

Major APIs

API	Description
static void addTable(TableInfo table, JobConf conf)	Add table to task input. It can be called more than once. Newly added tables are appended to input queue.
static void setTables(TableInfo [] tables, JobConf conf)	Add tables to task input.

1.8.3.2.8. OutputUtils

The following table lists the major function APIs.

Major APIs

API	Description

API	Description
static void addTable(TableInfo table, JobConf conf)	Adds a table to the task output. It can be called more than once. Newly added tables are appended to the output queue.
static void setTables(TableInfo [] tables, JobConf conf)	Adds multiple tables to the task output.

1.8.3.2.9. Pipeline

Pipeline is the main class of MR2. A Pipeline can be built with Pipeline.Builder. Major Pipeline APIs are as follows:

```
public Builder addMapper(Class<? extends Mapper> mapper)
public Builder addMapper(Class<? extends Mapper> mapper,Column[] keySchema, Column[] valueSchema,
String[] sortCols, SortOrder[] order, String[] partCols,Class<? extends Partitioner> theClass, String[] groupC
ols)
public Builder addReducer(Class<? extends Reducer> reducer)
public Builder addReducer(Class<? extends Reducer> reducer,Column[] keySchema, Column[] valueSchema,
String[] sortCols, SortOrder[] order, String[] partCols,Class<? extends Partitioner> theClass, String[] groupC
ols)
public setoutputkeyschema builder (Column [] keyschema)
public setoutputvalueschema builder (Column [] valueschema)
public setoutputkeysortcolumns builder (String [] sortcols)
public setoutputkeysortorder builder (Sortorder [] order)
public setpartitioncolumns builder (String [] partcols)
public Builder setPartitionerClass(Class<? extends Partitioner> theClass)
public Builder setOutputGroupingColumns(String[] cols)
```

Example:

```
job job = new job ();
pipeline pipeline = pipeline. builder ()
. Addmapper (maid. Class)
.setOutputKeySchema(
new Column[] { new Column("word", OdpsType.STRING) })
.setOutputValueSchema(
new Column[] { new Column("count", OdpsType.BIGINT) })
. addreducer (Sumreducer. class)
. setoutputkeyschema (
new Column[] { new Column("count", OdpsType.BIGINT) })
.setOutputValueSchema(
new column [] {new column ("word", OdpsType. string),
new column ("count", OdpsType. bigint)})
. addreducer (Identityreducer. class). createPipeline ();
job.setPipeline(pipeline); job.addInput(...)
job.addOutput(...) job.submit();
```

As shown in the preceding example, you can build MapReduce tasks of a Map operation followed by two Reduce operations in the MAIN function. If you are familiar with the basic features of MapReduce, you can use MR2 easily . We also recommend that you learn the basic features of MapReduce before using MR2, namely configuring MapReduce tasks through JobConf. JobConf can only configure MapReduce tasks of a Map operation followed by a single Reduce operation.

1.8.3.3. Compatibility with Hadoop MapReduce

The following table describes whether specific MaxCompute MapReduce interfaces are compatible with Hadoop MapReduce.

Type	Interface	Compatible with Hadoop MapReduce?
Mapper	void map(KEYIN key, VALUEIN value, org.apache.hadoop.mapreduce.Mapper.Context context)	Yes
Mapper	void run(org.apache.hadoop.mapreduce.Mapper.Context context)	Yes
Mapper	void setup(org.apache.hadoop.mapreduce.Mapper.Context context)	Yes
Reducer	void cleanup(org.apache.hadoop.mapreduce.Reducer.Context context)	Yes

Type	Interface	Compatible with Hadoop MapReduce?
Reducer	void reduce(KEYIN key, VALUEIN value, org.apache.hadoop.mapreduce.Reducer.Context context)	Yes
Reducer	void run(org.apache.hadoop.mapreduce.Reducer.Context context)	Yes
Reducer	void setup(org.apache.hadoop.mapreduce.Reducer.Context context)	Yes
Partitioner	int getPartition(KEY key, VALUE value, int numPartitions)	Yes
MapContext (which extends TaskInputOutputContext)	InputSplit getInputSplit()	No. An exception is reported.
ReduceContext	nextKey()	Yes
ReduceContext	getValues()	Yes
TaskInputOutputContext	getCurrentKey()	Yes
TaskInputOutputContext	getCurrentValue()	Yes
TaskInputOutputContext	getOutputCommitter()	No. An exception is reported.
TaskInputOutputContext	nextKeyValue()	Yes
TaskInputOutputContext	write(KEYOUT key, VALUEOUT value)	Yes
TaskAttemptContext	getCounter(Enum<? > counterName)	Yes
TaskAttemptContext	getCounter(String groupName, String counterName)	Yes
TaskAttemptContext	setStatus(String msg)	Empty implementation
TaskAttemptContext	getStatus()	Empty implementation
TaskAttemptContext	getTaskAttemptID()	No. An exception is reported.
TaskAttemptContext	getProgress()	No. An exception is reported.
TaskAttemptContext	progress()	Yes

Type	Interface	Compatible with Hadoop MapReduce?
Job	addArchiveToClassPath(Path archive)	No
Job	addCacheArchive(URI uri)	No
Job	addCacheFile(URI uri)	No
Job	addFileToClassPath(Path file)	No
Job	cleanupProgress()	No
Job	createSymlink()	No. An exception is reported.
Job	failTask(TaskAttemptID taskId)	No
Job	getCompletionPollInterval(Configuration conf)	Empty implementation
Job	getCounters()	Yes
Job	getFinishTime()	Yes
Job	getHistoryUrl()	Yes
Job	getInstance()	Yes
Job	getInstance(Cluster ignored)	Yes
Job	getInstance(Cluster ignored, Configuration conf)	Yes
Job	getInstance(Configuration conf)	Yes
Job	getInstance(Configuration conf, String jobName)	Empty implementation
Job	getInstance(JobStatus status, Configuration conf)	No. An exception is reported.
Job	getJobFile()	No. An exception is reported.
Job	getJobName()	Empty implementation
Job	getJobState()	No. An exception is reported.
Job	getPriority()	No. An exception is reported.
Job	getProgressPollInterval(Configuration conf)	Empty implementation
Job	getReservationId()	No. An exception is reported.

Type	Interface	Compatible with Hadoop MapReduce?
Job	getSchedulingInfo()	No. An exception is reported.
Job	getStartTime()	Yes
Job	getStatus()	No. An exception is reported.
Job	getTaskCompletionEvents(int startFrom)	No. An exception is reported.
Job	getTaskCompletionEvents(int startFrom, int numEvents)	No. An exception is reported.
Job	getTaskDiagnostics(TaskAttemptID taskid)	No. An exception is reported.
Job	getTaskOutputFilter(Configuration conf)	No. An exception is reported.
Job	getTaskReports(TaskType type)	No. An exception is reported.
Job	getTrackingURL()	Yes
Job	isComplete()	Yes
Job	isRetired()	No. An exception is reported.
Job	isSuccessful()	Yes
Job	isUber()	Empty implementation
Job	killJob()	Yes
Job	killTask(TaskAttemptID taskId)	No
Job	mapProgress()	Yes
Job	monitorAndPrintJob()	Yes
Job	reduceProgress()	Yes
Job	setCacheArchives(URI[] archives)	No. An exception is reported.
Job	setCacheFiles(URI[] files)	No. An exception is reported.
Job	setCancelDelegationTokenUponJobCompletion(boolean value)	No. An exception is reported.
Job	setCombinerClass(Class<? extends Reducer> cls)	Yes

Type	Interface	Compatible with Hadoop MapReduce?
Job	setCombinerKeyGroupingComparatorClass(Class<? extends RawComparator> cls)	Yes
Job	setGroupingComparatorClass(Class<? extends RawComparator> cls)	Yes
Job	setInputFormatClass(Class<? extends InputFormat> cls)	Empty implementation
Job	setJar(String jar)	Yes
Job	setJarByClass(Class<? > cls)	Yes
Job	setJobName(String name)	Empty implementation
Job	setJobSetupCleanupNeeded(boolean needed)	Empty implementation
Job	setMapOutputKeyClass(Class<? > theClass)	Yes
Job	setMapOutputValueClass(Class<? > theClass)	Yes
Job	setMapperClass(Class<? extends Mapper> cls)	Yes
Job	setMapSpeculativeExecution(boolean speculativeExecution)	Empty implementation
Job	setMaxMapAttempts(int n)	Empty implementation
Job	setMaxReduceAttempts(int n)	Empty implementation
Job	setNumReduceTasks(int tasks)	Yes
Job	setOutputFormatClass(Class<? extends OutputFormat> cls)	No. An exception is reported.
Job	setOutputKeyClass(Class<? > theClass)	Yes
Job	setOutputValueClass(Class<? > theClass)	Yes
Job	setPartitionerClass(Class<? extends Partitioner> cls)	Yes
Job	setPriority(JobPriority priority)	No. An exception is reported.

Type	Interface	Compatible with Hadoop MapReduce?
Job	setProfileEnabled(boolean newValue)	Empty implementation
Job	setProfileParams(String value)	Empty implementation
Job	setProfileTaskRange(boolean isMap, String newValue)	Empty implementation
Job	setReducerClass(Class<? extends Reducer> cls)	Yes
Job	setReduceSpeculativeExecution(boolean speculativeExecution)	Empty implementation
Job	setReservationId(ReservationId reservationId)	No. An exception is reported.
Job	setSortComparatorClass(Class<? extends RawComparator> cls)	No. An exception is reported.
Job	setSpeculativeExecution(boolean speculativeExecution)	Yes
Job	setTaskOutputFilter(Configuration conf, org.apache.hadoop.mapreduce.Job.TaskStatusFilter newValue)	No. An exception is reported.
Job	setupProgress()	No. An exception is reported.
Job	setUser(String user)	Empty implementation
Job	setWorkingDirectory(Path dir)	Empty implementation
Job	submit()	Yes
Job	toString()	No. An exception is reported.
Job	waitForCompletion(boolean verbose)	Yes
Task Execution & Environment	mapreduce.map.java.opts	Empty implementation
Task Execution & Environment	mapreduce.reduce.java.opts	Empty implementation
Task Execution & Environment	mapreduce.map.memory.mb	Empty implementation
Task Execution & Environment	mapreduce.reduce.memory.mb	Empty implementation
Task Execution & Environment	mapreduce.task.io.sort.mb	Empty implementation

Type	Interface	Compatible with Hadoop MapReduce?
Task Execution & Environment	mapreduce.map.sort.spill.percent	Empty implementation
Task Execution & Environment	mapreduce.task.io.soft.factor	Empty implementation
Task Execution & Environment	mapreduce.reduce.merge.inmem.thresholds	Empty implementation
Task Execution & Environment	mapreduce.reduce.shuffle.merge.percent	Empty implementation
Task Execution & Environment	mapreduce.reduce.shuffle.input.buffer.percent	Empty implementation
Task Execution & Environment	mapreduce.reduce.input.buffer.percent	Empty implementation
Task Execution & Environment	mapreduce.job.id	Empty implementation
Task Execution & Environment	mapreduce.job.jar	Empty implementation
Task Execution & Environment	mapreduce.job.local.dir	Empty implementation
Task Execution & Environment	mapreduce.task.id	Empty implementation
Task Execution & Environment	mapreduce.task.attempt.id	Empty implementation
Task Execution & Environment	mapreduce.task.is.map	Empty implementation
Task Execution & Environment	mapreduce.task.partition	Empty implementation
Task Execution & Environment	mapreduce.map.input.file	Empty implementation
Task Execution & Environment	mapreduce.map.input.start	Empty implementation
Task Execution & Environment	mapreduce.map.input.length	Empty implementation
Task Execution & Environment	mapreduce.task.output.dir	Empty implementation
JobClient	cancelDelegationToken(Token<DelegationTokenIdentifier> token)	No. An exception is reported.
JobClient	close()	Empty implementation
JobClient	displayTasks(JobID jobId, String type, String state)	No. An exception is reported.
JobClient	getAllJobs()	No. An exception is reported.

Type	Interface	Compatible with Hadoop MapReduce?
JobClient	getCleanupTaskReports(JobID jobId)	No. An exception is reported.
JobClient	getClusterStatus()	No. An exception is reported.
JobClient	getClusterStatus(boolean detailed)	No. An exception is reported.
JobClient	getDefaultMaps()	No. An exception is reported.
JobClient	getDefaultReduces()	No. An exception is reported.
JobClient	getDelegationToken(Text renewer)	No. An exception is reported.
JobClient	getFs()	No. An exception is reported.
JobClient	getJob(JobID jobid)	No. An exception is reported.
JobClient	getJob(String jobid)	No. An exception is reported.
JobClient	getJobsFromQueue(String queueName)	No. An exception is reported.
JobClient	getMapTaskReports(JobID jobId)	No. An exception is reported.
JobClient	getMapTaskReports(String jobId)	No. An exception is reported.
JobClient	getQueueAclsForCurrentUser()	No. An exception is reported.
JobClient	getQueueInfo(String queueName)	No. An exception is reported.
JobClient	getQueues()	No. An exception is reported.
JobClient	getReduceTaskReports(JobID jobId)	No. An exception is reported.
JobClient	getReduceTaskReports(String jobId)	No. An exception is reported.
JobClient	getSetupTaskReports(JobID jobId)	No. An exception is reported.
JobClient	getStagingAreaDir()	No. An exception is reported.
JobClient	getSystemDir()	No. An exception is reported.
JobClient	getTaskOutputFilter()	No. An exception is reported.
JobClient	getTaskOutputFilter(JobConf job)	No. An exception is reported.

Type	Interface	Compatible with Hadoop MapReduce?
JobClient	init(JobConf conf)	No. An exception is reported.
JobClient	isJobDirValid(Path jobDirPath, FileSystem fs)	No. An exception is reported.
JobClient	jobsToComplete()	No. An exception is reported.
JobClient	monitorAndPrintJob(JobConf conf, RunningJob job)	No. An exception is reported.
JobClient	renewDelegationToken(Token<DelegationTokenIdentifier> token)	No. An exception is reported.
JobClient	run(String[] argv)	No. An exception is reported.
JobClient	runJob(JobConf job)	Yes
JobClient	setTaskOutputFilter(JobClient.TaskStatusFilter newValue)	No. An exception is reported.
JobClient	setTaskOutputFilter(JobConf job, JobClient.TaskStatusFilter newValue)	No. An exception is reported.
JobClient	submitJob(JobConf job)	Yes
JobClient	submitJob(String jobFile)	No. An exception is reported.
JobConf	deleteLocalFiles()	No. An exception is reported.
JobConf	deleteLocalFiles(String subdir)	No. An exception is reported.
JobConf	normalizeMemoryConfigValue(long val)	Empty implementation
JobConf	setCombinerClass(Class<? extends Reducer> theClass)	Yes
JobConf	setCompressMapOutput(boolean compress)	Empty implementation
JobConf	setInputFormat(Class<? extends InputFormat> theClass)	No. An exception is reported.
JobConf	setJar(String jar)	No. An exception is reported.
JobConf	setJarByClass(Class cls)	No. An exception is reported.
JobConf	setJobEndNotificationURI(String uri)	No. An exception is reported.

Type	Interface	Compatible with Hadoop MapReduce?
JobConf	setJobName(String name)	Empty implementation
JobConf	setJobPriority(JobPriority prio)	No. An exception is reported.
JobConf	setKeepFailedTaskFiles(boolean keep)	No. An exception is reported.
JobConf	setKeepTaskFilesPattern(String pattern)	No. An exception is reported.
JobConf	setKeyFieldComparatorOptions(String keySpec)	No. An exception is reported.
JobConf	setKeyFieldPartitionerOptions(String keySpec)	No. An exception is reported.
JobConf	setMapDebugScript(String mDbgScript)	Empty implementation
JobConf	setMapOutputCompressorClass(Class<? extends CompressionCodec> codecClass)	Empty implementation
JobConf	setMapOutputKeyClass(Class<? > theClass)	Yes
JobConf	setMapOutputValueClass(Class<? > theClass)	Yes
JobConf	setMapperClass(Class<? extends Mapper> theClass)	Yes
JobConf	setMapRunnerClass(Class<? extends MapRunnable> theClass)	No. An exception is reported.
JobConf	setMapSpeculativeExecution(boolean speculativeExecution)	Empty implementation
JobConf	setMaxMapAttempts(int n)	Empty implementation
JobConf	setMaxMapTaskFailuresPercent(int percent)	Empty implementation
JobConf	setMaxPhysicalMemoryForTask(long mem)	Empty implementation
JobConf	setMaxReduceAttempts(int n)	Empty implementation
JobConf	setMaxReduceTaskFailuresPercent(int percent)	Empty implementation

Type	Interface	Compatible with Hadoop MapReduce?
JobConf	setMaxTaskFailuresPerTracker(int noFailures)	Empty implementation
JobConf	setMaxVirtualMemoryForTask(long vmem)	Empty implementation
JobConf	setMemoryForMapTask(long mem)	Yes
JobConf	setMemoryForReduceTask(long mem)	Yes
JobConf	setNumMapTasks(int n)	Yes
JobConf	setNumReduceTasks(int n)	Yes
JobConf	setNumTasksToExecutePerJvm(int numTasks)	Empty implementation
JobConf	setOutputCommitter(Class<? extends OutputCommitter> theClass)	No. An exception is reported.
JobConf	setOutputFormat(Class<? extends OutputFormat> theClass)	Empty implementation
JobConf	setOutputKeyClass(Class<? > theClass)	Yes
JobConf	setOutputKeyComparatorClass(Class<? extends RawComparator> theClass)	No. An exception is reported.
JobConf	setOutputValueClass(Class<? > theClass)	Yes
JobConf	setOutputValueGroupingComparator(Class<? extends RawComparator> theClass)	No. An exception is reported.
JobConf	setPartitionerClass(Class<? extends Partitioner> theClass)	Yes
JobConf	setProfileEnabled(boolean newValue)	Empty implementation
JobConf	setProfileParams(String value)	Empty implementation
JobConf	setProfileTaskRange(boolean isMap, String newValue)	Empty implementation

Type	Interface	Compatible with Hadoop MapReduce?
JobConf	setQueueName(String queueName)	No. An exception is reported.
JobConf	setReduceDebugScript(String rDbgScript)	Empty implementation
JobConf	setReducerClass(Class<? extends Reducer> theClass)	Yes
JobConf	setReduceSpeculativeExecution(boolean speculativeExecution)	Empty implementation
JobConf	setSessionId(String sessionId)	Empty implementation
JobConf	setSpeculativeExecution(boolean speculativeExecution)	No. An exception is reported.
JobConf	setUseNewMapper(boolean flag)	Yes
JobConf	setUseNewReducer(boolean flag)	Yes
JobConf	setUser(String user)	Empty implementation
JobConf	setWorkingDirectory(Path dir)	Empty implementation
FileInputFormat	N/A	No. An exception is reported.
TextInputFormat	N/A	Yes
InputSplit	mapred.min.split.size.	No. An exception is reported.
FileSplit	map.input.file	No. An exception is reported.
RecordWriter	N/A	No. An exception is reported.
RecordReader	N/A	No. An exception is reported.
OutputFormat	N/A	No. An exception is reported.
OutputCommitter	abortJob(JobContext jobContext, int status)	No. An exception is reported.
OutputCommitter	abortJob(JobContext context, JobStatus.State runState)	No. An exception is reported.
OutputCommitter	abortTask(TaskAttemptContext taskContext)	No. An exception is reported.
OutputCommitter	abortTask(TaskAttemptContext taskContext)	No. An exception is reported.

Type	Interface	Compatible with Hadoop MapReduce?
OutputCommitter	cleanupJob(JobContext jobContext)	No. An exception is reported.
OutputCommitter	cleanupJob(JobContext context)	No. An exception is reported.
OutputCommitter	commitJob(JobContext jobContext)	No. An exception is reported.
OutputCommitter	commitJob(JobContext context)	No. An exception is reported.
OutputCommitter	commitTask(TaskAttemptContext taskContext)	No. An exception is reported.
OutputCommitter	needsTaskCommit(TaskAttemptContext taskContext)	No. An exception is reported.
OutputCommitter	needsTaskCommit(TaskAttemptContext taskContext)	No. An exception is reported.
OutputCommitter	setupJob(JobContext jobContext)	No. An exception is reported.
OutputCommitter	setupJob(JobContext jobContext)	No. An exception is reported.
OutputCommitter	setupTask(TaskAttemptContext taskContext)	No. An exception is reported.
OutputCommitter	setupTask(TaskAttemptContext taskContext)	No. An exception is reported.
Counter	getDisplayName()	Yes
Counter	getName()	Yes
Counter	getValue()	Yes
Counter	increment(long incr)	Yes
Counter	setValue(long value)	Yes
Counter	setDisplayName(String displayName)	Yes
DistributedCache	CACHE_ARCHIVES	No. An exception is reported.
DistributedCache	CACHE_ARCHIVES_SIZES	No. An exception is reported.
DistributedCache	CACHE_ARCHIVES_TIMESTAMPS	No. An exception is reported.
DistributedCache	CACHE_FILES	No. An exception is reported.
DistributedCache	CACHE_FILES_SIZES	No. An exception is reported.

Type	Interface	Compatible with Hadoop MapReduce?
DistributedCache	CACHE_FILES_TIMESTAMPS	No. An exception is reported.
DistributedCache	CACHE_LOCALARCHIVES	No. An exception is reported.
DistributedCache	CACHE_LOCALFILES	No. An exception is reported.
DistributedCache	CACHE_SYMLINK	No. An exception is reported.
DistributedCache	addArchiveToClassPath(Path archive, Configuration conf)	No. An exception is reported.
DistributedCache	addArchiveToClassPath(Path archive, Configuration conf, FileSystem fs)	No. An exception is reported.
DistributedCache	addCacheArchive(URI uri, Configuration conf)	No. An exception is reported.
DistributedCache	addCacheFile(URI uri, Configuration conf)	No. An exception is reported.
DistributedCache	addFileToClassPath(Path file, Configuration conf)	No. An exception is reported.
DistributedCache	addFileToClassPath(Path file, Configuration conf, FileSystem fs)	No. An exception is reported.
DistributedCache	addLocalArchives(Configuration conf, String str)	No. An exception is reported.
DistributedCache	addLocalFiles(Configuration conf, String str)	No. An exception is reported.
DistributedCache	checkURIs(URI[] uriFiles, URI[] uriArchives)	No. An exception is reported.
DistributedCache	createAllSymlink(Configuration conf, File jobCacheDir, File workDir)	No. An exception is reported.
DistributedCache	createSymlink(Configuration conf)	No. An exception is reported.
DistributedCache	getArchiveClassPaths(Configuration conf)	No. An exception is reported.
DistributedCache	getArchiveTimestamps(Configuration conf)	No. An exception is reported.
DistributedCache	getCacheArchives(Configuration conf)	No. An exception is reported.

Type	Interface	Compatible with Hadoop MapReduce?
DistributedCache	getCacheFiles(Configuration conf)	No. An exception is reported.
DistributedCache	getFileClassPaths(Configuration conf)	No. An exception is reported.
DistributedCache	getFileStatus(Configuration conf, URI cache)	No. An exception is reported.
DistributedCache	getFileTimestamps(Configuration conf)	No. An exception is reported.
DistributedCache	getLocalCacheArchives(Configuration conf)	No. An exception is reported.
DistributedCache	getLocalCacheFiles(Configuration conf)	No. An exception is reported.
DistributedCache	getSymlink(Configuration conf)	No. An exception is reported.
DistributedCache	getTimestamp(Configuration conf, URI cache)	No. An exception is reported.
DistributedCache	setArchiveTimestamps(Configuration conf, String timestamps)	No. An exception is reported.
DistributedCache	setCacheArchives(URI[] archives, Configuration conf)	No. An exception is reported.
DistributedCache	setCacheFiles(URI[] files, Configuration conf)	No. An exception is reported.
DistributedCache	setFileTimestamps(Configuration conf, String timestamps)	No. An exception is reported.
DistributedCache	setLocalArchives(Configuration conf, String str)	No. An exception is reported.
DistributedCache	setLocalFiles(Configuration conf, String str)	No. An exception is reported.
IsolationRunner	N/A	No. An exception is reported.
Profiling	N/A	Empty implementation
Debugging	N/A	Empty implementation
Data Compression	N/A	Yes
Skipping Bad Records	N/A	No. An exception is reported.
Job Authorization	mapred.acls.enabled	No. An exception is reported.

Type	Interface	Compatible with Hadoop MapReduce?
Job Authorization	mapreduce.job.acl-view-job	No. An exception is reported.
Job Authorization	mapreduce.job.acl-modify-job	No. An exception is reported.
Job Authorization	mapreduce.cluster.administrators	No. An exception is reported.
Job Authorization	mapred.queue.queue-name.acl-administer-jobs	No. An exception is reported.
MultipleInputs	N/A	No. An exception is reported.
Multi{anchor:_GoBack}pleOutputs	N/A	Yes
org.apache.hadoop.mapreduce.lib.db	N/A	No. An exception is reported.
org.apache.hadoop.mapreduce.security	N/A	No. An exception is reported.
org.apache.hadoop.mapreduce.lib.jobcontrol	N/A	No. An exception is reported.
org.apache.hadoop.mapreduce.lib.chain	N/A	No. An exception is reported.
org.apache.hadoop.mapreduce.lib.db	N/A	No. An exception is reported.

1.8.4. Data types

MapReduce supports the following data types: bigint, double, string, datetime, boolean, decimal, tinyint, smallint, int, float, varchar, timestamp, binary, array, map, and struct. The following table lists the mappings between MaxCompute data types and Java types.

Data type mapping

MaxCompute type	Java type
Tinyint	java.lang.Byte
Smallint	java.lang.Short
Int	java.lang.Integer
Bigint	java.lang.Long
Float	java.lang.Float
Double	java.lang.Double

MaxCompute type	Java type
Decimal	java.math.BigDecimal
Boolean	java.lang.Boolean
String	java.lang.String
Varchar	com.aliyun.odps.data.Varchar
Binary	com.aliyun.odps.data.Binary
Datetime	java.util.Date
Timestamp	java.sql.Timestamp
Array	java.util.List
Map	java.util.Map
Struct	com.aliyun.odps.data.Struct

1.8.5. Limits

The following limits apply to MapReduce:

- A Map or Reduce worker consumes 2,048 MB memory by default. The value range is 256 MB to 12 GB.
- Each task can reference up to 256 resources. Each partitioned table is considered as one unit.
- Each task can have up to 1,024 inputs and up to 256 outputs.
- Each task can have up to 64 custom counters.
- The number of Map instances in a job is calculated by the framework based on the split size. If no input table is specified, you can use odps.stage.mapper.num to set the number of Map instances. The number is in the range of 1 to 100,000.
- The default number of Reduce instances in a job is 1/4 of the number of Map instances. You can set this number in the range of 0 to 2,000. The following situation may occur: Reduce instances process much more data than Map instances, which results in a slow Reduce stage. Furthermore, a maximum of 2,000 Reduce instances can be created.
- Each Map or Reduce instance can retry three times after failure. Exceptions that do not allow retries can cause a job to fail.
- For local jobs, the number of Map or Reduce workers cannot exceed 100, while the number of downloads for an input is 100 by default.
- Each Map or Reduce worker can read a resource a maximum of 64 times.
- A task can reference a maximum of 2 GB resources.
- The framework determines the number of Map instances based on the split size.
- The length of string columns in MaxCompute tables cannot exceed 8 MB.
- If no data access operations or heartbeat packets are sent through context.progress(), the default timeout period of a Map or Reduce worker is 600s.

1.8.6. Sample programs

1.8.6.1. WordCount example

Example:

```
package com.aliyun.odps.mapred.open.example;
import java.io.IOException; import java.util.Iterator;
import com.aliyun.odps.data.Record;
import com.aliyun.odps.data.TableInfo;
import com.aliyun.odps.mapred.JobClient;
import com.aliyun.odps.mapred.MapperBase;
import com.aliyun.odps.mapred.ReducerBase;
import com.aliyun.odps.mapred.TaskContext;
import com.aliyun.odps.mapred.conf.JobConf;
import com.aliyun.odps.mapred.utils.InputUtils;
import com.aliyun.odps.mapred.utils.OutputUtils;
import com.aliyun.odps.mapred.utils.SchemaUtils;
public class WordCount {
public static class TokenizerMapper extends MapperBase {
private Record word;
private Record one;
@Override
public void setup(TaskContext context) throws IOException {
word = context.createMapOutputKeyRecord();
one = context.createMapOutputValueRecord();
one.set(new Object[] { 1L });
System.out.println("TaskID:" + context.getTaskID().toString());
}
@Override
public void map(long recordNum, Record record, TaskContext context) throws IOException {
for (int i = 0; i < record.getColumnCount(); i++) {
word.set(new Object[] { record.get(i).toString() });
context.write(word, one);
}
}
}
/**
*A combiner class that combines map output by sum them.
**/
public static class SumCombiner extends ReducerBase {
private Record count;
```

```
@Override
public void setup(TaskContext context) throws IOException {
count = context.createMapOutputValueRecord();
}
@Override
public void reduce(Record key, Iterator<Record> values, TaskContext context)
throws IOException {
long c = 0;
while (values.hasNext()) {
Record val = values.next();
c += (Long) val.get(0);
}
count.set(0, c);
context.write(key, count);
}
}
/**
* A reducer class that just emits the sum of the input values.
**/
public static class SumReducer extends ReducerBase {
private Record result = null;
@Override
public void setup(TaskContext context) throws IOException { result = context.createOutputRecord();
}
@Override
public void reduce(Record key, Iterator<Record> values, TaskContext context)
throws IOException {
long count = 0;
while (values.hasNext()) {
Record val = values.next();
count += (Long) val.get(0);
}
result.set(0, key.get(0));
result.set(1, count);
context.write(result);
}
}
public static void main(String[] args)
throws Exception {
if (args.length ! = 2) {
```

```
System.err.println("Usage: WordCount <in_table> <out_table>");
System.exit(2);
}
JobConf job = new JobConf();
job.setMapperClass(TokenizerMapper.class);
job.setCombinerClass(SumCombiner.class);
job.setReducerClass(SumReducer.class);
job.setMapOutputKeySchema(SchemaUtils.fromString("word:string"));
job.setMapOutputValueSchema(SchemaUtils.fromString("count:bigint"));
InputUtils.addTable(TableInfo.builder().tableName(args[0]).build(), job);
OutputUtils.addTable(TableInfo.builder().tableName(args[1]).build(), job);
JobClient.runJob(job);
}
}
```

1.8.6.2. MapOnly example

For MapOnly jobs, Map directly sends < Key, Value > pairs to tables on MaxCompute. You only need to specify output tables. You do not need to specify the key-value metadata for map output.

Example:

```
package com.aliyun.odps.mapred.open.example;
import java.io.IOException;
import com.aliyun.odps.data.Record;
import com.aliyun.odps.mapred.JobClient;
import com.aliyun.odps.mapred.MapperBase;
import com.aliyun.odps.mapred.conf.JobConf;
import com.aliyun.odps.mapred.utils.SchemaUtils;
import com.aliyun.odps.mapred.utils.InputUtils;
import com.aliyun.odps.mapred.utils.OutputUtils;
import com.aliyun.odps.data.TableInfo;
public class MapOnly {
public static class MapperClass extends MapperBase {
@Override
public void setup(TaskContext context)
throws IOException {
boolean is = context.getJobConf().getBoolean("option.mapper.setup", false);
if (is) {
Record result = context.createOutputRecord();
result.set(0, "setup");
result.set(1, 1L); context.write(result);
}
```

```
}
@Override
public void map(long key, Record record, TaskContext context) throws IOException {
boolean is = context.getJobConf().getBoolean("option.mapper.map", false);
if (is) {
Record result = context.createOutputRecord();
result.set(0, record.get(0));
result.set(1, 1L); context.write(result);
}
}
@Override
public void cleanup(TaskContext context) throws IOException {
boolean is = context.getJobConf().getBoolean("option.mapper.cleanup", false);
if (is) {
Record result = context.createOutputRecord();
result.set(0, "cleanup");
result.set(1, 1L); context.write(result);
}
}
}
public static void main(String[] args) throws Exception {
if (args.length ! = 2 && args.length ! = 3) {
System.err.println("Usage: OnlyMapper <in_table> <out_table> [setup|map|cleanup]");
System.exit(2);
}
JobConf job = new JobConf();
job.setMapperClass(MapperClass.class);
job.setNumReduceTasks(0);
InputUtils.addTable(TableInfo.builder().tableName(args[0]).build(), job);
OutputUtils.addTable(TableInfo.builder().tableName(args[1]).build(), job);
if (args.length == 3) {
String options = new String(args[2]);
if (options.contains("setup")) {
job.setBoolean("option.mapper.setup", true);
}
if (options.contains("map")) {
job.setBoolean("option.mapper.map", true);
}
if (options.contains("cleanup")) {
job.setBoolean("option.mapper.cleanup", true);
```

```
}
}
JobClient.runJob(job);
}
}
```

1.8.6.3. Example: Input and output data to multiple objects

MaxCompute jobs can read data from multiple input tables, and write data to multiple output tables. All input tables for a job must have the same schema (number and type of columns). The output tables for a job can have different schemas (number and type of columns).

Example:

```
package com.aliyun.odps.mapred.open.example;
import java.io.IOException; import java.util.Iterator;
import java.util.LinkedHashMap;
import com.aliyun.odps.data.Record;
import com.aliyun.odps.data.TableInfo;
import com.aliyun.odps.mapred.JobClient;
import com.aliyun.odps.mapred.MapperBase;
import com.aliyun.odps.mapred.ReducerBase;
import com.aliyun.odps.mapred.TaskContext;
import com.aliyun.odps.mapred.conf.JobConf;
import com.aliyun.odps.mapred.utils.InputUtils;
import com.aliyun.odps.mapred.utils.OutputUtils;
import com.aliyun.odps.mapred.utils.SchemaUtils;
/**
*Multi input & output example.
*
*To run: jar -resources odps-mapred-example-0.12.0.jar com.aliyun.odps.mapred.open.example.MultipleInO
ut
*mr_src,mr_src1,mr_srcpart|pt=1,mr_srcpart|pt=2/ds=2
*mr_multiinout_out1,mr_multiinout_out2|a=1/b=1|out1,mr_multiinout_out2|a=2/b=2|out2;
*
**/
public class MultipleInOut {
public static class TokenizerMapper extends MapperBase {
private Record word;
private Record one;
@Override
```

```
public void setup(TaskContext context) throws IOException {
word = context.createMapOutputKeyRecord();
one = context.createMapOutputValueRecord();
one.set(new Object[] { 1L });
}
@Override
public void map(long recordNum, Record record, TaskContext context)
throws IOException {
for (int i = 0; i < record.getColumnCount(); i++) {
word.set(new Object[] { record.get(i).toString() });
context.write(word, one);
}
}
}
public static class SumReducer extends ReducerBase {
private Record result;
private Record result1;
private Record result2;
@Override
public void setup(TaskContext context) throws IOException {
result = context.createOutputRecord();
result1 = context.createOutputRecord("out1");
result2 = context.createOutputRecord("out2");
}
@Override
public void reduce(Record key, Iterator<Record> values, TaskContext context)
throws IOException { long count = 0;
while (values.hasNext()) {
Record val = values.next();
count += (Long) val.get(0);
}
long mod = count % 3;
if (mod == 0) {
result.set(0, key.get(0));
result.set(1, count);
// No label is specified. Default output is adopted.
context.write(result);
} else if (mod == 1) {
result1.set(0, key.get(0));
result1.set(1, count);
context.write(result1, "out1");
```

```
} else {
result2.set(0, key.get(0));
result2.set(1, count);
context.write(result2, "out2");
}
}
@Override
public void cleanup(TaskContext context) throws IOException {
Record result = context.createOutputRecord();
result.set(0, "default");
result.set(1, 1L);
context.write(result);
Record result1 = context.createOutputRecord("out1");
result1.set(0, "out1");
result1.set(1, 1L); context.write(result1, "out1");
Record result2 = context.createOutputRecord("out2");
result2.set(0, "out1");
result2.set(1, 1L); context.write(result2, "out2");
}
}
public static LinkedHashMap<String, String> convertPartSpecToMap( String partSpec) {
LinkedHashMap<String, String> map = new LinkedHashMap<String, String>();
if (partSpec ! = null && ! partSpec.trim().isEmpty()) {
String[] parts = partSpec.split("/");
for (String part : parts) {
String[] ss = part.split("=");
if (ss.length ! = 2) {
throw new RuntimeException("ODPS-0730001: error part spec format: "+ partSpec);
}
map.put(ss[0], ss[1]);
}
}
return map;
}
public static void main(String[] args) throws Exception {
String[] inputs = null;
String[] outputs = null;
if (args.length == 2) {
inputs = args[0].split(",");
outputs = args[1].split(",");
```

```
} else {
System.err.println("MultipleInOut in... out...");
System.exit(1);
}
JobConf job = new JobConf();
job.setMapperClass(TokenizerMapper.class);
job.setReducerClass(SumReducer.class);
job.setMapOutputKeySchema(SchemaUtils.fromString("word:string"));
job.setMapOutputValueSchema(SchemaUtils.fromString("count:bigint"));
 // Parse input table strings.
for (String in : inputs) { String[] ss = in.split("\\|");
if (ss.length == 1) {
InputUtils.addTable(TableInfo.builder().tableName(ss[0]).build(), job);
} else if (ss.length == 2) {
LinkedHashMap<String, String> map = convertPartSpecToMap(ss[1]);
InputUtils.addTable(TableInfo.builder().tableName(ss[0]).partSpec(map).build(), job);
} else {
System.err.println("Style of input: " + in + " is not right");
System.exit(1);
}
}
// Parse output table strings.
for (String out : outputs) { String[] ss = out.split("\\|");
if (ss.length == 1) {
OutputUtils.addTable(TableInfo.builder().tableName(ss[0]).build(), job);
} else if (ss.length == 2) {
LinkedHashMap<String, String> map = convertPartSpecToMap(ss[1]);
OutputUtils.addTable(TableInfo.builder().tableName(ss[0]).partSpec(map).build(), job);
} else if (ss.length == 3) {
if (ss[1].isEmpty()) {
LinkedHashMap<String, String> map = convertPartSpecToMap(ss[2]);
OutputUtils.addTable(TableInfo.builder().tableName(ss[0]).partSpec(map).build(), job);
} else {
LinkedHashMap<String, String> map = convertPartSpecToMap(ss[1]);
OutputUtils.addTable(TableInfo.builder().tableName(ss[0]).partSpec(map).label(ss[2]).build(), job);
}} else {
System.err.println("Style of output: " + out + " is not right");
System.exit(1);
}
}
JobClient.runJob(job);
```

```
}
}
```

1.8.6.4. Multi-task example

Example:

```
package com.aliyun.odps.mapred.open.example;
import java.io.IOException;
import java.util.Iterator;
import com.aliyun.odps.data.Record;
import com.aliyun.odps.data.TableInfo;
import com.aliyun.odps.mapred.JobClient;
import com.aliyun.odps.mapred.MapperBase;
import com.aliyun.odps.mapred.RunningJob;
import com.aliyun.odps.mapred.TaskContext;
import com.aliyun.odps.mapred.conf.JobConf;
import com.aliyun.odps.mapred.utils.InputUtils;
import com.aliyun.odps.mapred.utils.OutputUtils;
import com.aliyun.odps.mapred.utils.SchemaUtils;
/**
* MultiJobs
*
* Running multiple job
*
* To run: jar -resources > multijobs_res_table,odps-mapred-example-0.12.0.jar
* com.aliyun.odps.mapred.open.example.MultiJobs mr_multijobs_out;
*
**/
public class MultiJobs {
public static class InitMapper extends MapperBase {
@Override
public void setup(TaskContext context) throws IOException { Record record = context.createOutputRecord()
;
long v = context.getJobConf().getLong("multijobs.value", 2);
record.set(0, v);
context.write(record);
}
}
public static class DecreaseMapper extends MapperBase {
@Override
```

```
public void cleanup(TaskContext context) throws IOException {
 // Obtain the variable values defined by the main function from JobConf.
long expect = context.getJobConf().getLong("multijobs.expect.value", -1);
long v = -1;
int count = 0;
Iterator<Record> iter = context.readResourceTable("multijobs_res_table");
while (iter.hasNext()) {
Record r = iter.next();
v = (Long) r.get(0);
if (expect ! = v) {
throw new IOException("expect: " + expect + ", but: " + v);
}
count++;
}
if (count ! = 1) {
throw new IOException("res_table should have 1 record, but: " + count);
}
Record record = context.createOutputRecord();
v--;
record.set(0, v);
context.write(record);
context.getCounter("multijobs", "value").setValue(v);
}
}
public static void main(String[] args) throws Exception { if (args.length ! = 1) {
System.err.println("Usage: TestMultiJobs <table>");
System.exit(1);
}
String tbl = args[0];
long iterCount = 2;
System.err.println("Start to run init job.");
JobConf initJob = new JobConf();
initJob.setLong("multijobs.value", iterCount);
initJob.setMapperClass(InitMapper.class);
InputUtils.addTable(TableInfo.builder().tableName("mr_empty").build(), initJob);
OutputUtils.addTable(TableInfo.builder().tableName(tbl).build(), initJob);
initJob.setMapOutputKeySchema(SchemaUtils.fromString("key:string"));
initJob.setMapOutputValueSchema(SchemaUtils.fromString("value:string"));
initJob.setNumReduceTasks(0); JobClient.runJob(initJob);
while (true) {
System.err.println("Start to run iter job, count: " + iterCount);
```

```
JobConf decJob = new JobConf();
decJob.setLong("multijobs.expect.value", iterCount);
decJob.setMapperClass(DecreaseMapper.class);
InputUtils.addTable(TableInfo.builder().tableName("mr_empty").build(), decJob);
OutputUtils.addTable(TableInfo.builder().tableName(tbl).build(), decJob);
decJob.setNumReduceTasks(0);
RunningJob rJob = JobClient.runJob(decJob); iterCount--;
if (rJob.getCounters().findCounter("multijobs", "value").getValue() == 0) { break;
}
}
if (iterCount ! = 0) {
throw new IOException("Job failed.");
}
}
}
```

1.8.6.5. Secondary sorting example

Example:

```
package com.aliyun.odps.mapred.open.example;
import java.io.IOException;
import java.util.Iterator;
import com.aliyun.odps.data.Record;
import com.aliyun.odps.mapred.JobClient;
import com.aliyun.odps.mapred.MapperBase;
import com.aliyun.odps.mapred.ReducerBase;
import com.aliyun.odps.mapred.TaskContext;
import com.aliyun.odps.mapred.conf.JobConf;
import com.aliyun.odps.mapred.utils.SchemaUtils;
import com.aliyun.odps.mapred.utils.InputUtils;
import com.aliyun.odps.mapred.utils.OutputUtils;
import com.aliyun.odps.data.TableInfo;
/**
* This is an example ODPS Map/Reduce application. It reads the input > table that
* must contain two integers per record. The output is sorted by the > first and
* second number and grouped by the first number.
*
* To run: jar -resources odps-mapred-example-0.12.0.jar
* com.aliyun.odps.mapred.open.example.SecondarySort mr_sort_in > mr_secondarysort_out;
*
```

```
**/
public class SecondarySort {
/**
* Read two integers from each line and generate a key, value pair as > ((left,
* right), right).
**/
public static class MapClass extends MapperBase { private Record key;
private Record value;
@Override
public void setup(TaskContext context) throws IOException { key = context.createMapOutputKeyRecord();
value = context.createMapOutputValueRecord();
}
@Override
public void map(long recordNum, Record record, TaskContext context) throws IOException {
long left = 0;
long right = 0;
if (record.getColumnCount() > 0) { left = (Long) record.get(0);
if (record.getColumnCount() > 1) { right = (Long) record.get(1);
}
key.set(new Object[] { (Long) left, (Long) right });
value.set(new Object[] { (Long) right });
context.write(key, value);
}
}
}
/**
* A reducer class that just emits the sum of the input values.
**/
public static class ReduceClass extends ReducerBase {
private Record result = null;
@Override
public void setup(TaskContext context) throws IOException { result = context.createOutputRecord();
}
@Override
public void reduce(Record key, Iterator<Record> values, TaskContext context) throws IOException {
result.set(0, key.get(0));
while (values.hasNext()) {
Record value = values.next();
result.set(1, value.get(0));
context.write(result);
}
```

```
}
}
public static void main(String[] args) throws Exception {
if (args.length ! = 2) {
System.err.println("Usage: secondarysrot <in> <out>");
System.exit(2);
}
JobConf job = new JobConf();
job.setMapperClass(MapClass.class);
job.setReducerClass(ReduceClass.class);
// Set multiple columns as keys.
// compare first and second parts of the pair
job.setOutputKeySortColumns(new String[] { "i1", "i2" });
// partition based on the first part of the pair
job.setPartitionColumns(new String[] { "i1" });
// grouping comparator based on the first part of the pair
job.setOutputGroupingColumns(new String[] { "i1" });
// the map output is LongPair, Long
job.setMapOutputKeySchema(SchemaUtils.fromString("i1:bigint,i2:bigint"));
job.setMapOutputValueSchema(SchemaUtils.fromString("i2x:bigint"));
InputUtils.addTable(TableInfo.builder().tableName(args[0]).build(), job);
OutputUtils.addTable(TableInfo.builder().tableName(args[1]).build(), job);
JobClient.runJob(job); System.exit(0);
}
}
```

1.8.6.6. Resource usage example

Example:

```
package com.aliyun.odps.mapred.open.example;
import java.io.BufferedInputStream;
import java.io.FileNotFoundException;
import java.io.IOException;
import com.aliyun.odps.data.Record;
import com.aliyun.odps.data.TableInfo;
import com.aliyun.odps.mapred.JobClient;
import com.aliyun.odps.mapred.MapperBase;
import com.aliyun.odps.mapred.TaskContext;
import com.aliyun.odps.mapred.conf.JobConf;
import com.aliyun.odps.mapred.utils.InputUtils;
```

```
import com.aliyun.odps.mapred.utils.OutputUtils;
import com.aliyun.odps.mapred.utils.SchemaUtils;
/**
* Upload
*
* Import data from text file into table
*
* To run: jar -resources > odps-mapred-example-0.12.0.jar,mr_join_src1.txt
* com.aliyun.odps.mapred.open.example.Upload mr_join_src1.txt > mr_join_src1;
*
**/
public class Upload {
public static class UploadMapper extends MapperBase {
@Override
public void setup(TaskContext context) throws IOException { Record record = context.createOutputRecord()
;
StringBuilder importdata = new StringBuilder();
BufferedInputStream bufferedInput = null;
try {
byte[] buffer = new byte[1024]; int bytesRead = 0;
String filename = context.getJobConf().get("import.filename");
bufferedInput = context.readResourceFileAsStream(filename);
while ((bytesRead = bufferedInput.read(buffer)) ! = -1) {
String chunk = new String(buffer, 0, bytesRead);
importdata.append(chunk);
}
String lines[] = importdata.toString().split("\n"); for (int i = 0; i < lines.length; i++) {
String[] ss = lines[i].split(",");
record.set(0, Long.parseLong(ss[0].trim()));
record.set(1, ss[1].trim()); context.write(record);
}
} catch (FileNotFoundException ex) { throw new IOException(ex);
} catch (IOException ex) { throw new IOException(ex);
} finally {
}
}
@Override
public void map(long recordNum, Record record, TaskContext context) throws IOException {
}
}
public static void main(String[] args) throws Exception { if (args.length ! = 2) {
```

```
public static void main(String[] args) throws Exception { if (args.length != 2) {
System.err.println("Usage: Upload <import_txt> <out_table>");
System.exit(2);
}
JobConf job = new JobConf();
job.setMapperClass(UploadMapper.class);
job.set("import.filename", args[0]);
job.setNumReduceTasks(0);
job.setMapOutputKeySchema(SchemaUtils.fromString("key:bigint"));
job.setMapOutputValueSchema(SchemaUtils.fromString("value:string"));
InputUtils.addTable(TableInfo.builder().tableName("mr_empty").build(), job);
OutputUtils.addTable(TableInfo.builder().tableName(args[1]).build(), job);
JobClient.runJob(job);
}
}
```

> **Note**
>
> You can use the following methods to configure JobConf:
>
> - Use the JobConf API in the SDK. This method has the highest priority.
> - Use the -conf parameter in a jar command to specify a new JobConf file. This method has the lowest priority. For how to use -Conf, refer to the relevant command.

1.8.6.7. Example for using counters

Three counters are defined in this example: map_outputs, reduce_outputs, and global_counts. You can use the setup, map, reduce and cleanup APIs of the Map or Reduce function to obtain and operate custom counters.

Example:

```
package com.aliyun.odps.mapred.open.example;
import java.io.IOException; import java.util.Iterator;
import com.aliyun.odps.counter.Counter;
import com.aliyun.odps.counter.Counters;
import com.aliyun.odps.data.Record;
import com.aliyun.odps.mapred.JobClient;
import com.aliyun.odps.mapred.MapperBase;
import com.aliyun.odps.mapred.ReducerBase;
import com.aliyun.odps.mapred.RunningJob;
import com.aliyun.odps.mapred.conf.JobConf;
import com.aliyun.odps.mapred.utils.SchemaUtils;
import com.aliyun.odps.mapred.utils.InputUtils;
import com.aliyun.odps.mapred.utils.OutputUtils;
```

```
import com.aliyun.odps.mapred.utils.OutputUtils;
import com.aliyun.odps.data.TableInfo;
/**
* User Defined Counters
*
* To run: jar -resources odps-mapred-example-0.12.0.jar
* com.aliyun.odps.mapred.open.example.UserDefinedCounters mr_src > mr_testcounters_out;
*
**/
public class UserDefinedCounters {
enum MyCounter {
TOTAL_TASKS, MAP_TASKS, REDUCE_TASKS
}
public static class TokenizerMapper extends MapperBase {
private Record word;
private Record one;
@Override
public void setup(TaskContext context) throws IOException { super.setup(context);
Counter map_tasks = context.getCounter(MyCounter.MAP_TASKS);
Counter total_tasks = context.getCounter(MyCounter.TOTAL_TASKS);
map_tasks.increment(1);
total_tasks.increment(1);
word = context.createMapOutputKeyRecord();
one = context.createMapOutputValueRecord();
one.set(new Object[] { 1L });
}
@Override
public void map(long recordNum, Record record, TaskContext context) throws IOException {
for (int i = 0;
i < record.getColumnCount();
i++) {
word.set(new Object[] { record.get(i).toString() });
context.write(word, one);
}
}
}
public static class SumReducer extends ReducerBase {
private Record result = null;
@Override
public void setup(TaskContext context) throws IOException { result = context.createOutputRecord();
Counter reduce_tasks = context.getCounter(MyCounter.REDUCE_TASKS);
```

```
Counter total_tasks = context.getCounter(MyCounter.TOTAL_TASKS);
reduce_tasks.increment(1);
total_tasks.increment(1);
}
@Override
public void reduce(Record key, Iterator<Record> values, TaskContext context) throws IOException {
long count = 0;
while (values.hasNext()) {
Record val = values.next();
count += (Long) val.get(0);
}
result.set(0, key.get(0));
result.set(1, count);
context.write(result);
}
}
public static void main(String[] args) throws Exception { if (args.length ! = 2) {
System.err.println("Usage: TestUserDefinedCounters <in_table> <out_table>");
System.exit(2);
}
JobConf job = new JobConf();
job.setMapperClass(TokenizerMapper.class);
job.setReducerClass(SumReducer.class);
job.setMapOutputKeySchema(SchemaUtils.fromString("word:string"));
job.setMapOutputValueSchema(SchemaUtils.fromString("count:bigint"));
InputUtils.addTable(TableInfo.builder().tableName(args[0]).build(), job);
OutputUtils.addTable(TableInfo.builder().tableName(args[1]).build(), job);
RunningJob rJob = JobClient.runJob(job);
Counters counters = rJob.getCounters();
long m = counters.findCounter(MyCounter.MAP_TASKS).getValue();
long r = counters.findCounter(MyCounter.REDUCE_TASKS).getValue();
long total = counters.findCounter(MyCounter.TOTAL_TASKS).getValue();
System.exit(0);
}
}
```

1.8.6.8. grep example

Example:

```
package com.aliyun.odps.mapred.open.example;
```

```
import java.io.IOException;
import java.util.Iterator;
import java.util.regex.Matcher;
import java.util.regex.Pattern;
import com.aliyun.odps.data.Record;
import com.aliyun.odps.data.TableInfo;
import com.aliyun.odps.mapred.JobClient;
import com.aliyun.odps.mapred.Mapper;
import com.aliyun.odps.mapred.MapperBase;
import com.aliyun.odps.mapred.ReducerBase;
import com.aliyun.odps.mapred.RunningJob;
import com.aliyun.odps.mapred.TaskContext;
import com.aliyun.odps.mapred.conf.JobConf;
import com.aliyun.odps.mapred.utils.InputUtils;
import com.aliyun.odps.mapred.utils.OutputUtils;
import com.aliyun.odps.mapred.utils.SchemaUtils;
/**
* Extracts matching regexs from input files and counts them.
*
* To run: jar -resources odps-mapred-example-0.12.0.jar
* com.aliyun.odps.mapred.open.example.Grep mr_src mr_grep_tmp > mr_grep_out val;
**/
public class Grep {
/**
* RegexMapper
**/
public class RegexMapper extends MapperBase { private Pattern pattern;
private int group;
private Record word;
private Record one;
@Override
public void setup(TaskContext context) throws IOException {
JobConf job = (JobConf) context.getJobConf();
pattern = Pattern.compile(job.get("mapred.mapper.regex"));
group = job.getInt("mapred.mapper.regex.group", 0);
word = context.createMapOutputKeyRecord();
one = context.createMapOutputValueRecord();
one.set(new Object[] { 1L });
}
@Override
public void map(long recordNum, Record record, TaskContext context) throws IOException {
```

```
for (int i = 0; i < record.getColumnCount(); ++i) {
String text = record.get(i).toString();
Matcher = pattern. matcher (text );
while (matcher.find()) {
word.set(new Object[] { matcher.group(group) });
context.write(word, one);
}
}
}
}
/**
* LongSumReducer
**/
public class LongSumReducer extends ReducerBase {
private Record result = null;
@Override
public void setup(TaskContext context) throws IOException { result = context.createOutputRecord();
}
@Override
public void reduce(Record key, Iterator<Record> values, TaskContext context) throws IOException {
Long Count = 0;
while (values.hasNext()) {
Record val = values.next();
count += (Long) val.get(0);
}
result.set(0, key.get(0));
result.set(1, count);
context.write(result);
}
}
/**
* A {@link Mapper} that swaps keys and values.
**/
public class InverseMapper extends MapperBase {
private Record word;
private Record count;
@Override
public void setup(TaskContext context) throws IOException {
word = context.createMapOutputValueRecord();
count = context.createMapOutputKeyRecord();
}
```

```
/**
* The inverse function. Input keys and values are swapped.
**/
@Override
public void map(long recordNum, Record record, TaskContext context) throws IOException {
word.set(new Object[] { record.get(0).toString() });
count.set(new Object[] { (Long) record.get(1) });
context.write(count, word);
}
}
/**
* IdentityReducer
**/
public class IdentityReducer extends ReducerBase {
private Record result = null;
@Override
public void setup(TaskContext context) throws IOException {
result = context.createOutputRecord();
}
/** Writes all keys and values directly to output. **/
@Override
public void reduce(Record key, Iterator<Record> values, TaskContext context) throws IOException {
result.set(0, key.get(0));
while (values.hasNext()) {
Record val = values.next();
result.set(1, val.get(0));
context.write(result);
}
}
}
public static void main(String[] args) throws Exception {
if (args.length < 4) {
System.err.println("Grep <inDir> <tmpDir> <outDir> <regex> [<group>]"); System.exit(2);
}
JobConf grepJob = new JobConf();
grepJob.setMapperClass(RegexMapper.class);
grepJob.setReducerClass(LongSumReducer.class);
grepJob.setMapOutputKeySchema(SchemaUtils.fromString("word:string"));
grepJob.setMapOutputValueSchema(SchemaUtils.fromString("count:bigint"));
InputUtils.addTable(TableInfo.builder().tableName(args[0]).build(), grepJob);
```

```
OutputUtils.addTable(TableInfo.builder().tableName(args[1]).build(), grepJob);
grepJob.set("mapred.mapper.regex", args[3]);
if (args.length == 5) {
grepJob.set("mapred.mapper.regex.group", args[4]);
}
@SuppressWarnings("unused")
RunningJob rjGrep = JobClient.runJob(grepJob);
JobConf sortJob = new JobConf();
sortJob.setMapperClass(InverseMapper.class);
sortJob.setReducerClass(IdentityReducer.class);
sortJob.setMapOutputKeySchema(SchemaUtils.fromString("count:bigint"));
sortJob.setMapOutputValueSchema(SchemaUtils.fromString("word:string"));-
InputUtils.addTable(TableInfo.builder().tableName(args[1]).build(), sortJob);
OutputUtils.addTable(TableInfo.builder().tableName(args[2]).build(), sortJob);
sortJob.setNumReduceTasks(1); // write a single file
sortJob.setOutputKeySortColumns(new String[] { "count" });
 // sort by
// decreasing
// freq
@SuppressWarnings("unused")
RunningJob rjSort = JobClient.runJob(sortJob);
}
}
```

1.8.6.9. JOIN example

The MaxCompute MapReduce framework does not support the JOIN logic. However, you can use custom Map and Reduce functions to complete JOIN operations. This requires extra work.

Table mr_join_src1(key bigint, value string) must be joined with mr_join_src2(key bigint, value string). The output table is mr_join_out(key bigint, value1 string, value2 string), where value1 indicates the value of mr_join_src1 and value2 indicates the value of mr_join_src2.

Example:

```
package com.aliyun.odps.mapred.open.example;
import java.io.IOException;
Import java. util. arraylist;
import java.util.Iterator;
import java.util.List;
import com.aliyun.odps.counter.Counter;
import com.aliyun.odps.data.Record;
import com.aliyun.odps.data.TableInfo;
import com.aliyun.odps.mapred.JobClient;
```

```
import com.aliyun.odps.mapred.MapperBase;
import com.aliyun.odps.mapred.ReducerBase;
import com.aliyun.odps.mapred.TaskContext;
import com.aliyun.odps.mapred.conf.JobConf;
import com.aliyun.odps.mapred.utils.InputUtils;
import com.aliyun.odps.mapred.utils.OutputUtils;
import com.aliyun.odps.mapred.utils.SchemaUtils;
/**
* Join
*
* To run: jar -resources odps-mapred-example-0.12.0.jar
* com.aliyun.odps.mapred.open.example.Join mr_join_src11 > mr_join_src22 mr_join_out;
*
**/
public class Join {
public static class JoinMapper extends MapperBase {
private Record mapkey;
private Record mapvalue;
@Override
public void setup(TaskContext context) throws IOException {
mapkey = context.createMapOutputKeyRecord();
mapvalue = context.createMapOutputValueRecord();
}
@Override
public void map(long key, Record record, TaskContext context) throws IOException {
/* Determine the source table of the record based on the value field. This is the user code logic. If the source
table of the record cannot be determined based on the value field, you can add a field in the input table. The
tag generated based on the value field is used in connection operations in the Reduce stage. */
long tag = 1;
String val = record.get(1).toString();
if (val.startsWith("valb_")) {
tag = 2;
}
mapkey.set(0, Long.parseLong(record.get(0).toString()));
mapkey.set(1, tag);
mapvalue.set(0, tag);
for (int i = 1; i < record.getColumnCount(); i++) {
mapvalue.set(i, record.get(i));
}
context.write(mapkey, mapvalue);
}
```

```
}
}
public static class JoinReducer extends ReducerBase {
private Record result = null;
@Override
public void setup(TaskContext context) throws IOException {
result = context.createOutputRecord();
}
@Override
public void reduce(Record key, Iterator<Record> values, TaskContext context) throws IOException {
long k = (Long) key.get(0);
List<Object[]> list1 = new ArrayList<Object[]>();
Counter cnt = context.getCounter("MyCounters", "reduce_outputs");
 cnt.increment(1);
while (values.hasNext()) {
Record value = values.next();
long tag = (Long) value.get(0);
if (tag == 1) {
//If the data comes from the first table, the data is cached in the list.
//Data is sorted by key and tag, so the value with tag==1 is sorted on the top.
//We recommended that you exercise caution when using this method in practice. If a key has many values,
//the memory usage of Reduce stage increases. When the memory usage exceeds the value set by JobConf::s
etMemoryForReduceTask,
//the Reduce stage may be terminated by the system due to memory overflow.
list1.add(value.toArray().clone());
} else {
//If the data comes from the second table, the data is sorted by key and tag.
//All values in the first table have been saved in list1.
//For the values in the first table
for (Object r1: list1) { int index = 0;
//Set the key first.
result.set(index++, k);
Object[] s_arr = (Object[])r1;
result.set(index++, s_arr[1].toString());
result.set(index++, value.get(1).toString());
context.write(result);
}
}
}
}
}
```

```
public static void main(String[] args) throws Exception {
if (args.length ! = 3) {
System.err.println("Usage: Join <input table1> <input table2> <out>");
System.exit(2);
}
JobConf job = new JobConf();
job.setMapperClass(JoinMapper.class);
job.setReducerClass(JoinReducer.class);
job.setMapOutputKeySchema(SchemaUtils.fromString("key:bigint,tag:bigint"));
job.setMapOutputValueSchema(SchemaUtils.fromString("tagx:bigint,value:string"));
job.setPartitionColumns(new String[] { "key" });
//Sort data by key and tag. The JOIN operation can be performed in the Reduce stage only after data sorting
by key.
//The tag indicates the source table of the current record.
job.setOutputKeySortColumns(new String[] { "key", "tag" });
job.setOutputGroupingColumns(new String[] { "key" });
//The Reduce stage uses lists to cache data. Therefore, we recommend that you increase the memory size fo
r Reduce workers.
job.setMemoryForReduceTask(4096);
job.setInt("table.counter", 0);
InputUtils.addTable(TableInfo.builder().tableName(args[0]).build(), job);
InputUtils.addTable(TableInfo.builder().tableName(args[1]).build(), job);
OutputUtils.addTable(TableInfo.builder().tableName(args[2]).build(), job);
JobClient.runJob(job);
}
}
```

1.8.6.10. Sleep example

Example:

```
package com.aliyun.odps.mapred.open.example;
import java.io.IOException;
Import java. util. iterator;
importjava.util.LinkedHashMap;
import java.util.Map;
import org.apache.commons.logging.Log;
import org.apache.commons.logging.LogFactory;
import com.aliyun.odps.OdpsException;
Import com. aliyun. ODPS. Data. record;
import com.aliyun.odps.data.TableInfo;
```

```
import com.aliyun.odps.mapred.JobClient;
import com.aliyun.odps.mapred.MapperBase;
import com.aliyun.odps.mapred.ReducerBase;
import com.aliyun.odps.mapred.TaskContext;
import com.aliyun.odps.mapred.conf.JobConf;
import com.aliyun.odps.mapred.utils.InputUtils;
import com.aliyun.odps.mapred.utils.OutputUtils;
import com.aliyun.odps.mapred.utils.SchemaUtils;
/**
* Dummy class for testing MR framefork. Sleeps for a defined period of > time in
* mapper and reducer. Generates fake input for map / reduce jobs. Note > that
* generated number of input pairs is in the order of
* <code>numMappers
* mapSleepTime / 100</code>, so the > job uses some disk
* space.
* To run: jar -resources odps-mapred-example-0.12.0.jar > com.aliyun.odps.mapred.open.example.SleepJob
* -m 1 -r 1 -mt 1 -rt 1;
*
**/
public class SleepJob {
private static Log LOG = LogFactory.getLog(SleepJob.class);
public static class SleepMapper extends MapperBase {
private LinkedHashMap<Integer, Integer> inputs = new LinkedHashMap<Integer, Integer>();
private long mapSleepDuration = 100;
private int mapSleepCount = 1;
private int count = 0;
private Record key;
@Override
public void setup(TaskContext context) throws IOException{
LOG.info("map setup called");
JobConf conf = (JobConf) context.getJobConf();
mapSleepCount = conf.getInt("sleep.job.map.sleep.count", 1);
if (mapSleepCount < 0)
throw new IOException("Invalid map count: " + mapSleepCount);
mapSleepDuration = conf.getLong("sleep.job.map.sleep.time", 100)
/ mapSleepCount;
LOG.info("mapSleepCount = " + mapSleepCount + ", mapSleepDuration = " + mapSleepDuration);
final int redcount = conf.getInt("sleep.job.reduce.sleep.count", 1);
if (redcount < 0)
throw new IOException("Invalid reduce count: " + redcount);
final int emitPerMapTask = (redcount * conf.getNumReduceTasks());
```

```
int records = 0;
int emitCount = 0;
while (records++ < mapSleepCount) {
int key = emitCount;
int emit = emitPerMapTask / mapSleepCount;
if ((emitPerMapTask) % mapSleepCount > records) {
++emit;
}
emitCount += emit;
int value = emit;
inputs.put(key, value);
}
key = context.createMapOutputKeyRecord();
}
@Override
public void cleanup(TaskContext context) throws IOException {
// it is expected that every map processes mapSleepCount number of
// records.
LOG.info("map run called");
for (Map.Entry<Integer, Integer> entry : inputs.entrySet()) {
LOG.info("Sleeping... (" + (mapSleepDuration * (mapSleepCount - count)) + ") ms left");
try {
Thread.sleep(mapSleepDuration);
} catch (InterruptedException e) { throw new IOException(e);
}
++count;
// output reduceSleepCount * numReduce number of random values, so that
// each reducer will get reduceSleepCount number of keys.
int k = entry.getKey();
int v = entry.getValue();
for (int i = 0; i < v; ++i) {
key.set(new Object[] { (Long) ((long) (k + i)) });
context.write(key, key);
}
}
}
}
public static class SleepReducer extends ReducerBase {
private long reduceSleepDuration = 100;
private int reduceSleepCount = 1;
private int count = 0;
```

```
@Override
public void setup(TaskContext context) throws IOException {
LOG.info("reduce setup called");
JobConf conf = (JobConf) context.getJobConf();
reduceSleepCount = conf.getInt("sleep.job.reduce.sleep.count",
reduceSleepCount);
reduceSleepDuration = conf.getLong("sleep.job.reduce.sleep.time", 100)
/ reduceSleepCount;
LOG.info("reduceSleepCount = " + reduceSleepCount
+ ", reduceSleepDuration = " + reduceSleepDuration);
}
@Override
public void reduce(Record key, Iterator<Record> values, TaskContext context) throws IOException {
LOG.info("reduce called");
LOG.info("Sleeping... ("
+ (reduceSleepDuration * (reduceSleepCount - count)) + ") ms left"); try {
Thread.sleep(reduceSleepDuration);
} catch (InterruptedException e) {
throw new IOException(e);
}
count++;
}
}
public static int run(int numMapper, int numReducer, long mapSleepTime, int mapSleepCount, long reduce
SleepTime, int reduceSleepCount)
throws OdpsException {
JobConf job = setupJobConf(numMapper, numReducer, mapSleepTime, mapSleepCount, reduceSleepTime,
reduceSleepCount);
JobClient.runJob(job);
return 0;
}
public static JobConf setupJobConf(int numMapper, int numReducer, long mapSleepTime, int mapSleepCo
unt, long reduceSleepTime, int reduceSleepCount) {
JobConf job = new JobConf();
InputUtils.addTable(TableInfo.builder().tableName("mr_empty").build(), job);
OutputUtils.addTable(TableInfo.builder().tableName("mr_sleep_out").build(), job);
job.setNumReduceTasks(numReducer);
job.setMapperClass(SleepMapper.class);
job.setReducerClass(SleepReducer.class);
job.setMapOutputKeySchema(SchemaUtils.fromString("int1:bigint"));
```

```
job.setMapOutputValueSchema(SchemaUtils.fromString("int2:bigint"));
job.setPartitionColumns(new String[] { "int1" });
job.setLong("sleep.job.map.sleep.time", mapSleepTime);
job.setLong("sleep.job.reduce.sleep.time", reduceSleepTime);
job.setInt("sleep.job.map.sleep.count", mapSleepCount);
job.setInt("sleep.job.reduce.sleep.count", reduceSleepCount);
return job;
}
private static void printUsage() {
System.err.println("SleepJob [-m numMapper] [-r numReducer]"
+ " [-mt mapSleepTime (msec)] [-rt reduceSleepTime (msec)]"
+ " [-recordt recordSleepTime (msec)]");
}
public static void main(String[] args) throws Exception {
if (args.length < 1) {
printUsage();
return;
}
int numMapper = 1, numReducer = 1;
long mapSleepTime = 100, reduceSleepTime = 100, recSleepTime = 100;
int mapSleepCount = 1, reduceSleepCount = 1;
for (int i = 0; i < args.length; i++) { if (args[i].equals("-m")) {
numMapper = Integer.parseInt(args[++i]);
} else if (args[i].equals("-r")) {
numReducer = Integer.parseInt(args[++i]);
} else if (args[i].equals("-mt")) {
mapSleepTime = Long.parseLong(args[++i]);
} else if (args[i].equals("-rt")) {
reduceSleepTime = Long.parseLong(args[++i]);
} else if (args[i].equals("-recordt")) { recSleepTime = Long.parseLong(args[++i]);
}
}
// sleep for *SleepTime duration in Task by recSleepTime per record
mapSleepCount = (int) Math.ceil(mapSleepTime / ((double) recSleepTime));
reduceSleepCount = (int) Math.ceil(reduceSleepTime
/ ((double) recSleepTime));
run(numMapper, numReducer, mapSleepTime, mapSleepCount, reduceSleepTime, reduceSleepCount);
}
}
```

1.8.6.11. unique example

Example:

```
package com.aliyun.odps.mapred.open.example;
import java.io.IOException;
import java.util.Iterator;
import com.aliyun.odps.data.Record;
import com.aliyun.odps.data.TableInfo;
import com.aliyun.odps.mapred.JobClient;
import com.aliyun.odps.mapred.MapperBase;
import com.aliyun.odps.mapred.ReducerBase;
import com.aliyun.odps.mapred.TaskContext;
import com.aliyun.odps.mapred.conf.JobConf;
import com.aliyun.odps.mapred.utils.InputUtils;
import com.aliyun.odps.mapred.utils.OutputUtils;
import com.aliyun.odps.mapred.utils.SchemaUtils;
/**
* Unique Remove duplicate words
*
* To run: jar -resources odps-mapred-example-0.12.0.jar
* com.aliyun.odps.open.mapred.example.Unique mr_sort_in > mr_unique_out
* key|value|all;
*
**/
public class Unique {
public static class OutputSchemaMapper extends MapperBase {
private Record key;
private Record value;
@Override
public void setup(TaskContext context) throws IOException {
key = context.createMapOutputKeyRecord();
value = context.createMapOutputValueRecord();
}
@Override
public void map(long recordNum, Record record, TaskContext context) throws IOException {
long left = 0;
long right = 0;
if (record.getColumnCount() > 0) { left = (Long) record.get(0);
if (record.getColumnCount() > 1) { right = (Long) record.get(1);
}
```

```
key.set(new Object[] { (Long) left, (Long) right });
value.set(new Object[] { (Long) left, (Long) right });
context.write(key, value);
}
}
}
public static class OutputSchemaReducer extends ReducerBase {
private Record result = null;
@Override
public void setup(TaskContext context) throws IOException {
result = context.createOutputRecord();
}
@Override
public void reduce(Record key, Iterator<Record> values, TaskContext context) throws IOException {
result.set(0, key.get(0));
while (values.hasNext()) {
Record value = values.next();
result.set(1, value.get(1));
}
context.write(result);
}
}
public static void main(String[] args) throws Exception {
if (args.length > 3 || args.length < 2) {
System.err.println("Usage: unique <in> <out> [key|value|all]");
System.exit(2);
}
String ops = "all";
if (args.length == 3) { ops = args[2];
}
// Key Unique
if (ops.equals("key")) {
JobConf job = new JobConf();
job.setMapperClass(OutputSchemaMapper.class);
job.setReducerClass(OutputSchemaReducer.class);
job.setMapOutputKeySchema(SchemaUtils.fromString("key:bigint,value:bigint"));
job.setMapOutputValueSchema(SchemaUtils.fromString("key:bigint,value:bigint"));
job.setPartitionColumns(new String[] { "key" });
job.setOutputKeySortColumns(new String[] { "key", "value" });
job.setOutputGroupingColumns(new String[] { "key" });
job.set("tablename2", args[1]); job.setNumReduceTasks(1);
```

```
job.setInt("table.counter", 0);
InputUtils.addTable(TableInfo.builder().tableName(args[0]).build(), job);
OutputUtils.addTable(TableInfo.builder().tableName(args[1]).build(), job);
JobClient.runJob(job);
}
// Key&Value Unique
if (ops.equals("all")) {
JobConf job = new JobConf();
job.setMapperClass(OutputSchemaMapper.class);
job.setReducerClass(OutputSchemaReducer.class);
job.setMapOutputKeySchema(SchemaUtils.fromString("key:bigint,value:bigint"));
job.setMapOutputValueSchema(SchemaUtils.fromString("key:bigint,value:bigint"));
job.setPartitionColumns(new String[] { "key" });
job.setOutputKeySortColumns(new String[] { "key", "value" });
job.setOutputGroupingColumns(new String[] { "key", "value" });
job.set("tablename2", args[1]); job.setNumReduceTasks(1);
job.setInt("table.counter", 0);
InputUtils.addTable(TableInfo.builder().tableName(args[0]).build(), job);
OutputUtils.addTable(TableInfo.builder().tableName(args[1]).build(), job);
JobClient.runJob(job);
}
// Value Unique
if (ops.equals("value")) { JobConf job = new JobConf();
job.setMapperClass(OutputSchemaMapper.class);
job.setReducerClass(OutputSchemaReducer.class);
job.setMapOutputKeySchema(SchemaUtils.fromString("key:bigint,value:bigint"));
job.setMapOutputValueSchema(SchemaUtils.fromString("key:bigint,value:bigint"));
job.setPartitionColumns(new String[] { "value" });
job.setOutputKeySortColumns(new String[] { "value" });
job.setOutputGroupingColumns(new String[] { "value" });
job.set("tablename2", args[1]); job.setNumReduceTasks(1);
job.setInt("table.counter", 0);
InputUtils.addTable(TableInfo.builder().tableName(args[0]).build(), job);
OutputUtils.addTable(TableInfo.builder().tableName(args[1]).build(), job);
JobClient.runJob(job);
}
}
}
```

1.8.6.12. Sort example

Example:

```
package com.aliyun.odps.mapred.open.example;
import java.io.IOException; import java.util.Date;
import com.aliyun.odps.data.Record;
import com.aliyun.odps.data.TableInfo;
 import com.aliyun.odps.mapred.JobClient;
import com.aliyun.odps.mapred.MapperBase;
import com.aliyun.odps.mapred.TaskContext;
import com.aliyun.odps.mapred.conf.JobConf;
import com.aliyun.odps.mapred.example.lib.IdentityReducer;
import com.aliyun.odps.mapred.utils.InputUtils;
import com.aliyun.odps.mapred.utils.OutputUtils;
import com.aliyun.odps.mapred.utils.SchemaUtils;
/**
* This is the trivial map/reduce program that does absolutely nothing > other
* than use the framework to fragment and sort the input values.
*
* To run: jar -resources odps-mapred-example-0.12.0.jar > com.aliyun.odps.mapred.open.example.Sort
* mr_sort_in mr_sort_out;
*
**/
public class Sort {
static int printUsage() {
System.out.println("sort <input> <output>"); return -1;
}
/**
* Implement the identity function, mapping record's first two columns > to
* outputs.
**/
public static class IdentityMapper extends MapperBase {
private Record key;
private Record value;
@Override
public void setup(TaskContext context) throws IOException {
key = context.createMapOutputKeyRecord();
value = context.createMapOutputValueRecord();
}
@Override
```

```
public void map(long recordNum, Record record, TaskContext context) throws IOException {
Key.set (new object [] {(long) record.get (0 )});
value.set(new Object[] { (Long) record.get(1) });
context.write(key, value);
}
}
/**
* The main driver for sort program. Invoke this method to submit the
* map/reduce job.
*
* @throws IOException
* When there is communication problems with the job tracker.
**/
public static void main(String[] args) throws Exception {
JobConf jobConf = new JobConf();
jobConf.setMapperClass(IdentityMapper.class);
jobConf.setReducerClass(IdentityReducer.class);
jobConf.setNumReduceTasks(1);
Jobconf.setmapoutputkeyschema schemautils schemeiutils.fromstring ("key: bigint "));
jobConf.setMapOutputValueSchema(SchemaUtils.fromString("value:bigint"));
InputUtils.addTable(TableInfo.builder().tableName(args[0]).build(), jobConf);
OutputUtils.addTable(TableInfo.builder().tableName(args[1]).build(), jobConf);
Date startTime = new Date(); System.out.println("Job started: " + startTime);
JobClient.runJob(jobConf);
Date end_time = new Date(); System.out.println("Job ended: " + end_time); System.out.println("The job to
ok " + (end_time.getTime() - startTime.getTime()) / 1000 + " seconds.") ;
}
}
```

1.8.6.13. Example of using partitioned table as an input

The following examples use partitions as an input.

Example 1:

```
public static void main(String[] args) throws Exception {
JobConf job = new JobConf();
...
LinkedHashMap<String, String> input = new LinkedHashMap<String, String>();
input.put("pt", "123456");
InputUtils.addTable(TableInfo.builder().tableName("input_table").partSpec(input).build(), job);
LinkedHashMap<String, String> output = new LinkedHashMap<String, String>(); output.put("ds", "654321")
;
OutputUtils.addTable(TableInfo.builder().tableName("output_table").partSpec(output).build(), job);
JobClient.runJob(job);
}
```

Example 2:

```
package com.aliyun.odps.mapred.open.example;
...
public static void main(String[] args) throws Exception {
if (args.length ! = 2) {
System.err.println("Usage: WordCount <in_table> <out_table>");
System.exit(2);
}
JobConf job = new JobConf();
job.setMapperClass(TokenizerMapper.class);
job.setCombinerClass(SumCombiner.class);
job.setReducerClass(SumReducer.class);
job.setMapOutputKeySchema(SchemaUtils.fromString("word:string"));
job.setMapOutputValueSchema(SchemaUtils.fromString("count:bigint"));
Account account = new AliyunAccount("my_access_id", "my_access_key");
Odps odps = new Odps(account);
odps.setEndpoint("odps_endpoint_url");
odps.setDefaultProject("my_project");
Table table = odps.tables().get(tblname);
TableInfoBuilder builder = TableInfo.builder().tableName(tblname);
for (Partition p : table.getPartitions()) { if (applicable(p)) {
LinkedHashMap<String, String> partSpec = new LinkedHashMap<String, String>();
for (String key : p.getPartitionSpec().keys()) {
partSpec.put(key, p.getPartitionSpec().get(key));
}
InputUtils.addTable(builder.partSpec(partSpec).build(), conf);
}
}
OutputUtils.addTable(TableInfo.builder().tableName(args[1]).build(), job);
JobClient.runJob(job);
}
```

Note In the preceding example, the MaxCompute SDK and MapReduce SDK are used together to allow MapReduce tasks to read data from partitions. The preceding code cannot be compiled for execution. It is just an example of the main function. In the preceding example, the applicable function is the user logic that determines whether the partitions can be used as an input of the MapReduce job.

1.8.6.14. Pipeline example

Example:

```
package com.aliyun.odps.mapred.example;
import java.io.IOException;
import java.util.Iterator;
import com.aliyun.odps.Column;
import com.aliyun.odps.OdpsException;
import com.aliyun.odps.OdpsType;
import com.aliyun.odps.data.Record;
import com.aliyun.odps.data.TableInfo;
import com.aliyun.odps.mapred.Job;
import com.aliyun.odps.mapred.MapperBase;
import com.aliyun.odps.mapred.ReducerBase;
import com.aliyun.odps.pipeline.Pipeline;
public class Histogram {
public static class TokenizerMapper extends MapperBase {
Record word;
Record one;
@Override
public void setup(TaskContext context) throws IOException {
word = context.createMapOutputKeyRecord();
one = context.createMapOutputValueRecord();
one.setBigint(0, 1L);
}
@Override
public void map(long recordNum, Record record, TaskContext context)
throws IOException {
for (int i = 0; i < record.getColumnCount(); i++) {
String[] words = record.get(i).toString().split("\\s+");
for (String w : words) {
word.setString(0, w);
context.write(word, one);
}
}
}
}
public static class SumReducer extends ReducerBase { private Record num;
private Record result;
@Override
public void setup(TaskContext context) throws IOException {
num = context.createOutputKeyRecord();
result = context.createOutputValueRecord();
```

```
}
@Override
public void reduce(Record key, Iterator<Record> values, TaskContext context) throws IOException {
long count = 0;
while (values.hasNext()) {
Record val = values.next();
count += (Long) val.get(0);
}
result.set(0, key.get(0));
num.set(0, count);
context.write(num, result);
}
}
public static class IdentityReducer extends ReducerBase {
@Override
public void reduce(Record key, Iterator<Record> values, TaskContext context) throws IOException {
while (values.hasNext()) {
context.write(values.next());
}
}
}
public static void main(String[] args) throws OdpsException {
if (args.length ! = 2) {
System.err.println("Usage: orderedwordcount <in_table> <out_table>");
System.exit(2);
}
Job job = new Job();
/***
* In the process of constructing pipeline, if you do not specify mapper's OutputKeySortColumns, PartitionC
olumns, OutputGroupingColumns,
* the framework defaults to its OutputKey as the default configuration for the three
***/
Pipeline pipeline = Pipeline.builder()
.addMapper(TokenizerMapper.class)
.setOutputKeySchema(
new Column[] { new Column("word", OdpsType.STRING) })
.setOutputValueSchema(
new Column[] { new Column("count", OdpsType.BIGINT) })
.setOutputKeySortColumns(new String[] { "word" })
.setPartitionColumns(new String[] { "word" })
.setOutputGroupingColumns(new String[] { "word" })
```

```
.addReducer(SumReducer.class)
.setOutputKeySchema(
new Column[] { new Column("count", OdpsType.BIGINT) })
.setOutputValueSchema(
new Column[] { new Column("word", OdpsType.STRING)})
.addReducer(IdentityReducer.class).createPipeline();
job. setpipeline (pipeline);
job.addInput(TableInfo.builder().tableName(args[0]).build());
job.addOutput(TableInfo.builder().tableName(args[1]).build());
job.submit(); job.waitForCompletion();
System.exit(job.isSuccessful() == true ? 0 : 1);
}
}
```

1.9. MaxCompute Graph

1.9.1. Graph overview

1.9.1.1. Graph overview

MaxCompute Graph is a processing framework designed for iterative graph computing. Graph computing jobs use graphs to build models. Graphs are composed of vertices and edges with values. MaxCompute Graph supports the following operations to edit a graph:

- Editing the value of vertex or edge.
- Adding/deleting vertex.
- Adding/deleting edge.

> **Note** When editing the vertex or edge, you must maintain the relationship between the two items.

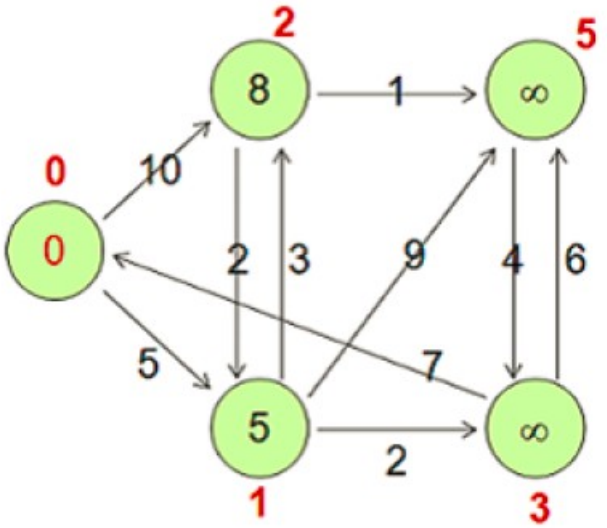
After performing iterative graph editing and evolution, you can get the final result. Typical applications include PageRank, SSSP algorithm, and K-Means algorithm. Furthermore, you can use the Java SDK provided by MaxCompute Graph to compile computing programs.

1.9.1.2. Graph data structure

MaxCompute Graph processes directed graphs, or digraphs, that consist of a vertex and an edge. MaxCompute stores data in two-dimensional tables, so you must convert graph data into two-dimensional tables and store them in MaxCompute. To perform graph analysis, you must use a custom GraphLoader to convert two-dimensional table data to vertexes and edges in the MaxCompute Graph engine. You can then determine how to break down and analyze your graph data based on your business requirements. In the following chapter, the examples provided use different tabular expressions to represent the data structure of a graph.

The vertex structure can be expressed as < ID, Value, Halted, Edges >, indicating respectively the vertex identifier, the value, the state (Halted, meaning whether to stop iteration), and the edge set (Edges, indicating lists of all edges starting from the vertex). The edge structure can be described as < DestVertexID, Value >, indicating respectively the destination vertex (DestVertexID) and value (Value). The following figure shows Graph data structure.

Graph data structure



The preceding figure involves the following vertexes.

Graph data structure

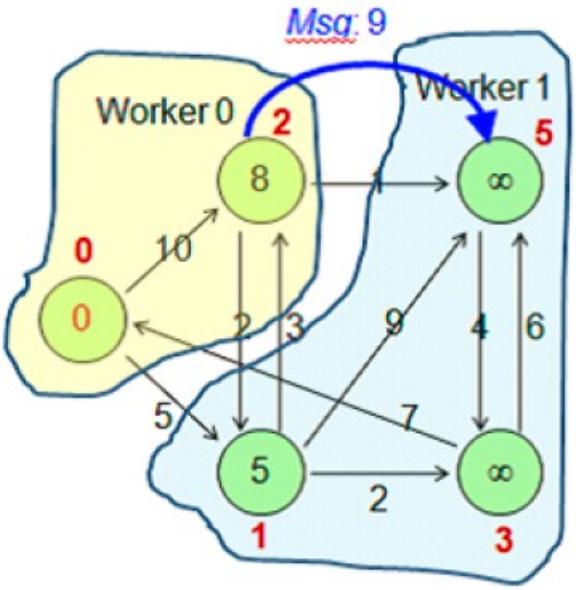
Vertex	<ID, Value, Halted, Edges>
v0	<0, 0, false, [<1, 5 >, <2, 10 >] >
v1	<1, 5, false, [<2, 3>, <3, 2>, <5, 9>]>
v2	<2, 8, false, [<1, 2>, <5, 1 >]>
v3	<3, Long.MAX_VALUE, false, [<0, 7>, <5, 6>]>
v5	<5, Long.MAX_VALUE, false, [<3, 4 >]>

1.9.1.3. Graph logic

1.9.1.3.1. Load graph

- Graph load: The framework calls the custom GraphLoader to parse the records in the input table into vertices or edges.
- Partitioning: The framework calls the custom Partitioner to partition vertices (default partition logic: the hash value of the vertex ID modulo the number of workers). Then, the framework distributes the partitions to the corresponding workers.

Load graph



Based on the preceding figure, if there are two workers, v0 and v2 are distributed to Worker0, because the result of the ID modulo 2 (total number of workers) is 0. v1, v3, and v5 are distributed to Worker1, because the result of the ID modulo 2 is 1.

1.9.1.3.2. Iterative computation

An iteration is a superstep. During a superstep, all vertices not in the halted state (Halted value is false) or vertices that receive messages (vertices in the halted state automatically wake up when receiving a message) are traversed. The compute method (ComputeContext context, Iterable messages) of these vertices is called.

In a custom compute method (ComputeContext context, Iterable messages):

- The messages sent by the previous superstep to the current vertex are processed.
- The graph is edited as required:
  - The values of vertices or edges are modified.
  - Messages are sent to some vertices.
  - Vertices or edges are added or deleted.
- The aggregator aggregates information to obtain global information.
- The current vertex is set to the halted or non-halted state.
- During each iteration, the framework automatically sends messages to the corresponding workers asynchronously. The messages are processed in the next superstep.

1.9.1.3.3. End of iteration

An iteration ends if any of the following conditions is satisfied.

- All vertices are in the halted state (Halted value is true), and no new messages are generated.
- The maximum number of iterations is reached.
- The terminate method of an aggregator returns true.

Example:

```
// 1. Load
for each record in input_table { GraphLoader.load();
}
// 2. Setup
WorkerComputer.setup();
for each aggr in aggregators { aggr.createStartupValue();
}
for each v in vertices { v.setup();
}
// 3. Superstep
for (step = 0; step < max; step ++) { for each aggr in aggregators { aggr.createInitialValue();
}
for each v in vertices { v.compute();
}
}
// 4. Cleanup
for each v in vertices { v.cleanup();
}
WorkerComputer.cleanup();
```

1.9.1.4. Aggregator overview

Aggregator is a common feature in MaxCompute Graph jobs and is especially suited for solving machine learning issues. In MaxCompute Graph, Aggregator is used to summarize and process global information.

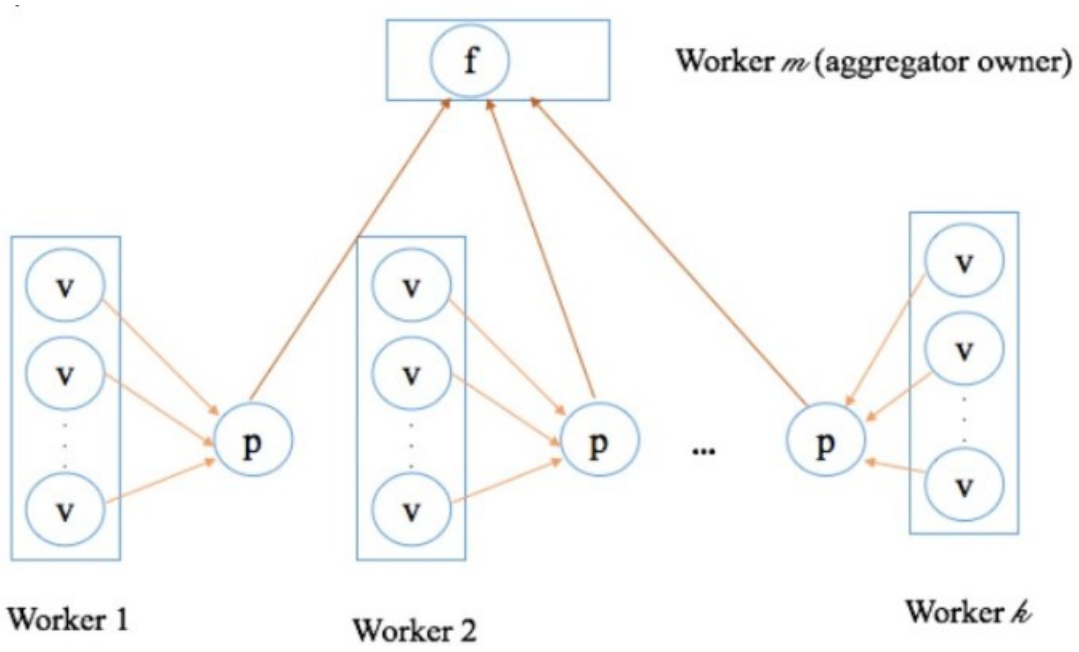
This topic describes the implementation mechanism and related API operations of Aggregator and uses Kmeans Clustering as an example to demonstrate how to use Aggregator.

Implementation mechanism

The logic of Aggregator is divided into two parts:

- One part is implemented on all Workers in distributed mode.
- The other part is only implemented on the Worker where Aggregator Owner is located in single vertex mode.

Initial values are created and partially aggregated on each Worker, and then the partial aggregation results of all Workers are sent to the Worker where Aggregator Owner is located. This Worker then aggregates the received partial aggregation objects into a global aggregation result and determines whether to end the iteration. The global aggregation result is distributed to all Workers in the next superstep for iteration.



API operations

Aggregator provides five API operations. The following parts describe when to call these API operations and for what purposes.

- **createStartupValue(context)**

  This API operation is performed once on all Workers before all supersteps start. It is used to initialize AggregatorValue. In the first superstep iteration (superstep 0), WorkerContext.getLastAggregatedValue() or ComputeContext.getLastAggregatedValue() is called to obtain the initialized AggregatorValue object.

- **createInitialValue(context)**

  This API operation is performed once on all Workers when each superstep starts. It is used to initialize AggregatorValue for the current iteration. Generally, WorkerContext.getLastAggregatedValue() is called to obtain the result of the previous iteration, and then partial initialization is implemented.

- **aggregate(value, item)**

  This API operation is also performed on all Workers. It is triggered by an explicit call to ComputeContext#aggregate(item), while the preceding two API operations are automatically called by the framework.

This API operation is used to implement partial aggregation. The first parameter value indicates the aggregation result of the Worker in the current superstep. The initial value is the object returned by createInitialValue. The second parameter is passed in when ComputeContext#aggregate(item) is called by using user code. In this API operation, item is typically used to update value for aggregation. After all the aggregate operations are performed, the obtained value is the partial aggregation result of the Worker. The result is then sent by the framework to the Worker where Aggregator Owner is located.

- **merge(value, partial)**

  This API operation is performed on the Worker where Aggregator Owner is located. It is used to merge partial aggregation results of Workers to obtain the global aggregation object. Similar to aggregate, value in this API operation indicates the aggregated results, while partial indicates objects to be aggregated. partial is used to update value.

  Assume that there are three Workers w0, w1, and w2, and the corresponding partial aggregation results are p0, p1, and p2. If p1, p0, and p2 are sent to the Worker where Aggregator Owner is located in sequence, the following merge operations are performed:

  i. merge(p1, p0) is executed first to aggregate p1 and p0 as p1.

  ii. Then, merge(p1, p2) is executed to aggregate p1 and p2 as p1. p1 is the global aggregation result in this superstep.

  Therefore, when only one Worker exists, the merge method is not required. In this case, merge() is not called.

- **terminate(context, value)**

  After the Worker where Aggregator Owner is located executes merge(), the framework calls terminate(context, value) to perform the final processing. The second parameter value indicates the global aggregation result obtained by calling merge(). The global aggregation result can be further modified in this API operation. After terminate() is executed, the framework distributes the global aggregation object to all Workers for the next superstep.

  If true is returned for terminate(), iteration is ended for the entire job. Otherwise, the iteration continues. In machine learning scenarios, jobs end generally when true is returned after convergence.

Kmeans Clustering example

This section uses typical Kmeans Clustering as an example to demonstrate how to use Aggregator.

> **Note** If you need the complete code, see Kmeans. In this section, the code is resolved and is for reference only.

- GraphLoader

  GraphLoader is used to load an input table and convert it to vertices or edges of a graph. In this example, each row of data in the input table is a sample, each sample constructs a vertex, and vertex values are used to store samples.

  A Writable class KmeansValue is defined as the value type of a vertex.

```
public static class KmeansValue implements Writable {
  DenseVector sample;
  public KmeansValue() {
  }
  public KmeansValue(DenseVector v) {
    this.sample = v;
  }
  @Override
    public void write(DataOutput out) throws IOException {
    wirteForDenseVector(out, sample);
  }
  @Override
    public void readFields(DataInput in) throws IOException {
    sample = readFieldsForDenseVector(in);
  }
}
```

A DenseVector object is encapsulated in KmeansValue to store a sample. The DenseVector type stems from matrix-toolkits-java. wirteForDenseVector() and readFieldsForDenseVector() are used for serialization and deserialization. For more information, see the complete code.

Custom KmeansReader code:

```
public static class KmeansReader extends
  GraphLoader<LongWritable, KmeansValue, NullWritable, NullWritable> {
  @Override
    public void load(
    LongWritable recordNum,
    WritableRecord record,
    MutationContext<LongWritable, KmeansValue, NullWritable, NullWritable> context)
    throws IOException {
    KmeansVertex v = new KmeansVertex();
    v.setId(recordNum);
    int n = record.size();
    DenseVector dv = new DenseVector(n);
    for (int i = 0; i < n; i++) {
      dv.set(i, ((DoubleWritable)record.get(i)).get());
    }
    v.setValue(new KmeansValue(dv));
    context.addVertexRequest(v);
  }
}
```

In KmeansReader, a vertex is created when each row of data (a record) is read. recordNum is used as the vertex ID, and the record content is converted to a DenseVector object and encapsulated in VertexValue.

- Vertex

  Custom KmeansVertex code:

```
public static class KmeansVertex extends
  Vertex<LongWritable, KmeansValue, NullWritable, NullWritable> {
  @Override
    public void compute(
    ComputeContext<LongWritable, KmeansValue, NullWritable, NullWritable> context,
    Iterable<NullWritable> messages) throws IOException {
    context.aggregate(getValue());
  }
}
```

  The logic of the preceding code is to implement partial aggregation for samples maintained for each iteration. For more information about the logic, see the implementation of Aggregator in the following section.

- Aggregator

  The main logic of Kmeans is concentrated on Aggregator. Custom KmeansAggrValue is used to maintain the content you want to aggregate and distribute.

```
public static class KmeansAggrValue implements Writable {
  DenseMatrix centroids;
  DenseMatrix sums; // used to recalculate new centroids
  DenseVector counts; // used to recalculate new centroids
  @Override
    public void write(DataOutput out) throws IOException {
    wirteForDenseDenseMatrix(out, centroids);
    wirteForDenseDenseMatrix(out, sums);
    wirteForDenseVector(out, counts);
  }
  @Override
    public void readFields(DataInput in) throws IOException {
    centroids = readFieldsForDenseMatrix(in);
    sums = readFieldsForDenseMatrix(in);
    counts = readFieldsForDenseVector(in);
  }
}
```

  In the preceding code, three objects are maintained in KmeansAggrValue:

- **centroids**: indicates the existing K centers. If the sample is m-dimensional, centroids is a matrix of K × m.
- **sums**: indicates a matrix of the same size as centroids. Each element records the sum of a specific dimension of the sample closest to a specific center. For example, sums(i,j) indicates the sum of dimension j of the sample closest to center i.
- **counts** is a K-dimensional vector. It records the number of samples closest to each center. counts is used with sums to calculate a new center, which is the main content to be aggregated.

KmeansAggregator is a custom Aggregator implementation class. The implementation is described below in order of the preceding API operations:

i. Implementation of **createStartupValue()**

```
public static class KmeansAggregator extends Aggregator<KmeansAggrValue> {
  public KmeansAggrValue createStartupValue(WorkerContext context) throws IOException {
    KmeansAggrValue av = new KmeansAggrValue();
    byte[] centers = context.readCacheFile("centers");
    String lines[] = new String(centers).split("\n");
    int rows = lines.length;
    int cols = lines[0].split(",").length; // assumption rows >= 1
    av.centroids = new DenseMatrix(rows, cols);
    av.sums = new DenseMatrix(rows, cols);
    av.sums.zero();
    av.counts = new DenseVector(rows);
    av.counts.zero();
    for (int i = 0; i < lines.length; i++) {
      String[] ss = lines[i].split(",");
      for (int j = 0; j < ss.length; j++) {
        av.centroids.set(i, j, Double.valueOf(ss[j]));
      }
    }
    return av;
  }
```

This method initializes a KmeansAggrValue object, reads the initial center from the resource file centers, and assigns a value to centroids. The initial values of sums and counts are 0.

ii. Implementation of **createInitialValue()**

```
@Override
public KmeansAggrValue createInitialValue(WorkerContext context)
  throws IOException {
  KmeansAggrValue av = (KmeansAggrValue)context.getLastAggregatedValue(0);
  // reset for next iteration
  av.sums.zero();
  av.counts.zero();
  return av;
}
```

This method first obtains KmeansAggrValue of the previous iteration, and then clears the values of sums and counts. Only the centroids value of the previous iteration is retained.

iii. Implementation of **aggregate()**

```
@Override
public void aggregate(KmeansAggrValue value, Object item)
  throws IOException {
  DenseVector sample = ((KmeansValue)item).sample;
  // find the nearest centroid
  int min = findNearestCentroid(value.centroids, sample);
  // update sum and count
  for (int i = 0; i < sample.size(); i ++) {
    value.sums.add(min, i, sample.get(i));
  }
  value.counts.add(min, 1.0d);
}
```

This method calls findNearestCentroid() to find the index of the center closest to the sample item, uses sums to add up all dimensions, and increments the value of counts by 1.

The preceding three methods are executed on all Workers to implement partial aggregation. The global aggregation operations performed on the Worker where Aggregator Owner is located are described as follows:

i. Implementation of **merge()**

```
@Override
public void merge(KmeansAggrValue value, KmeansAggrValue partial)
  throws IOException {
  value.sums.add(partial.sums);
  value.counts.add(partial.counts);
}
```

In the preceding example, the implementation logic of merge is to sum up the values of sums and counts aggregated by each Worker.

ii. Implementation of **terminate()**

```
@Override
public boolean terminate(WorkerContext context, KmeansAggrValue value)
  throws IOException {
  // Calculate the new means to be the centroids (original sums)
  DenseMatrix newCentriods = calculateNewCentroids(value.sums, value.counts, value.centroids);
  // print old centroids and new centroids for debugging
  System.out.println("\nsuperstep: " + context.getSuperstep() +
          "\nold centriod:\n" + value.centroids + " new centriod:\n" + newCentriods);
  boolean converged = isConverged(newCentriods, value.centroids, 0.05d);
  System.out.println("superstep: " + context.getSuperstep() + "/"
          + (context.getMaxIteration() - 1) + " converged: " + converged);
  if (converged || context.getSuperstep() == context.getMaxIteration() - 1) {
    // converged or reach max iteration, output centriods
    for (int i = 0; i < newCentriods.numRows(); i++) {
      Writable[] centriod = new Writable[newCentriods.numColumns()];
      for (int j = 0; j < newCentriods.numColumns(); j++) {
        centriod[j] = new DoubleWritable(newCentriods.get(i, j));
      }
      context.write(centriod);
    }
    // true means to terminate iteration
    return true;
  }
  // update centriods
  value.centroids.set(newCentriods);
  // false means to continue iteration
  return false;
}
```

In the preceding example, terminate() calls calculateNewCentroids() based on sums and counts to calculate the average value and obtain a new center. isConverged() is then called to determine whether the center is converged based on the Euclidean distance between the new and old centers. If the number of convergences or iterations reaches the upper limit, the new center is generated, and true is returned to end the iteration. Otherwise, the center is updated, and false is returned to continue the iteration.

iii. **main** method

The main method is used to construct GraphJob, configure related settings, and submit a job.

```
public static void main(String[] args) throws IOException {
  if (args.length < 2)
    printUsage();
  GraphJob job = new GraphJob();
  job.setGraphLoaderClass(KmeansReader.class);
  job.setRuntimePartitioning(false);
  job.setVertexClass(KmeansVertex.class);
  job.setAggregatorClass(KmeansAggregator.class);
  job.addInput(TableInfo.builder().tableName(args[0]).build());
  job.addOutput(TableInfo.builder().tableName(args[1]).build());
  // default max iteration is 30
  job.setMaxIteration(30);
  if (args.length >= 3)
    job.setMaxIteration(Integer.parseInt(args[2]));
  long start = System.currentTimeMillis();
  job.run();
  System.out.println("Job Finished in "
          + (System.currentTimeMillis() - start) / 1000.0 + " seconds");
}
```

Note If job.setRuntimePartitioning(false) is set to false, data loaded by each Worker is not partitioned based on Partitioner. Data is maintained by the Worker that loads it.

Summary

The basic steps of Aggregator are as follows:

1. When each Worker starts, it executes createStartupValue to create AggregatorValue.
2. Before each iteration starts, each Worker executes createInitialValue to initialize AggregatorValue for the iteration.
3. In an iteration, each vertex uses context.aggregate() to call aggregate() to implement partial iteration in the Worker.
4. Each Worker sends the partial iteration result to the Worker where Aggregator Owner is located.
5. The Worker where Aggregator Owner is located executes merge multiple times to implement global aggregation.
6. The Worker where Aggregator Owner is located executes terminate to process the global aggregation result and determines whether to end the iteration.

1.9.2. Graph feature overview

1.9.2.1. Run a job

The MaxCompute client provides a jar command for running MaxCompute Graph jobs. This command is used in the same way as the jar command in MapReduce.

Command syntax:

```
Usage: jar [<GENERIC_OPTIONS>] <MAIN_CLASS> [ARGS]
-conf <configuration_file> Specify an application configuration file
-classpath <local_file_list> classpaths used to run mainClass
-D <name>=<value> Property value pair, which will be used to run mainClass
-local Run job in local mode
-resources <resource_name_list> file/table resources used in graph, seperate by comma
```

The following table describes the parameters.

Parameters

Parameter	Description
-conf <configuration file>	Indicates a JobConf file.
-classpath <local_file_list>	Indicates the classpath for local execution. It specifies the local paths (including relative path and absolute path) of the JAR package where the main function is located.
-D <prop_name>=<prop_value>	Indicates the Java attribute of <mainClass> in local execution. You can define multiple attributes.
-local	Runs the MapReduce job locally, mainly for program debugging.
-resources <resource_name_list>	Declares the resources used for running the Graph job. You typically need to specify the name of the resource where the Graph job is located in resource_name_list. **Notice** If you read other MaxCompute resources while running the Graph job, you also need to add those resource names to resource_name_list. Multiple resources must be separated by commas (,). If you need to use resources of another project, add the prefix PROJECT_NAME/resources/, for example, -resources otherproject/resources/resfile.

Note The preceding optional parameters are included in <GENERIC_OPTIONS>.

You can directly run the main function in the Graph job to submit the job to MaxCompute, instead of submitting the job through the MaxCompute client. Take the PageRank algorithm as an example.

Example:

```
public static void main(String[] args) throws IOException {
if (args.length < 2)
printUsage();
GraphJob job = new GraphJob();
job.setGraphLoaderClass(PageRankVertexReader.class);
job.setVertexClass(PageRankVertex.class);
job.addInput(TableInfo.builder().tableName(args[0]).build());
job.addOutput(TableInfo.builder().tableName(args[1]).build());
// Add the resources used in the job to cache resource. These resources correspond to those specified by -re
sources and libjars in the jar command.
job.addCacheResource("mapreduce-examples.jar");
// Add the used JAR file and other files to the class cache resource. These resources correspond to those spe
cified by -libjars in the jar command.
job.addCacheResourceToClassPath("mapreduce-examples.jar");
// Set the configuration item corresponding to odps_config.ini in the client. Replace it with the actual one in
your configuration file.
Account account = new AliyunAccount(accessId, accessKey);
Odps odps = new Odps(account);
odps.setDefaultProject(project);
odps.setEndpoint(endpoint);
SessionState.get().setOdps(odps);
SessionState.get().setLocalRun(false); // default max iteration is 30
job.setMaxIteration(30);
if (args.length >= 3)
job.setMaxIteration(Integer.parseInt(args[2]));
long startTime = System.currentTimeMillis(); job.run();
System.out.println("Job Finished in "
+ (System.currentTimeMillis() - startTime) / 1000.0 + " seconds");
}
```

1.9.2.2. Input and output

The input and output of MaxCompute Graph jobs must be tables. You cannot customize the input or output format.

Job input definition:

```
GraphJob job = new GraphJob();
job.addInput(TableInfo.builder().tableName("tblname").build());
// Tables are used as input.
job.addInput(TableInfo.builder().tableName("tblname").partSpec("pt1=a/pt2=b").build());
// Partitions are used as input.
job.addInput(TableInfo.builder().tableName("tblname").partSpec("pt1=a/pt2=b").build(), new String[]{"col2", "col0 "});
// Read only col2 and col0 of the input table. Use record.get(0) to obtain col2 in the load() method of GraphLoader. Both are read in the same sequence.
```

> Note
>
> - Multiple inputs are supported.
> - Partition filtering is not supported. For more application limits, see Application limits.
> - For more information about job input definition, see the addInput method description in GraphJob.
> - The framework reads records from the input table and transfers the records to the user-defined GraphLoader to load graph data.

Job output definition:

```
GraphJob job = new GraphJob();
job.addOutput(TableInfo.builder().tableName("table_name").partSpec("pt1=a/pt2=b").build());
// If the output table is a partitioned table, the last level of partitions must be provided.
job.addOutput(TableInfo.builder().tableName("table_name").partSpec("pt1=a/pt2=b").lable("output1").build(), true);
// True indicates that the code will overwrite partitions specified in tableinfo, which is similar to the INSERT OVERWRITE operation. False is similar to the INSERT INTO operation.
```

> Note
>
> - Multiple outputs are supported, and each output is identified by a label.
> - A Graph job can use the Write method of WorkContext to write data to an output table during runtime. Multiple outputs must be labeled.
> - For more information about job output definition, see the addOutput method description in GraphJob.

1.9.2.3. Read data from resources

1.9.2.3.1. Add resource in Graph program

In addition to the jar command, the following two methods of GraphJob can be used to specify the resources read by Graph:

```
void addCacheResources(String resourceNames)
void addCacheResourcesToClassPath(String resourceNames)
```

1.9.2.3.2. Use resources in Graph

In Graph, you can use the following methods of the corresponding context object WorkerContext to read resources:

```
public byte[] readCacheFile(String resourceName) throws IOException;
public Iterable<byte[]> readCacheArchive(String resourceName) throws IOException;
public Iterable<byte[]> readCacheArchive(String resourceName, String relativePath)throws IOException;
public Iterable<WritableRecord> readResourceTable(String resourceName);
public BufferedInputStream readCacheFileAsStream(String resourceName) throws IOException;
public Iterable<BufferedInputStream> readCacheArchiveAsStream(String resourceName) throws IOExcepti
on;
public Iterable<BufferedInputStream> readCacheArchiveAsStream(String resourceName, String relativePat
h) throws IOException;
```

> Note
>
> - Normally, resources are read in the setup of WorkerComputer, saved in WorkerValue, and obtained through getWorkerValue.
> - The preceding stream API is recommended while reading and processing to reduce memory consumption.
> - For more information about limits, see Application limits.

1.9.3. Graph SDK introduction

Major APIs

API	Description
GraphJob	GraphJob is inherited from JobConf to define, submit, and manage a MaxCompute Graph job.
Vertex	Vertex is an abstract of a graph and has the following attributes: id, value, halted, and edges. It is implemented through the setVertexClass API in GraphJob.
Edge	Edge is an abstract of a graph and has the following attributes: destVertexId and value. The graph data structure is maintained by an adjacency list. The outgoing edges of a vertex are stored in its edges attribute.
GraphLoader	GraphLoader is used to load graphs. It is set through the setGraphLoaderClass API in GraphJob.

API	Description
VertexResolver	VertexResolver is used to customize the collision processing logic of the revising graph topology. It provides this logic through the setLoadingVertexResolverClass and setComputingVertexResolverClass APIs in GraphJob for graph loading and iteration computing.
Partitioner	Partitioner is used to partition graphs for partition computing. It is set through the setPartitionerClass API in GraphJob. By default, the HashPartitioner is used to first obtain the Vertex ID Hash value, and then to model the number of Workers.
WorkerComputer	WorkerComputer allows customized logic to be executed while Worker starts and exits. WorkerComputer is set through the setWorkerComputerClass API in GraphJob.
Aggregator	Allows you to define one or multiple Aggregators through the setAggregatorClass(Class ...) API in Aggregator.
Combiner	You can set Combiner through the setCombinerClass API in Combiner.
Counters	In the job operating logic, counters can be taken and counted through the WorkerContext API, and the framework will automatically summarize them.
WorkerContext	Context objects encapsulate the functions provided by the framework, such as revising the topology of graphs, sending messages, writing results, reading resources, and so on.

1.9.4. Development and debugging

1.9.4.1. Development procedure

MaxCompute does not provide plug-ins for Graph development. Instead, you can develop MaxCompute Graph programs in Eclipse. The recommended development procedure is as follows:

1. Write Graph code and perform local debugging to test basic functions.
2. Perform cluster debugging to verify results.

1.9.4.2. Development example

Context

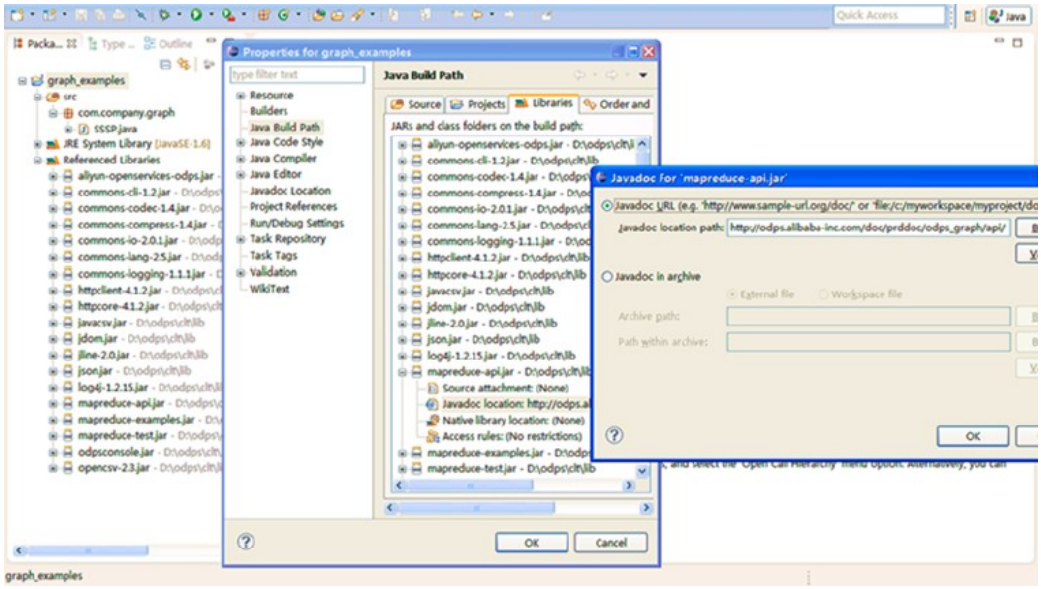
This topic uses the SSSP algorithm as an example to describe how to use Eclipse to develop and debug a Graph program. The development procedure is as follows:

Procedure

1. Create a Java project.

   In this example, the project is graph_examples. Add the JAR package in the lib directory of the MaxCompute client to Build Path of the Eclipse project. The following figure shows a configured Eclipse project.

   Create a Java project



2. Develop a MaxCompute Graph program.

   In the actual development process, you can copy a sample program (such as SSSP) and then modify it as required. In this example, only the package path is changed to *package com.aliyun.odps.graph.example*.

3. Compile and build the package. In an Eclipse environment, right-click the source code directory (the src directory in the figure) and choose **Export > Java > JAR file** to generate a JAR package. Select the path for storing the target JAR package, such as *D:\odps\clt\odps-graph-example-sssp.jar*.
4. Use the MaxCompute client to run SSSP. For more information, see Compile and run a Graph job.

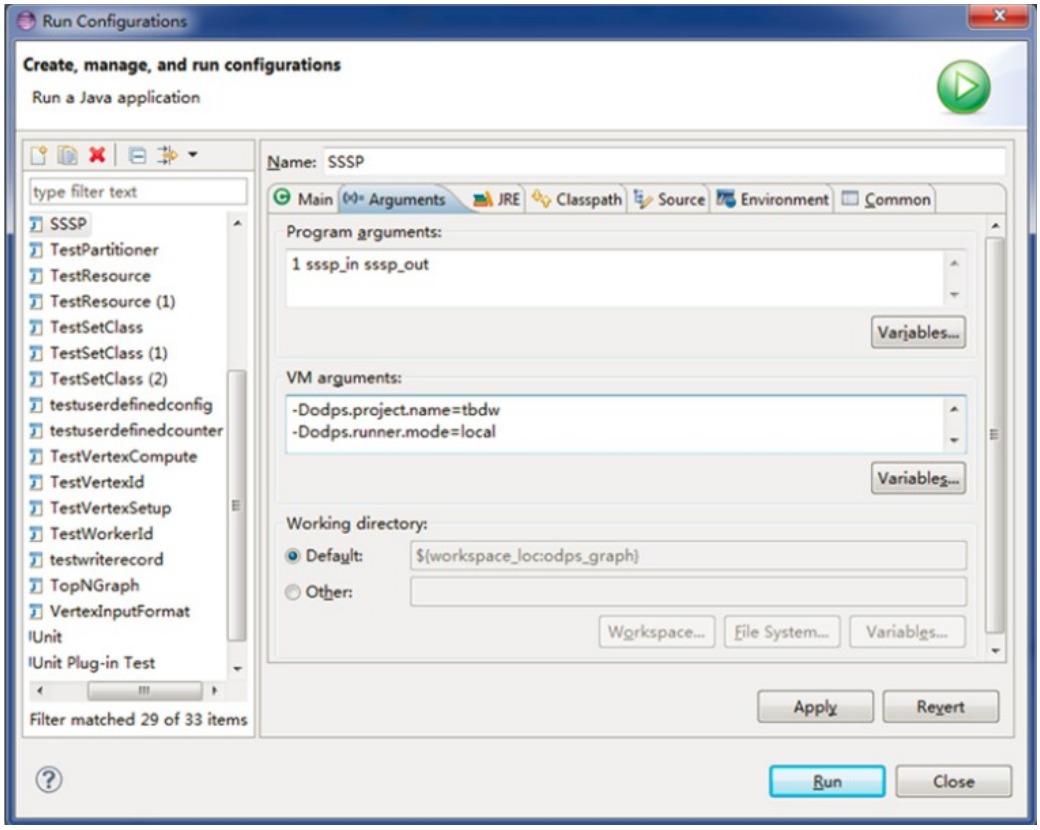
1.9.4.3. Local debugging

MaxCompute Graph supports the local debugging mode. You can use Eclipse for breakpoint debugging. The breakpoint debugging procedure is as follows:

Procedure

1. Select an Eclipse project. Right-click the Graph job main program file (the file that contains the main function), and configure its execution arguments, as shown in the following figure.

   Local debugging



2. On the **Arguments** tab page, set the following arguments as the input parameters of the main program:
   - Program arguments: 1 sssp_in sssp_out.
   - VM arguments: Dodps.runner.mode=local, Dodps.project.name=<project.name>, Dodps.end.point=<end.point>, Dodps.access.id=<access.id>, and Dodps.access.key=<access.key>.
   - For the local mode (odps.end.point not specified), you need to create the sssp_in and sssp_out tables in the warehouse, and add the following data to sssp_in:

     ```
     1,"2:2,3:1,4:4"
     2,"1:2,3:2,4:1"
     3,"1:1,2:2,5:1"
     4,"1:4,2:1,5:1"
     5,"3:1,4:1"
     ```

     > **Note** For more information about the warehouse, see Run MapReduce tasks locally.

3. Click **Run** to run SSSP on the local machine.

   Refer to conf/odps_config.ini in the MaxCompute client for the settings of common parameters. The other parameters are described as follows:
   - odps.runner.mode: The value is local. It is required for the local debugging feature.
   - odps.project.name: specifies the current project, which is required.
   - odps.end.point: specifies the current MaxCompute service address, which is optional. If this

parameter is not specified, SSSP only reads metadata and data from the tables or resources in the warehouse. If the data does not exist, an error is returned. If this parameter is specified, SSSP first reads data from the warehouse. If the data does not exist, it reads data from the remote MaxCompute service.

- odps.access.id: specifies the AccessKey ID for accessing the MaxCompute service. It is valid only if odps.end.point is specified.
- odps.access.key: specifies the AccessKey secret for accessing the MaxCompute service. It is effective only if odps.end.point is specified.
- odps.cache.resources: specifies the resource list to be used. This parameter is the same as -resources of the jar command.
- odps.local.warehouse: specifies the local warehouse path. It is ./warehouse by default.

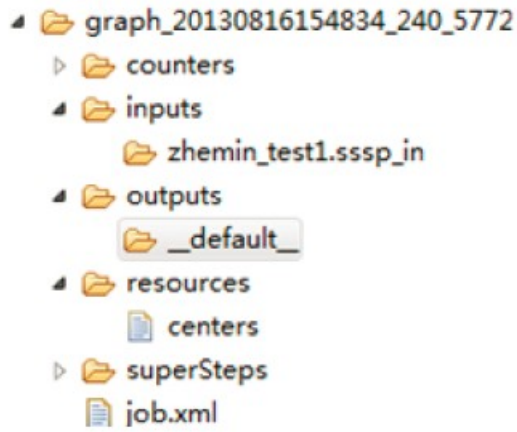
The output is as follows:

```
Counters: 3
com.aliyun.odps.graph.local.COUNTER
TASK_INPUT_BYTE=211
TASK_INPUT_RECORD=5
TASK_OUTPUT_BYTE=161
TASK_OUTPUT_RECORD=5
graph task finish
```

Notice In the preceding examples, the local warehouse must contain the sssp_in and sssp_out tables. For more information about sssp_in and sssp_out, see Compile and run Graph.

1.9.4.4. Temporary directory for local jobs

Each time MaxCompute Graph runs a local debugging job, it creates a temporary directory in the Eclipse project directory, as shown in the following figure.



The temporary directory for a local Graph job contains the following directories and files:

- counters: stores the counter information that is generated during the running of the job.
- inputs: stores the input data of the job. Graph first reads data from the local warehouse. If no data is found, Graph uses the MaxCompute SDK to read data from the server (if odps.end.point is

configured). An input operation reads 10 records by default. You can use the Dodps.mapred.local.record.limit parameter to modify the number of records read during each input operation. Up to 10,000 records can be read each time.

- outputs: stores the output data of the job. If there is an output table in the local warehouse, the results in outputs will overwrite data in that table after the job is executed.
- resources: stores the resources used by the job. Similarly, Graph first reads data from the local warehouse. If no data is found, Graph uses the MaxCompute SDK to read data from the server (if odps.end.point is configured).
- job.xml: stores job configurations.
- superstep: stores persistent message information from each iteration.

> **Notice** If you need to output detailed logs during local debugging, place the log4j configuration file named log4j.properties_odps_graph_cluster_debug in the src directory.

1.9.4.5. Cluster debugging

After you perform local debugging, you can perform the following steps to submit a job for cluster testing:

1. Configure the MaxCompute client.
2. Run the `add jar /path/work.jar -f;` command to update the JAR package.
3. Run a JAR command to execute the job and check the operation log and command output.

> **Notice** For more information about running a Graph job in a cluster, see Compile and run a Graph job.

1.9.4.6. Performance optimization

1.9.4.6.1. Configure job parameters

The following table lists the GraphJob configuration parameters that affect job performance.

GraphJob configuration parameters

Parameter	Description
setSplitSize(long)	Indicates the split size in MB. The value must be greater than 0. Default value: 64.
setNumWorkers(int)	Indicates the number of job workers. Value range: 1 to 1,000. Default value: 1. The number of workers is determined by the number of input bytes and split size.
setWorkerCPU(int)	Indicates the CPU resources for a map job. 100 resources are equivalent to one CPU core. Value range: 50 to 800. Default value: 200.
setWorkerMemory(int)	Indicates the memory resources in MB for a map job. Value range: 256M to 12G. Default value: 4,096.

Parameter	Description
setMaxIteration(int)	Indicates the maximum number of iterations. Default value: -1. If the value is equal to or smaller than 0, the job is not terminated after the maximum number of iterations.
setJobPriority(int)	Indicates the job priority. Value range: 0 to 9. Default value: 9. A greater value indicates a lower priority.

Recommendations:

1. Use setNumWorkers to increase the number of workers.
2. Use setSplitSize to reduce the split size and increase the data loading speed.
3. Use setWorkerCPU or setWorkerMemory to increase the CPU or memory resources for workers.
4. Use setMaxIteration to set the maximum number of iterations. For applications that do not require precise results, you can reduce the number of iterations to accelerate the iterating process.

Use setNumWorkers and setSplitSize together to accelerate data loading. If setNumWorkers is workerNum, setSplitSize is splitSize, and the total number of input bytes is inputSize, splitNum equals inputSize divided by splitSize. The relationship between workerNum and splitNum is as follows:

1. If splitNum is equal to workerNum, each worker loads one split.
2. If splitNum is greater than workerNum, each worker loads one or more splits.
3. If splitNum is smaller than workerNum, each worker loads zero or one split.

Therefore, you can adjust workerNum and splitSize to obtain a suitable loading speed. In the first two cases, data loading is faster. In the iteration phase, you only need to adjust workerNum. If you set runtime partitioning to false, we recommend that you either use setSplitSize to adjust the number of workers, or ensure the conditions in the first two cases are met. In the third case, the number of vertices in some of the workers is 0. In this case, you can use set odps.graph.split.size=<m>; set odps.graph.worker.num=<n>; before the JAR command, which achieves the same effect as setNumWorkers and setSplitSize.

Another common performance problem is data skew. As indicated by the counters, some workers process much more vertices or edges than others.

Data skew usually occurs when the number of vertices, edges, or messages corresponding to certain keys is far greater than that corresponding to other keys. These keys are distributed for processing by a small number of workers, resulting in long execution time of these workers. You can use the following methods to resolve this issue:

- Use Combiner to aggregate the messages of vertices corresponding to the keys, to reduce the number of generated messages.
- Improve the business logic.

1.9.4.6.2. Use Combiner

Developers can set Combiner to reduce the memory and network traffic consumed by message storage, and reduce job execution time. For more information, see the Combiner description in Graph SDK overview.

1.9.4.6.3. Reduce data input

If a disk stores large volumes of data, reading data from the disk may prolong the processing time. You can reduce the number of bytes to be read to increase the overall throughput and improve job performance. You can use either of the following methods:

- Reduce data input: For some decision-making applications, processing sampled data only affects the precision of the results, not the overall accuracy. In this case, you can sample specific data to the input table for further processing.
- Avoid reading unnecessary fields: The TableInfo class provided in the MaxCompute Graph framework can read specific columns (sent through a column name array), instead of the entire table or partition. This effectively reduces the amount of input data and improves job performance.

1.9.4.6.4. JAR packages

The following JAR packages are loaded on the JVM that runs Graph programs by default. You do not need to manually upload these resources, or use -libjars to specify them in a command.

- commons-codec-1.3.jar
- commons-io-2.0.1.jar
- commons-lang-2.5.jar
- commons-logging-1.0.4.jar
- commons-logging-api-1.0.4.jar
- guava-14.0.jar
- json.jar
- log4j-1.2.15.jar
- slf4j-api-1.4.3.jar
- slf4j-log4j12-1.4.3.jar
- xmlenc-0.52.jar

> **Notice** In CLASSPATH of the running JVM, the preceding JAR packages are loaded before your JAR package. This may cause version conflicts. For example, your program calls a certain class function of commons-codec-1.5.jar, but the function is not included in the current MaxCompute packages. In this case, you can choose to call a similar function in version 1.3 or wait until MaxCompute is upgraded to the required version.

1.9.5. Application limits

- Each job can reference up to 256 resources. Each table or archive is considered as one unit.
- The total resource size referenced by a job cannot exceed 512 MB.
- Each job can have up to 1,024 inputs (the number of input tables cannot exceed 64). Each job can have up to 256 outputs.
- Labels specified for multiple outputs cannot be null or empty strings. The label length cannot exceed 256, and the label can contain only upper-case letters (A to Z), lower-case letters (a to z), digits (0 to 9), underlines (_), pound signs (#), periods (.), and hyphens (-).
- The number of custom counters in a job cannot exceed 64. The counter group name and counter name cannot contain pound signs (#), and the total length of both names cannot exceed 100.
- The number of workers for each job is calculated by the framework. The maximum number of workers is 1,000. An error is returned when the number of workers exceeds this value.

- Each worker consumes 200 units of CPU resources by default. The range of resources consumed is 50 to 800.
- Each worker consumes 4,096 MB memory by default. The range of memory consumed is 256 MB to 12 GB.
- Each worker can read from a single resource up to 64 times.
- The split size is 64 MB by default, but can be defined by the user. The split size must be greater than 0, and the maximum value is in the range of 20 to 9223372036854775807.
- GraphLoader/Vertex/Aggregator in MaxCompute Graph are restricted by Java Sandbox (however, the main program of a Graph job is not subject to this restriction) while they run in a cluster. For more information, see Java sandbox restrictions.

1.9.6. Sample programs

1.9.6.1. SSSP

Dijkstra's algorithm is a typical algorithm for calculating the Single Source Shortest Path (SSSP) in a directed graph.

Shortest path: For a weighted directed graph G = (V, E), many paths are available from source vertex s to sink vertex v. The path with the smallest sum of edge weights is called the shortest path from s to v. The algorithm is implemented as follows:

- Initialization: The distance from s to s is 0 (d[s] = 0), and the distance from u to s is infinite (d[u] = ∞).
- Iteration: If an edge from u to v exists, the shortest distance from s to v is updated to d[v] = min(d[v], d[u] + weight(u, v)). The iteration ends until the distance from all vertices to s does not change.

> **Note** The implementation process determines that the algorithm is applicable to the MaxCompute Graph program. Each vertex maintains the current shortest distance to the source vertex. If the value changes, a message containing the new value and the edge weight is sent to the adjacent vertices. In the next iteration, the adjacent vertices update the current shortest distance based on the received message. The iteration ends when the current shortest distance values of all vertices do not change.

Example:

```
import java.io.IOException;
import com.aliyun.odps.io.WritableRecord;
import com.aliyun.odps.graph.Combiner;
import com.aliyun.odps.graph.ComputeContext;
import com.aliyun.odps.graph.Edge;
import com.aliyun.odps.graph.GraphJob;
import com.aliyun.odps.graph.GraphLoader;
import com.aliyun.odps.graph.MutationContext;
import com.aliyun.odps.graph.Vertex;
import com.aliyun.odps.graph.WorkerContext;
import com.aliyun.odps.io.LongWritable;
import com.aliyun.odps.data.TableInfo;
public class SSSP {
```

```
public static final String START_VERTEX = "sssp.start.vertex.id";
/**Define SSSPVertex, where:
* The vertex value indicates the current shortest distance from this vertex to source vertex startVertexId.
* The compute() method uses the iteration formula d[v] = min(d[v], d[u] + weight(u, v)) to update the vertex value.
* The cleanup() method writes the vertex and its shortest distance to the source vertex to the result table.
 **/
public static class SSSPVertex extends
Vertex<LongWritable, LongWritable, LongWritable, LongWritable> {
private static long startVertexId = -1;
public SSSPVertex() {
this.setValue(new LongWritable(Long.MAX_VALUE));
}
public boolean isStartVertex(
ComputeContext<LongWritable, LongWritable, LongWritable, LongWritable> context) {
if (startVertexId == -1) {
String s = context.getConfiguration().get(START_VERTEX);
startVertexId = Long.parseLong(s);
}
return getId().get() == startVertexId;
}
@Override
public void compute(
ComputeContext<LongWritable, LongWritable, LongWritable, LongWritable> context, Iterable<LongWritable> messages) throws IOException {
long minDist = isStartVertex(context) ? 0 : Integer.MAX_VALUE;
for (LongWritable msg : messages) { if (msg.get() < minDist) {
minDist = msg.get();
}
}
if (minDist < this.getValue().get()) {
this.setValue(new LongWritable(minDist));
if (hasEdges()) {
for (Edge<LongWritable, LongWritable> e : this.getEdges()) {
context.sendMessage(e.getDestVertexId(), new LongWritable(minDist + e.getValue().get()));
}
}
} else {
voteToHalt();
// If the vertex value does not change, voteToHalt() is called to notify the framework that this vertex enters the halted state. The calculation ends when all vertices enter the halted state.
```

```
he halted state. The calculation ends when all vertices enter the halted state.
}
}
@Override
public void cleanup(
WorkerContext<LongWritable, LongWritable, LongWritable, LongWritable> context) throws IOException {
context.write(getId(), getValue());
}
}
/** Define MinLongCombiner and combine messages sent to the same vertex to optimize performance and r
educe memory usage.**/
public static class MinLongCombiner extends
Combiner<LongWritable, LongWritable> {
@Override
public void combine(LongWritable vertexId, LongWritable combinedMessage, LongWritable messageToCom
bine) throws IOException {
if (combinedMessage.get() > messageToCombine.get()) {
combinedMessage.set(messageToCombine.get());
}
}
}
/** Define the SSSPVertexReader class, load a graph, and parse each record in the table into a vertex. The firs
t column of the record is the vertex ID, and the second column stores all edge sets starting from the vertex, s
uch as 2:2,3:1,4:4.**/
public static class SSSPVertexReader extends
GraphLoader<LongWritable, LongWritable, LongWritable, LongWritable> {
@Override
public void load(LongWritable recordNum, WritableRecord record,
MutationContext<LongWritable, LongWritable, LongWritable, LongWritable> context) throws IOException {
SSSPVertex vertex = new SSSPVertex();
vertex.setId((LongWritable) record.get(0));
String[] edges = record.get(1).toString().split(",");
for (int i = 0; i < edges.length; i++) {
String[] ss = edges[i].split(":");
vertex.addEdge(new LongWritable(Long.parseLong(ss[0])), new LongWritable(Long.parseLong(ss[1])));
}
context.addVertexRequest(vertex);
}
}
public static void main(String[] args) throws IOException { if (args.length < 2) {
System.out.println("Usage: <startnode> <input> <output>");
```

```
System.exit(-1);
}
GraphJob job = new GraphJob();
// Define GraphJob, specify the implementation of Vertex/GraphLoader/Combiner, and specify input and out
put tables.
job.setGraphLoaderClass(SSSPVertexReader.class);
job.setVertexClass(SSSPVertex.class);
job.setCombinerClass(MinLongCombiner.class);
job.set(START_VERTEX, args[0]);
job.addInput(TableInfo.builder().tableName(args[1]).build());
job.addOutput(TableInfo.builder().tableName(args[2]).build());
long startTime = System.currentTimeMillis(); job.run();
System.out.println("Job Finished in " + (System.currentTimeMillis() - startTime) / 1000.0 + " seconds");
}
}
```

1.9.6.2. PageRank

PageRank is an algorithm for Web page ranking. For more information, see PageRank. The input of the algorithm is a digraph G, where Vertex represents pages. If there is a link between page A to page B, there is an Edge linking A and B. Basic principles of the algorithm are as follows:

- Initialization: Vertex value means rank value of PageRank (double type). Initially, the value of all Vertices is 1/TotalNumVertices.
- Iteration formula: PageRank(i)=0.15/TotalNumVertices+0.85*sum. Sum indicates the sum of PageRank(j)/out_degree(j). (j indicates all vertices pointing to vertex i.)

> **Note** The PageRank algorithm is best suited to be run on MaxCompute Graph as each j point maintains its PageRank value and sends PageRank(j)/out_degree(j) to its adjacent vertex (to vote it) per iteration. Upon the next iteration, each vertex re-calculates the PageRank value using the iteration formula.

Example:

```
import java.io.IOException;
import org.apache.log4j.Logger;
import com.aliyun.odps.io.WritableRecord;
import com.aliyun.odps.graph.ComputeContext;
import com.aliyun.odps.graph.GraphJob;
import com.aliyun.odps.graph.GraphLoader;
import com.aliyun.odps.graph.MutationContext;
import com.aliyun.odps.graph.Vertex;
import com.aliyun.odps.graph.WorkerContext;
import com.aliyun.odps.io.DoubleWritable;
```

```
import com.aliyun.odps.io.LongWritable;
import com.aliyun.odps.io.NullWritable;
import com.aliyun.odps.data.TableInfo;
import com.aliyun.odps.io.Text;
import com.aliyun.odps.io.Writable;
public class PageRank {
private final static Logger LOG = Logger.getLogger(PageRank.class);
/**
* Defines PageRankVertex, where:
* The vertex value indicates the current PageRank value of the vertex (web page).
* The compute() method uses the iteration formula PageRank(i)=0.15/TotalNumVertices+0.85*sum to updat
e the vertex value.
* The cleanup() method writes the vertex and its PageRank value to the result table.
**/
public static class PageRankVertex extends
Vertex<Text, DoubleWritable, NullWritable, DoubleWritable> {
@Override
public void compute(
ComputeContext<Text, DoubleWritable, NullWritable, DoubleWritable> context, Iterable<DoubleWritable>
messages) throws IOException {
if (context.getSuperstep() == 0) {
setValue(new DoubleWritable(1.0 / context.getTotalNumVertices()));
} else if (context.getSuperstep() >= 1) { double sum = 0;
for (DoubleWritable msg : messages) { sum += msg.get();
}
DoubleWritable vertexValue = new DoubleWritable( (0.15f / context.getTotalNumVertices()) + 0.85f * sum);
setValue(vertexValue);
}
if (hasEdges()) {
context.sendMessageToNeighbors(this, new DoubleWritable(getValue()
.get() / getEdges().size()));
}
}
@Override
public void cleanup(
WorkerContext<Text, DoubleWritable, NullWritable, DoubleWritable> context) throws IOException {
context.write(getId(), getValue());
}
}
/** Define the PageRankVertexReader class, load a graph, and resolve each record in the table into a vertex. T
he first column of the record is the start vertex and other columns are the destination vertices.**/
```

```
public static class PageRankVertexReader extends
GraphLoader<Text, DoubleWritable, NullWritable, DoubleWritable> {
@Override public void load(
LongWritable recordNum, WritableRecord record,
MutationContext<Text, DoubleWritable, NullWritable, DoubleWritable> context) throws IOException {
PageRankVertex vertex = new PageRankVertex();
vertex.setValue(new DoubleWritable(0));
vertex.setId((Text) record.get(0));
System.out.println(record.get(0));
for (int i = 1; i < record.size(); i++) {
Writable edge = record.get(i);
System.out.println(edge.toString());
if (!( edge.equals(NullWritable.get()))) {
vertex.addEdge(new Text(edge.toString()), NullWritable.get());
}
}
LOG.info("vertex edgs size: " + (vertex.hasEdges() ? vertex.getEdges().size() : 0));
context.addVertexRequest(vertex);
}
}
private static void printUsage() {
System.out.println("Usage: <in> <out> [Max iterations (default 30)]");
System.exit(-1);
}
public static void main(String[] args) throws IOException { if (args.length < 2)
printUsage();
GraphJob job = new GraphJob();
// Define GraphJob and specify the implementation method of Vertex/GraphLoader, the maximum number o
f iterations (> 30 by default), and input and output tables.
job.setGraphLoaderClass(PageRankVertexReader.class);
job.setVertexClass(PageRankVertex.class);
job.addInput(TableInfo.builder().tableName(args[0]).build());
job.addOutput(TableInfo.builder().tableName(args[1]).build());
// default max iteration is 30
job.setMaxIteration(30); if (args.length >= 3)
job.setMaxIteration(Integer.parseInt(args[2]));
long startTime = System.currentTimeMillis(); job.run();
System.out.println("Job Finished in "
+ (System.currentTimeMillis() - startTime) / 1000.0 + " seconds");
}
}
```

```
}
```

1.9.6.3. K-means clustering

K-means clustering is a basic macro-clustering algorithm. Basic principles of the K-means clustering algorithm are as follows: Clustering is performed around k points in space, and the closest vertices are classified. The values of the clustering centers are successively updated through iterations until the optimal clustering result is obtained.

Assuming the sample set is divided into k sets or categories, the steps in the algorithm are as follows:

- Select initial center of k classes.
- In the ith iteration, select any sample, solve its path to k center, and then classify the sample into the class of shortest path to center.
- Use the mean method to update the center value of the class.
- For all k clustering centers, if the value remains unchanged or is less than a certain threshold after iteration of the first two steps, the iteration ends. Otherwise, the iteration continues.

Example:

```
import java.io.DataInput; import java.io.DataOutput;
import java.io.IOException;
importorg.apache.log4j.Logger;
import com.aliyun.odps.io.WritableRecord;
import com.aliyun.odps.graph.Aggregator;
import com.aliyun.odps.graph.ComputeContext;
import com.aliyun.odps.graph.GraphJob;
import com.aliyun.odps.graph.GraphLoader;
import com.aliyun.odps.graph.MutationContext;
import com.aliyun.odps.graph.Vertex;
import com.aliyun.odps.graph.WorkerContext;
import com.aliyun.odps.io.DoubleWritable;
import com.aliyun.odps.io.LongWritable;
import com.aliyun.odps.io.NullWritable;
import com.aliyun.odps.data.TableInfo;
import com.aliyun.odps.io.Text;
import com.aliyun.odps.io.Tuple;
import com.aliyun.odps.io.Writable;
public class Kmeans {
private final static Logger LOG = Logger.getLogger(Kmeans.class);
/**Define KmeansVertex. The compute() method is simple. It calls the aggregate() method of the context obj
ect and transmits the value of the current vertex (in Tuple type and expressed by vector).**/
public static class KmeansVertex extends
Vertex<Text, Tuple, NullWritable, NullWritable> {
@Override
public void compute(
```

```
public void compute(
ComputeContext<Text, Tuple, NullWritable, NullWritable> context, Iterable<NullWritable> messages) throw
s IOException { context.aggregate(getValue());
}
}
/** Define the KmeansVertexReader class, load a graph, and parse each record in the table as a vertex. The ve
rtex ID does not matter, and transmitted recordNum is used as the ID. The vertex value is the Tuple consistin
g of all columns of the record.**/
public static class KmeansVertexReader extends
GraphLoader<Text, Tuple, NullWritable, NullWritable> {
@Override
public void load(LongWritable recordNum, WritableRecord record, MutationContext<Text, Tuple, NullWrita
ble, NullWritable> context) throws IOException {
KmeansVertex vertex = new KmeansVertex();
vertex.setId(new Text(String.valueOf(recordNum.get())));
vertex.setValue(new Tuple(record.getAll()));
context.addVertexRequest(vertex);
}
}
public static class KmeansAggrValue implements Writable {
Tuple centers = new Tuple();
Tuple sums = new Tuple();
Tuple counts = new Tuple();
@Override
public void write(DataOutput out) throws IOException {
centers.write(out);
sums.write(out); counts.write(out);
}
@Override
public void readFields(DataInput in) throws IOException {
centers = new Tuple();
centers.readFields(in);
sums = new Tuple();
sums.readFields(in);
counts = new Tuple();
counts.readFields(in);
}
@Override
public String toString() {
return "centers " + centers.toString() + ", sums " + sums.toString()
+ ", counts " + counts.toString();
```

```
}
}
/**
* Defines KmeansAggregator. This class encapsulates the main logic of the Kmeans algorithm, where,
* createInitialValue creates an initial value for each iteration (k-class center point). In first iteration (superste
p equals to 0), the value is the initial center point. Otherwise, the value is the new center point when the last
iteration ends.
* The aggregate() method calculates the distance from each vertex to centers of different classes, classifies t
he vertex as the class of the nearest center, and updates sum and count of the class.
* The merge() method combines sums and counts collected by each Worker.
* The terminate() method calculates the new central point based on the sum and count of each class. If the d
istance between the new and old central points is less than a threshold value or the number of iterations re
aches the upper limit, the iteration ends (false is returned). The final central point is written to the resulting
table.
**/
public static class KmeansAggregator extends Aggregator<KmeansAggrValue> {
@SuppressWarnings("rawtypes")
@Override
public KmeansAggrValue createInitialValue(WorkerContext context)
throws IOException {
KmeansAggrValue aggrVal = null;
if (context.getSuperstep() == 0) {
aggrVal = new KmeansAggrValue();
aggrVal.centers = new Tuple();
aggrVal.sums = new Tuple();
aggrVal.counts = new Tuple();
byte[] centers = context.readCacheFile("centers");
String lines[] = new String(centers).split("\n");
for (int i = 0;
i < lines.length; i++) { String[] ss = lines[i].split(",");
Tuple center = new Tuple();
Tuple sum = new Tuple();
for (int j = 0; j < ss.length; ++j) {
center.append(new DoubleWritable(Double.valueOf(ss[j].trim())));
sum.append(new DoubleWritable(0.0));
}
LongWritable count = new LongWritable(0);
aggrVal.sums.append(sum); aggrVal.counts.append(count);
aggrVal.centers.append(center);
}
} else {
```

```
aggrVal = (KmeansAggrValue) context.getLastAggregatedValue(0);
}
return aggrVal;
}
@Override
Public void aggregate (glasvalue, object item ){
int min = 0;
double mindist = Double.MAX_VALUE;
Tuple point = (Tuple) item;
for (int i = 0;
i < value.centers.size();
i++) { Tuple center = (Tuple) value.centers.get(i);
// use Euclidean Distance, no need to calculate sqrt
double dist = 0.0d;
for (int j = 0; j < center.size(); j++) {
double v = ((DoubleWritable) point.get(j)).get()
- ((DoubleWritable) center.get(j)).get();
dist += v * v;
}
if (dist < mindist) { mindist = dist; min = i;
}
}
// update sum and count
Tuple sum = (Tuple) value.sums.get(min);
for (int i = 0;
i < point.size(); i++) {
DoubleWritable s = (DoubleWritable) sum.get(i); s.set(s.get() + ((DoubleWritable) point.get(i)).get());
}
LongWritable count = (LongWritable) value.counts.get(min);
count.set(count.get() + 1);
}
@Override
public void merge(KmeansAggrValue value, KmeansAggrValue partial) {
for (int i = 0; i < value.sums.size(); i++) {
Tuple sum = (Tuple) value.sums.get(i);
Tuple that = (Tuple) partial.sums.get(i);
for (int j = 0; j < sum.size(); j++) {
DoubleWritable s = (DoubleWritable) sum.get(j);
s.set(s.get() + ((DoubleWritable) that.get(j)).get());
}
```

```
}
for (int i = 0; i < value.counts.size(); i++) {
LongWritable count = (LongWritable) value.counts.get(i);
count.set(count.get() + ((LongWritable) partial.counts.get(i)).get());
}
}
@SuppressWarnings("rawtypes")
@Override
public boolean terminate(WorkerContext context, KmeansAggrValue value) throws IOException {
// compute new centers
Tuple newCenters = new Tuple(value.sums.size());
for (int i = 0; i < value.sums.size(); i++) {
Tuple sum = (Tuple) value.sums.get(i);
Tuple newCenter = new Tuple(sum.size());
LongWritable c = (LongWritable) value.counts.get(i);
for (int j = 0; j < sum.size(); j++) {
DoubleWritable s = (DoubleWritable) sum.get(j);
double val = s.get() / c.get();
newCenter.set(j, new DoubleWritable(val));
// reset sum for next iteration
s.set(0.0d);
}
// reset count for next iteration
c.set(0);
newCenters.set(i, newCenter);
}
// update centers
Tuple oldCenters = value.centers; value.centers = newCenters;
LOG.info("old centers: " + oldCenters + ", new centers: " + newCenters);
// compare new/old centers
boolean converged = true;
for (int i = 0; i < value.centers.size() && converged; i++) {
Tuple oldCenter = (Tuple) oldCenters.get(i);
Tuple newCenter = (Tuple) newCenters.get(i); double sum = 0.0d;
for (int j = 0; j < newCenter.size(); j++) {
double v = ((DoubleWritable) newCenter.get(j)).get() - ((DoubleWritable) oldCenter.get(j)).get();
sum += v * v;
}
double dist = Math.sqrt(sum);
LOG.info("old center: " + oldCenter + ", new center: " + newCenter + ", dist: " + dist);
// converge threshold for each center: 0.05
```

```
converged = dist < 0.05d;
}
if (converged || context.getSuperstep() == context.getMaxIteration() - 1) {
// converged or reach max iteration, output centers
for (int i = 0; i < value.centers.size(); i++) { context.write(((Tuple) value.centers.get(i)).toArray());
}
// true means to terminate iteration
return true;
}
// false means to continue iteration
return false;
}
}
private static void printUsage() {
System.out.println("Usage: <in> <out> [Max iterations (default 30)]");
System.exit(-1);
}
/**Define GraphJob, and specify the implementation method of Vertex, GraphLoader, or Aggregator, the ma
ximum number of iterations (30 by default), and input and output tables. **/
public static void main(String[] args) throws IOException {
if (args.length < 2)
printUsage();
GraphJob job = new GraphJob();
job.setGraphLoaderClass(KmeansVertexReader.class);
job.setRuntimePartitioning(false);
// Specify job.setRuntimePartitioning(false). For the K-means algorithm, vertices do not need to be distribut
ed during graph loading. If RuntimePartitioning is set to false, the performance for graph loading is improve
d.
job.setVertexClass(KmeansVertex.class);
job.setAggregatorClass(KmeansAggregator.class);
job.addInput(TableInfo.builder().tableName(args[0]).build());
job.addOutput(TableInfo.builder().tableName(args[1]).build());
// default max iteration is 30
job.setMaxIteration(30); if (args.length >= 3)
job.setMaxIteration(Integer.parseInt(args[2]));
long start = System.currentTimeMillis(); job.run();
System.out.println("Job Finished in " + (System.currentTimeMillis() - start) / 1000.0 + " seconds");
}
}
```

1.9.6.4. BiPartiteMatching

In a bipartite graph, all vertices can be divided into two sets, to which the two vertices of each edge respectively belong. For a bipartite graph G, M is its subgraph. If any two edges of M's edge set are not attached to the same vertex, then M is a match. The bipartite graph matching is usually used for information matching in scenarios with clear supply and demand relationships (such as online dating websites).

The procedure is as follows:

- Start from the first vertex on the left, select unmatched vertex to search for augmented path.
- If it goes through an unmatched vertex, the search is successful.
- Update path information, match number of Edge +1, and stop searching.
- If no augmented path is found, it does not search again from the specific vertex.

Example:

```
import java.io.DataInput;
import java.io.DataOutput;
import java.io.IOException;
import java.util.Random;
import com.aliyun.odps.data.TableInfo;
import com.aliyun.odps.graph.ComputeContext;
import com.aliyun.odps.graph.GraphJob;
import com.aliyun.odps.graph.MutationContext;
import com.aliyun.odps.graph.WorkerContext;
import com.aliyun.odps.graph.Vertex;
import com.aliyun.odps.graph.GraphLoader;
import com.aliyun.odps.io.LongWritable;
import com.aliyun.odps.io.NullWritable;
import com.aliyun.odps.io.Text;
import com.aliyun.odps.io.Writable;
import com.aliyun.odps.io.WritableRecord;
public class BipartiteMatching {
private static final Text UNMATCHED = new Text("UNMATCHED");
public static class TextPair implements Writable {
public Text first; public Text second;
public TextPair() { first = new Text();
second = new Text();
}
public TextPair(Text first, Text second) {
this.first = new Text(first);
this.second = new Text(second);
}
@Override
```

```
public void write(DataOutput out) throws IOException {
first.write(out);
second.write(out);
}
@Override
public void readFields(DataInput in) throws IOException {
first = new Text();
first.readFields(in);
second = new Text();
second.readFields(in);
}
@Override
public String toString() { return first + ": " + second;
}
}
public static class BipartiteMatchingVertexReader extends
GraphLoader<Text, TextPair, NullWritable, Text> {
@Override
public void load(LongWritable recordNum, WritableRecord record, MutationContext<Text, TextPair, NullWri
table, Text> context) throws IOException {
BipartiteMatchingVertex vertex = new BipartiteMatchingVertex();
vertex.setId((Text) record.get(0));
vertex.setValue(new TextPair(UNMATCHED, (Text) record.get(1)));
String[] adjs = record.get(2).toString().split(",");
for (String adj:adjs) {
vertex.addEdge(new Text(adj), null);
}
context.addVertexRequest(vertex);
}
}
public static class BipartiteMatchingVertex extends
Vertex<Text, TextPair, NullWritable, Text> {
private static final Text LEFT = new Text("LEFT");
private static final Text RIGHT = new Text("RIGHT");
private static Random rand = new Random();
@Override
public void compute(
ComputeContext<Text, TextPair, NullWritable, Text> context, Iterable<Text> messages) throws IOException
{
if (isMatched()) { voteToHalt();
return;
```

```
return;
}
switch ((int) context.getSuperstep() % 4) {
case 0:
if (isLeft()) {
context.sendMessageToNeighbors(this, getId());
}
break;
case 1:
if (isRight()) {
Text luckyLeft = null;
for (Text message : messages) { if (luckyLeft == null) {
luckyLeft = new Text(message);
} else {
if (rand.nextInt(1) == 0) { luckyLeft.set(message);
}
}
}
if (luckyLeft ! = null) { context.sendMessage(luckyLeft, getId());
}
}
break;
case 2:
if (isLeft()) {
Text luckyRight = null;
for (Text msg : messages) { if (luckyRight == null) {
luckyRight = new Text(msg);
} else {
if (rand.nextInt(1) == 0) { luckyRight.set(msg);
}
}
}
if (luckyRight ! = null) {
setMatchVertex(luckyRight);
context.sendMessage(luckyRight, getId());
}
}
break; case 3:
if (isRight()) {
for (Text msg : messages) { setMatchVertex(msg);
}
```

```
}
break;
}
}
@Override
public void cleanup(
WorkerContext<Text, TextPair, NullWritable, Text> context) throws IOException {
context.write(getId(), getValue().first);
}
private boolean isMatched() {
return ! getValue().first.equals(UNMATCHED);
}
private boolean isLeft() {
return getValue().second.equals(LEFT);
}
private boolean isRight() {
return getValue().second.equals(RIGHT);
}
private void setMatchVertex(Text matchVertex) { getValue().first.set(matchVertex);
}
}
private static void printUsage() {
System.err.println("BipartiteMatching <input> <output> [maxIteration]");
}
public static void main(String[] args) throws IOException { if (args.length < 2) {
printUsage();
}
GraphJob job = new GraphJob();
job.setGraphLoaderClass(BipartiteMatchingVertexReader.class);
job.setVertexClass(BipartiteMatchingVertex.class);
job.addInput(TableInfo.builder().tableName(args[0]).build());
job.addOutput(TableInfo.builder().tableName(args[1]).build());
int maxIteration = 30;
if (args.length > 2) {
maxIteration = Integer.parseInt(args[2]);
}
job.setMaxIteration(maxIteration);
job.run();
}
}
```

1.9.6.5. Strongly-connected component

A directed graph is called a strongly-connected graph if every vertex is reachable from every other vertex. A strongly-connected sub-graph with a large number of vertices in a directed graph is called a strongly-connected component. This algorithm example is based on the parallel coloring algorithm.

Each vertex contains the following two parts:

- colorID: stores the color of the vertex (v) during forward traversal. At the end of computing, the vertices with the same colorID belong to one strongly-connected component.
- transposeNeighbors: stores neighbor IDs of v in the transpose graph of the input graph.

The algorithm is implemented as follows:

- Transpose graph formation: contains two supersteps. In the first superstep, each vertex sends a message with its ID to all its outgoing neighbors. These IDs are stored in transposeNeighbors in the second superstep.
- Triming: contains one superstep. Each vertex with only one incoming or outgoing edge sets its colorID to its own ID, and becomes inactive. Subsequent messages sent to these vertexes are ignored.
- Forward traversal: contains two subphases (supersteps): Start and Rest. In the Start phase, each vertex sets its colorID to its own ID, and sends the ID to outgoing neighbors. In the Rest phase, each vertex uses the maximum colorID it received to update its own colorID, and propagates the colorID until the colorIDs converge. When the colorIDs converge, the master process sets the phase to backward traversal.
- Backward traversal: contains two subphases, Start and Rest. In the Start phase, each vertex whose ID equals its colorID propagates its ID to the vertices in transposeNeighbors and sets its status as inactive. Subsequent messages sent to these vertexes are ignored. In each of the Rest phase supersteps, each vertex receives a message matching its colorID, propagates its colorID in the transpose graph, and sets its status as inactive. If there are still active vertices after this step, the process goes back to the trimming phase.

Example:

```
import java.io.DataInput;
import java.io.DataOutput;
import java.io.IOException;
import com.aliyun.odps.data.TableInfo;
import com.aliyun.odps.graph.Aggregator;
import com.aliyun.odps.graph.ComputeContext;
import com.aliyun.odps.graph.GraphJob;
import com.aliyun.odps.graph.GraphLoader;
import com.aliyun.odps.graph.MutationContext;
import com.aliyun.odps.graph.Vertex;
import com.aliyun.odps.graph.WorkerContext;
import com.aliyun.odps.io.BooleanWritable;
import com.aliyun.odps.io.IntWritable;
import com.aliyun.odps.io.LongWritable;
import com.aliyun.odps.io.NullWritable;
import com.aliyun.odps.io.Tuple;
```

```
import com.aliyun.odps.io.Writable;
import com.aliyun.odps.io.WritableRecord;
/**
* Definition from Wikipedia:
* In the mathematical theory of directed graphs, a graph is said
* to be strongly connected if every vertex is reachable from every
* other vertex. The strongly connected components of an arbitrary
* directed graph form a partition into subgraphs that are themselves
* strongly connected.
*
* Algorithms with four phases as follows.
* 1. Transpose Graph Formation: Requires two supersteps. In the first
* superstep, each vertex sends a message with its ID to all its > outgoing
* neighbors, which in the second superstep are stored > in transposeNeighbors.
*
* 2. Trimming: Takes one superstep. Every vertex with only in-coming or
* only outgoing edges (or neither) sets its colorID to its own ID and
* becomes inactive. Messages subsequently sent to the vertex > are ignored.
*
* 3. Forward-Traversal: There are two sub phases: Start and Rest. In the
* Start phase, each vertex sets its colorID to its own ID and > propagates
* its ID to its outgoing neighbors. In the Rest phase, vertices update
* their own colorIDs with the minimum colorID they have seen, and > propagate
* their colorIDs, if updated, until the colorIDs converge.
* Set the phase to Backward-Traversal when the colorIDs converge.
*
* 4. Backward-Traversal: We again break the phase into Start and Rest.
* In Start, every vertex whose ID equals its colorID propagates its ID > to
* the vertices in transposeNeighbors and sets itself inactive. > Messages
* subsequently sent to the vertex are ignored. In each of the Rest > phase supersteps,
* each vertex receiving a message that matches its colorID: (1) > propagates
* its colorID in the transpose graph; (2) sets itself inactive. > Messages
* subsequently sent to the vertex are ignored. Set the phase back to Trimming
* if not all vertex are inactive.
*
* http://ilpubs.stanford.edu:8090/1077/3/p535-salihoglu.pdf
**/
public class StronglyConnectedComponents {
public final static int STAGE_TRANSPOSE_1 = 0;
public final static int STAGE_TRANSPOSE_2 = 1;
public final static int STAGE_TRIMMING = 2;
```

```
public final static int STAGE_TRIMMING = 2;
public final static int STAGE_FW_START = 3;
public final static int STAGE_FW_REST = 4;
public final static int STAGE_BW_START = 5;
public final static int STAGE_BW_REST = 6;
/**
* The value is composed of component id, incoming neighbors,
* active status and updated status.
**/
public static class MyValue implements Writable {
LongWritable sccID;// strongly connected component id
Tuple inNeighbors; // transpose neighbors
BooleanWritable active; // vertex is active or not
BooleanWritable updated; // sccID is updated or not
public MyValue() {
this.sccID = new LongWritable(Long.MAX_VALUE);
this.inNeighbors = new Tuple();
this.active = new BooleanWritable(true);
this.updated = new BooleanWritable(false);
}
public void setSccID(LongWritable sccID) {
this.sccID = sccID;
}
public LongWritable getSccID() {
return this.sccID;
}
public void setInNeighbors(Tuple inNeighbors) {
this.inNeighbors = inNeighbors;
}
public Tuple getInNeighbors() {
return this.inNeighbors;
}
public void addInNeighbor(LongWritable neighbor) {
this.inNeighbors.append(new LongWritable(neighbor.get()));
}
public boolean isActive() {
return this.active.get();
}
public void setActive(boolean status) {
this.active.set(status);
}
```

```
public boolean isUpdated() {
return this.updated.get();
}
public void setUpdated(boolean update) {
this.updated.set(update);
}
@Override
public void write(DataOutput out) throws IOException {
this.sccID.write(out);
this.inNeighbors.write(out);
this.active.write(out);
this.updated.write(out);
}
@Override
public void readFields(DataInput in) throws IOException {
this.sccID.readFields(in);
this.inNeighbors.readFields(in);
this.active.readFields(in);
this.updated.readFields(in);
}
@Override
public String toString() {
StringBuilder sb = new StringBuilder();
sb.append("sccID: " + sccID.get());
sb.append(" inNeighbores: " + inNeighbors.toDelimitedString(','));
sb.append(" active: " + active.get());
sb.append(" updated: " + updated.get());
return sb.toString();
}
}
public static class SCCVertex extends
Vertex<LongWritable, MyValue, NullWritable, LongWritable> {
public SCCVertex() {
this.setValue(new MyValue());
}
@Override
public void compute(
ComputeContext<LongWritable, MyValue, NullWritable, LongWritable> context, Iterable<LongWritable> ms
gs) throws IOException {
// Messages sent to inactive vertex are ignored.
if (! this.getValue().isActive()) {
```

```
this.voteToHalt(); return;
}
int stage = ((SCCAggrValue)context.getLastAggregatedValue(0)).getStage(); switch (stage) {
case STAGE_TRANSPOSE_1:
context.sendMessageToNeighbors(this, this.getId());
break;
case STAGE_TRANSPOSE_2:
for (LongWritable msg: msgs) {
this.getValue().addInNeighbor(msg);
}
case STAGE_TRIMMING:
this.getValue().setSccID(getId());
if (this.getValue().getInNeighbors().size() == 0 || this.getNumEdges() == 0) {
this.getValue().setActive(false);
}
break;
case STAGE_FW_START: this.getValue().setSccID(getId());
context.sendMessageToNeighbors(this, this.getValue().getSccID());
break;
case STAGE_FW_REST:
long minSccID = Long.MAX_VALUE;
for (LongWritable msg : msgs) {
if (msg.get() < minSccID) { minSccID = msg.get();
}
}
if (minSccID < this.getValue().getSccID().get()) {
this.getValue().setSccID(new LongWritable(minSccID));
context.sendMessageToNeighbors(this, this.getValue().getSccID());
this.getValue().setUpdated(true);
} else {
this.getValue().setUpdated(false);
}
break;
case STAGE_BW_START:
if (this.getId().equals(this.getValue().getSccID())) {
for (Writable neighbor : this.getValue().getInNeighbors().getAll()) {
context.sendMessage((LongWritable)neighbor, this.getValue().getSccID());
}
this.getValue().setActive(false);
}
break;
```

```
break;
case STAGE_BW_REST: this.getValue().setUpdated(false);
for (LongWritable msg : msgs) {
if (msg.equals(this.getValue().getSccID())) {
for (Writable neighbor : this.getValue().getInNeighbors().getAll()) {
context.sendMessage((LongWritable)neighbor, this.getValue().getSccID());
}
this.getValue().setActive(false);
this.getValue().setUpdated(true);
break;
}
}
break;
}
context.aggregate(0, getValue());
}
@Override
public void cleanup(
WorkerContext<LongWritable, MyValue, NullWritable, LongWritable> context)
throws IOException {
context.write(getId(), getValue().getSccID());
}
}
/**
* The SCCAggrValue maintains global stage and graph updated and > active status.
* updated is true only if one vertex is updated.
* active is true only if one vertex is active.
*/
public static class SCCAggrValue implements Writable {
IntWritable stage = new IntWritable(STAGE_TRANSPOSE_1);
BooleanWritable updated = new BooleanWritable(false);
BooleanWritable active = new BooleanWritable(false);
public void setStage(int stage) { this.stage.set(stage);
}
public int getStage() { return this.stage.get();
}
public void setUpdated(boolean updated) {
this.updated.set(updated);
}
public boolean getUpdated() {
return this.updated.get();
```

```
}
public void setActive(boolean active) {
this.active.set(active);
}
public boolean getActive() {
return this.active.get();
}
@Override
public void write(DataOutput out) throws IOException {
this.stage.write(out);
this.updated.write(out);
this.active.write(out);
}
@Override
public void readFields(DataInput in) throws IOException {
this.stage.readFields(in);
this.updated.readFields(in);
this.active.readFields(in);
}
}
/**
* The job of SCCAggregator is to schedule global stage in > every superstep.
*/
public static class SCCAggregator extends Aggregator<SCCAggrValue> {
@SuppressWarnings("rawtypes")
@Override
public SCCAggrValue createStartupValue(WorkerContext context) throws IOException { return new SCCAggr
Value();
}
@SuppressWarnings("rawtypes")
@Override
public SCCAggrValue createInitialValue(WorkerContext context) throws IOException {
return (SCCAggrValue) context.getLastAggregatedValue(0);
}
@Override
public void aggregate(SCCAggrValue value, Object item) throws IOException { MyValue v = (MyValue)item;
if ((value.getStage() == STAGE_FW_REST || value.getStage() == STAGE_BW_REST)&& v.isUpdated()) { value.se
tUpdated(true);
}
// only active vertex invoke aggregate()
value.setActive(true);
```

```
}
@Override
public void merge(SCCAggrValue value, SCCAggrValue partial) throws IOException {
boolean updated = value.getUpdated() || partial.getUpdated();
value.setUpdated(updated);
boolean active = value.getActive() || partial.getActive();
value.setActive(active);
}
@SuppressWarnings("rawtypes")
@Override
public boolean terminate(WorkerContext context, SCCAggrValue value) throws IOException {
// If all vertices is inactive, job is over.
if (! value.getActive()) { return true;
}
// state machine
switch (value.getStage()) {
case STAGE_TRANSPOSE_1:value.setStage(STAGE_TRANSPOSE_2);
break;
case STAGE_TRANSPOSE_2:value.setStage(STAGE_TRIMMING);
break;
case STAGE_TRIMMING:value.setStage(STAGE_FW_START);
break;
case STAGE_FW_START: value.setStage(STAGE_FW_REST);
break;
case STAGE_FW_REST:if (value.getUpdated()) {
value.setStage(STAGE_FW_REST);
} else {
value.setStage(STAGE_BW_START);
}
break;
case STAGE_BW_START: value.setStage(STAGE_BW_REST);
break;
case STAGE_BW_REST:if (value.getUpdated()) { value.setStage(STAGE_BW_REST);
} else { value.setStage(STAGE_TRIMMING);
}
break;
}
value.setActive(false);
value.setUpdated(false);
return false;
}
```

```
}
}
public static class SCCVertexReader extends
GraphLoader<LongWritable, MyValue, NullWritable, LongWritable> {
@Override public void load(
LongWritable recordNum, WritableRecord record,
MutationContext<LongWritable, MyValue, NullWritable, LongWritable> context) throws IOException {
SCCVertex vertex = new SCCVertex();
vertex.setId((LongWritable) record.get(0));
String[] edges = record.get(1).toString().split(",");
for (int i = 0; i < edges.length; i++) { try {
long destID = Long.parseLong(edges[i]);
vertex.addEdge(new LongWritable(destID), NullWritable.get());
} catch(NumberFormatException nfe) { System.err.println("Ignore " + nfe);
}
}
context.addVertexRequest(vertex);
}
}
public static void main(String[] args) throws Exception {
if (args.length < 2) {
System.out.println("Usage: <input> <output>");
System.exit(-1);
}
GraphJob job = new GraphJob();
job.setGraphLoaderClass(SCCVertexReader.class);
job.setVertexClass(SCCVertex.class);
job.setAggregatorClass(SCCAggregator.class);
job.addInput(TableInfo.builder().tableName(args[0]).build());
job.addOutput(TableInfo.builder().tableName(args[1]).build());
long startTime = System.currentTimeMillis();
job.run();
System.out.println("Job Finished in " + (System.currentTimeMillis() - startTime) / 1000.0 + " seconds");
}
}
```

1.9.6.6. Connected component

Two vertices are connected if a path exists between them. Undirected graph G is called a connected graph if every two vertices in the graph are connected. Otherwise, G is called an unconnected graph. A connected sub-graph with a large number of vertices is called a connected component. This algorithm calculates connected component members of each vertex, and outputs the connected component of the vertex value that includes the smallest vertex ID. The smallest vertex ID is propagated along edges to all vertices of the connected component.

Example:

```
import java.io.IOException;
import com.aliyun.odps.data.TableInfo;
import com.aliyun.odps.graph.ComputeContext;
import com.aliyun.odps.graph.GraphJob;
import com.aliyun.odps.graph.GraphLoader;
import com.aliyun.odps.graph.MutationContext;
import com.aliyun.odps.graph.Vertex;
import com.aliyun.odps.graph.WorkerContext;
import com.aliyun.odps.graph.examples.SSSP.MinLongCombiner;
import com.aliyun.odps.io.LongWritable;
import com.aliyun.odps.io.NullWritable;
import com.aliyun.odps.io.WritableRecord;
/**
* Compute the connected component membership of each vertex and output
* each vertex which's value containing the smallest id in the > connected
* component containing that vertex.
*
* Algorithm: propagate the smallest vertex id along the edges to all
* vertices of a connected component.
*
*/
public class ConnectedComponents {
public static class CCVertex extends
Vertex<LongWritable, LongWritable, NullWritable, LongWritable> {
@Override
public void compute(
ComputeContext<LongWritable, LongWritable, NullWritable, LongWritable> context, Iterable<LongWritable
> msgs) throws IOException {
if (context.getSuperstep() == 0L) {
this.setValue(getId());
context.sendMessageToNeighbors(this, getValue());
return;
}
long minID = Long.MAX_VALUE;
```

```
for (LongWritable id : msgs) {
if (id.get() < minID) { minID = id.get();
}
}
if (minID < this.getValue().get()) {
this.setValue(new LongWritable(minID));
context.sendMessageToNeighbors(this, getValue());
} else {
this.voteToHalt();
}
}
/**
* Output Table Description:
* +-----------------+----------------------------------------+
* Field | Type | Comment |
* +-----------------+----------------------------------------+
* v | bigint | vertex id |
* minID | bigint | smallest id in the connected component |
* +-----------------+----------------------------------------+
*/
@Override
public void cleanup(
WorkerContext<LongWritable, LongWritable, NullWritable, LongWritable> context) throws IOException {
context.write(getId(), getValue());
}
}
/**
* Input Table Description:
* +-----------------+-------------------------------------------------------+
* Field | Type | Comment |
* +-----------------+-------------------------------------------------------+
* v | bigint | vertex id |
* es | string | comma separated target vertex id of outgoing edges |
* +-----------------+-------------------------------------------------------+
*
* Example:
* For graph:
* 1 ----- 2
* | |
* 3 ----- 4
* Input table:
```

```
* +-----------+
* v | es |
* +-----------+
* | 1 | 2,3 |
* | 2 | 1,4 |
* | 3 | 1,4 |
* | 4 | 2,3 |
* +-----------+
*/
public static class CCVertexReader extends
GraphLoader<LongWritable, LongWritable, NullWritable, LongWritable> {
@Override
public void load(
LongWritable recordNum, WritableRecord record,
MutationContext<LongWritable, LongWritable, NullWritable, LongWritable> context) throws IOException {
CCVertex vertex = new CCVertex();
vertex.setId((LongWritable) record.get(0));
String[] edges = record.get(1).toString().split(",");
for (int i = 0; i < edges.length; i++) {
long destID = Long.parseLong(edges[i]);
vertex.addEdge(new LongWritable(destID), NullWritable.get());
}
context.addVertexRequest(vertex);
}
}
public static void main(String[] args) throws IOException {
if (args.length < 2) {
System.out.println("Usage: <input> <output>");
System.exit(-1);
}
GraphJob job = new GraphJob();
job.setGraphLoaderClass(CCVertexReader.class);
job.setVertexClass(CCVertex.class);
job.setCombinerClass(MinLongCombiner.class);
job.addInput(TableInfo.builder().tableName(args[0]).build());
job.addOutput(TableInfo.builder().tableName(args[1]).build());
long startTime = System.currentTimeMillis();
job.run();
System.out.println("Job Finished in " + (System.currentTimeMillis() - startTime) / 1000.0 + " seconds");
}
```

```
}
```

1.9.6.7. Topological sorting

For a directed edge (u,v), all vertex sequences satisfying u < v are called topological sequences. Topological sorting is an algorithm that is used to calculate the topological sequence of a directed graph.

The algorithm is implemented as follows:

- A vertex without incoming edges in the graph is found and output.
- The output vertex and all its outgoing edges are deleted.
- The preceding steps are repeated until all vertices are output.

Example:

```
import java.io.IOException;
import org.apache.commons.logging.Log;
import org.apache.commons.logging.LogFactory;
import com.aliyun.odps.data.TableInfo;
import com.aliyun.odps.graph.Aggregator;
import com.aliyun.odps.graph.Combiner;
import com.aliyun.odps.graph.ComputeContext;
import com.aliyun.odps.graph.GraphJob;
import com.aliyun.odps.graph.GraphLoader;
import com.aliyun.odps.graph.MutationContext;
import com.aliyun.odps.graph.Vertex;
import com.aliyun.odps.graph.WorkerContext;
import com.aliyun.odps.io.LongWritable;
import com.aliyun.odps.io.NullWritable;
import com.aliyun.odps.io.BooleanWritable;
import com.aliyun.odps.io.WritableRecord;
public class TopologySort {
private final static Log LOG = LogFactory.getLog(TopologySort.class);
public static class TopologySortVertex extends
Vertex<LongWritable, LongWritable, NullWritable, LongWritable> {
@Override
public void compute(
ComputeContext<LongWritable, LongWritable, NullWritable, LongWritable> context, Iterable<LongWritable
> messages) throws IOException {
// in superstep 0, each vertex sends message whose value is 1 to its
// neighbors
if (context.getSuperstep() == 0) { if (hasEdges()) {
context.sendMessageToNeighbors(this, new LongWritable(1L));
}
```

```
} else if (context.getSuperstep() >= 1) {
// compute each vertex's indegree
long indegree = getValue().get();
for (LongWritable msg : messages) {
indegree += msg.get();
}
setValue(new LongWritable(indegree));
if (indegree == 0) {
voteToHalt();
if (hasEdges()) {
context.sendMessageToNeighbors(this, new LongWritable(-1L));
}
context.write(new LongWritable(context.getSuperstep()), getId());
LOG.info("vertex: " + getId());
}
context.aggregate(new LongWritable(indegree));
}
}
}
public static class TopologySortVertexReader extends
GraphLoader<LongWritable, LongWritable, NullWritable, LongWritable> {
@Override public void load(
LongWritable recordNum, WritableRecord record,
MutationContext<LongWritable, LongWritable, NullWritable, LongWritable> context) throws IOException {
TopologySortVertex vertex = new TopologySortVertex();
vertex.setId((LongWritable) record.get(0));
vertex.setValue(new LongWritable(0));
String[] edges = record.get(1).toString().split(",");
for (int i = 0; i < edges.length; i++) {
long edge = Long.parseLong(edges[i]);
if (edge >= 0) {
vertex.addEdge(new LongWritable(Long.parseLong(edges[i])), NullWritable.get());
}
}
LOG.info(record.toString());
context.addVertexRequest(vertex);
}
}
public static class LongSumCombiner extends
Combiner<LongWritable, LongWritable> {
```

```
@Override
public void combine(LongWritable vertexId, LongWritable combinedMessage, LongWritable messageToCom
bine) throws IOException {
combinedMessage.set(combinedMessage.get() + messageToCombine.get());
}
}
public static class TopologySortAggregator extends
Aggregator<BooleanWritable> {
@SuppressWarnings("rawtypes")
@Override
public BooleanWritable createInitialValue(WorkerContext context) throws IOException {
return new BooleanWritable(true);
}
@Override
public void aggregate(BooleanWritable value, Object item) throws IOException {
boolean hasCycle = value.get();
boolean inDegreeNotZero = ((LongWritable) item).get() == 0 ? false : true;
value.set(hasCycle && inDegreeNotZero);
}
@Override
public void merge(BooleanWritable value, BooleanWritable partial) throws IOException {
value.set(value.get() && partial.get());
}
@SuppressWarnings("rawtypes")
@Override
public boolean terminate(WorkerContext context, BooleanWritable value) throws IOException {
if (context.getSuperstep() == 0) {
// since the initial aggregator value is true, and in superstep we don't
// do aggregate
return false;
}
return value.get();
}
}
public static void main(String[] args) throws IOException { if (args.length ! = 2) {
System.out.println("Usage : <inputTable> <outputTable>");
System.exit(-1);
}
// Input format
// 0 1, 2
// 1 3
```

```
// 2 3
// 3 -1
// The first column is vertexid, and the second column is the destination vertexid of the vertex. If the value is
-1, the vertex does not have any outgoing edges.
// Output format
// 0 0
// 1 1
// 1 2
// 2 3
// The first column is the supstep value, in which the topological sequence is hidden. The second column is v
ertexid.
// TopologySortAggregator is used to determine if the graph has any loops.
// If the input graph has a loop, the iteration ends when the indegree of all active vertices is not 0.
// You can use records in the input and output tables to determine if the graph has loops.
GraphJob job = new GraphJob();
job.setGraphLoaderClass(TopologySortVertexReader.class);
job.setVertexClass(TopologySortVertex.class);
job.addInput(TableInfo.builder().tableName(args[0]).build());
job.addOutput(TableInfo.builder().tableName(args[1]).build());
job.setCombinerClass(LongSumCombiner.class);
job.setAggregatorClass(TopologySortAggregator.class);
long startTime = System.currentTimeMillis(); job.run();
System.out.println("Job Finished in " + (System.currentTimeMillis() - startTime) / 1000.0 + " seconds");
}
}
```

1.9.6.8. Linear regression

In statistics, linear regression is a statistical analysis method used to determine the dependency between two or more variables. compared with the classification algorithm that predicts discrete data, the regression algorithm can predict continuous value-type data. The linear regression algorithm defines the loss function as the sum of the least square errors of a sample set. It solves the weight vector by minimizing the loss function.

A common solution is the gradient descent method. It is implemented as follows:

- Initialize the weight vector to provide the descent speed and iterations (or iteration convergence condition).
- Calculate the least square error for each sample.
- Calculate the sum of the least square error, and update the weight based on the descent speed.
- Repeat iterations until convergence occurs.

Example:

```
import java.io.DataInput;
```

```
import java.io.DataOutput;
import java.io.IOException;
import com.aliyun.odps.data.TableInfo;
import com.aliyun.odps.graph.Aggregator;
import com.aliyun.odps.graph.ComputeContext;
import com.aliyun.odps.graph.GraphJob;
import com.aliyun.odps.graph.MutationContext;
import com.aliyun.odps.graph.WorkerContext;
import com.aliyun.odps.graph.Vertex;
import com.aliyun.odps.graph.GraphLoader;
import com.aliyun.odps.io.DoubleWritable;
import com.aliyun.odps.io.LongWritable;
import com.aliyun.odps.io.NullWritable;
import com.aliyun.odps.io.Tuple;
import com.aliyun.odps.io.Writable;
import com.aliyun.odps.io.WritableRecord;
/**
* LineRegression input: y,x1,x2,x3,.....
*
* @author shiwan.ch
* @update jiasheng.tjs running parameters are like: tjs_lr_in > tjs_lr_out 1500 2
* 0.07
*/
public class LinearRegression {
public static class GradientWritable implements Writable {
Tuple lastTheta;
Tuple currentTheta;
Tuple tmpGradient;
LongWritable count;
DoubleWritable lost;
@Override
public void readFields(DataInput in) throws IOException {
lastTheta = new Tuple();
lastTheta.readFields(in);
currentTheta = new Tuple();
currentTheta.readFields(in);
tmpGradient = new Tuple();
tmpGradient.readFields(in);
count = new LongWritable();
count.readFields(in);
/* update 1: add a variable to store lost at every iteration */
```

```
/* update 1: add a variable to store lost at every iteration */
lost = new DoubleWritable();
lost.readFields(in);
}
@Override
public void write(DataOutput out) throws IOException {
lastTheta.write(out);
currentTheta.write(out);
tmpGradient.write(out);
count.write(out);
lost.write(out);
}
}
public static class LinearRegressionVertex extends
Vertex<LongWritable, Tuple, NullWritable, NullWritable> {
@Override
public void compute(
ComputeContext<LongWritable, Tuple, NullWritable, NullWritable> context, Iterable<NullWritable> message
s) throws IOException {
context.aggregate(getValue());
}
}
public static class LinearRegressionVertexReader extends
GraphLoader<LongWritable, Tuple, NullWritable, NullWritable> {
@Override
public void load(LongWritable recordNum, WritableRecord record, MutationContext<LongWritable, Tuple, N
ullWritable, NullWritable> context)
throws IOException {
LinearRegressionVertex vertex = new LinearRegressionVertex();
vertex.setId(recordNum);
vertex.setValue(new Tuple(record.getAll())); context.addVertexRequest(vertex);
}
}
public static class LinearRegressionAggregator extends
Aggregator<GradientWritable> {
@SuppressWarnings("rawtypes")
@Override
public GradientWritable createInitialValue(WorkerContext context) throws IOException {
if (context.getSuperstep() == 0) {
/* set initial value, all 0 */
GradientWritable grad = new GradientWritable();
```

```
grad.lastTheta = new Tuple();
grad.currentTheta = new Tuple();
grad.tmpGradient = new Tuple();
grad.count = new LongWritable(1);
grad.lost = new DoubleWritable(0.0);
int n = (int) Long.parseLong(context.getConfiguration().get("Dimension"));
for (int i = 0; i < n; i++) { grad.lastTheta.append(new DoubleWritable(0));
grad.currentTheta.append(new DoubleWritable(0));
grad.tmpGradient.append(new DoubleWritable(0));
}
return grad;
} else
return (GradientWritable) context.getLastAggregatedValue(0);
}
public static double vecMul(Tuple value, Tuple theta) {
/* perform this partial computing: y(i)-hθ(x(i)) for each sample */
/* value denote a piece of sample and value(0) is y */
double sum = 0.0;
for (int j = 1; j < value.size(); j++)
sum += Double.parseDouble(value.get(j).toString()) * Double.parseDouble(theta.get(j).toString());
Double tmp = Double.parseDouble(theta.get(0).toString()) + sum -Double.parseDouble(value.get(0).toStrin
g());
return tmp;
}
@Override
public void aggregate(GradientWritable gradient, Object value) throws IOException {
/*
* perform on each vertex--each sample i:set theta(j) for each sample > i
* for each dimension
*/
double tmpVar = vecMul((Tuple) value, gradient.currentTheta);
/*
* update 2:local worker aggregate(), perform like merge() below. This
* means the variable gradient denotes the previous aggregated value
*/
gradient.tmpGradient.set(0, new DoubleWritable( ((DoubleWritable) gradient.tmpGradient.get(0)).get() + t
mpVar));
gradient.lost.set(Math.pow(tmpVar, 2));
/*
* calculate (y(i)-hθ(x(i)))x(i)(j) for each sample i for each
* dimension j
```

```
*/
for (int j = 1; j < gradient.tmpGradient.size(); j++) gradient.tmpGradient.set(j, new DoubleWritable(
((DoubleWritable) gradient.tmpGradient.get(j)).get() + tmpVar * Double.parseDouble(((Tuple) value).get(j).t
oString())));
}
@Override
public void merge(GradientWritable gradient, GradientWritable partial) throws IOException {
/* perform SumAll on each dimension for all samples. */
Tuple master = (Tuple) gradient.tmpGradient;
Tuple part = (Tuple) partial.tmpGradient;
for (int j = 0; j < gradient.tmpGradient.size(); j++) {
DoubleWritable s = (DoubleWritable) master.get(j);
s.set(s.get() + ((DoubleWritable) part.get(j)).get());
}
gradient.lost.set(gradient.lost.get() + partial.lost.get());
}
@SuppressWarnings("rawtypes")
@Override
public boolean terminate(WorkerContext context, GradientWritable gradient) throws IOException {
/*
* 1. calculate new theta 2. judge the diff between last step and this
* step, if smaller than the threshold, stop iteration
*/
gradient.lost = new DoubleWritable(gradient.lost.get()/ (2 * context.getTotalNumVertices()));
/*
* we can calculate lost in order to make sure the algorithm is running > on
* the right direction (for debug)
*/
System.out.println(gradient.count + " lost:" + gradient.lost);
Tuple tmpGradient = gradient.tmpGradient;
System.out.println("tmpGra" + tmpGradient);
Tuple lastTheta = gradient.lastTheta;
Tuple tmpCurrentTheta = new Tuple(gradient.currentTheta.size());
System.out.println(gradient.count + " terminate_start_last:" + lastTheta);
double alpha = 0.07; // learning rate
// alpha =
// Double.parseDouble(context.getConfiguration().get("Alpha"));
/* perform theta(j) = theta(j)-alpha*tmpGradient */
long M = context.getTotalNumVertices();
/*
* update 2. add (/M) on the code. The original code forgot this step
```

```
* update 3: add (/M) on the code. The original code forget this step
*/
for (int j = 0; j < lastTheta.size(); j++) { tmpCurrentTheta
.set( j,
new DoubleWritable(Double.parseDouble(lastTheta.get(j)
.toString()) – alpha / M * Double.parseDouble(tmpGradient.get(j).toString())));
}
System.out.println(gradient.count + " terminate_start_current:" + tmpCurrentTheta);
// judge if convergence is happening.
double diff = 0.00d;
for (int j = 0; j < gradient.currentTheta.size(); j++)
diff += Math.pow(((DoubleWritable) tmpCurrentTheta.get(j)).get() - ((DoubleWritable) lastTheta.get(j)).get(),
2);
if (
/*
* Math.sqrt(diff) < 0.00000000005d ||
*/
Long.parseLong(context.getConfiguration().get("Max_Iter_Num")) == gradient.count
.get()) { context.write(gradient.currentTheta.toArray());
return true;
}
gradient.lastTheta = tmpCurrentTheta;
gradient.currentTheta = tmpCurrentTheta;
gradient.count.set(gradient.count.get() + 1);
int n = (int) Long.parseLong(context.getConfiguration().get("Dimension"));
/*
* update 4: Important!!! Remember this step. Graph won't reset the
* initial value for global variables at the beginning of each iteration
*/
for (int i = 0; i < n; i++) {
gradient.tmpGradient.set(i, new DoubleWritable(0));
}
return false;
}
}
public static void main(String[] args) throws IOException { GraphJob job = new GraphJob();
job.setGraphLoaderClass(LinearRegressionVertexReader.class); job.setRuntimePartitioning(false);
job.setNumWorkers(3);
job.setVertexClass(LinearRegressionVertex.class);
job.setAggregatorClass(LinearRegressionAggregator.class);
job.addInput(TableInfo.builder().tableName(args[0]).build());
```

```
job.addOutput(TableInfo.builder().tableName(args[1]).build());
job.setMaxIteration(Integer.parseInt(args[2])); // Numbers of Iteration
job.setInt("Max_Iter_Num", Integer.parseInt(args[2]));
job.setInt("Dimension", Integer.parseInt(args[3])); // Dimension
job.setFloat("Alpha", Float.parseFloat(args[4])); // Learning rate
long start = System.currentTimeMillis(); job.run();
System.out.println("Job Finished in " + (System.currentTimeMillis() - start) / 1000.0 + " seconds");
}
}
```

1.9.6.9. Count triangles

This algorithm is used to calculate the number of triangles passing through each vertex. The algorithm is implemented as follows:

- Each vertex sends its ID to all outgoing neighbors.
- Each vertex stores information about incoming and outgoing neighbors, and sends this information to outgoing neighbors.
- Each vertex calculates the number of endpoint intersections for each edge, calculates the sum, and outputs the results to a table.
- The number of triangles is the sum of the output results in the table divided by 3.

Example:

```
import java.io.IOException;
import com.aliyun.odps.data.TableInfo;
import com.aliyun.odps.graph.ComputeContext;
import com.aliyun.odps.graph.Edge;
import com.aliyun.odps.graph.GraphJob;
import com.aliyun.odps.graph.GraphLoader;
import com.aliyun.odps.graph.MutationContext;
import com.aliyun.odps.graph.Vertex;
import com.aliyun.odps.graph.WorkerContext;
import com.aliyun.odps.io.LongWritable;
import com.aliyun.odps.io.NullWritable;
import com.aliyun.odps.io.Tuple;
import com.aliyun.odps.io.Writable;
import com.aliyun.odps.io.WritableRecord;
/**
* Compute the number of triangles passing through each vertex.
*
* The algorithm can be computed in three supersteps:
* I. Each vertex sends a message with its ID to all its outgoing
* neighbors.
```

```
* II. The incoming neighbors and outgoing neighbors are stored and
* send to outgoing neighbors.
* III. For each edge compute the intersection of the sets at destination
* vertex and sum them, then output to table.
*
* The triangle count is the sum of output table and divide by three > since
* each triangle is counted three times.
*
**/
public class TriangleCount {
public static class TCVertex extends
Vertex<LongWritable, Tuple, NullWritable, Tuple> {
@Override
public void setup(
WorkerContext<LongWritable, Tuple, NullWritable, Tuple> context) throws IOException {
// collect the outgoing neighbors
Tuple t = new Tuple();
if (this.hasEdges()) {
for (Edge<LongWritable, NullWritable> edge : this.getEdges()) {
t.append(edge.getDestVertexId());
}
}
this.setValue(t);
}
@Override
public void compute(
ComputeContext<LongWritable, Tuple, NullWritable, Tuple> context, Iterable<Tuple> msgs) throws IOExcep
tion {
if (context.getSuperstep() == 0L) {
// sends a message with its ID to all its outgoing neighbors
Tuple t = new Tuple(); t.append(getId());
context.sendMessageToNeighbors(this, t);
} else if (context.getSuperstep() == 1L) {
// store the incoming neighbors
for (Tuple msg : msgs) {
for (Writable item : msg.getAll()) {
if (! this.getValue().getAll().contains((LongWritable)item)) {
this.getValue().append((LongWritable)item);
}
}
```

```
}
// send both incoming and outgoing neighbors to all outgoing neighbors
context.sendMessageToNeighbors(this, getValue());
} else if (context.getSuperstep() == 2L) {
// count the sum of intersection at each edge
long count = 0;
for (Tuple msg : msgs) {
for (Writable id : msg.getAll()) {
if (getValue().getAll().contains(id)) { count ++;
}
}
}
// output to table
context.write(getId(), new LongWritable(count));
this.voteToHalt();
}
}
}
public static class TCVertexReader extends
GraphLoader<LongWritable, Tuple, NullWritable, Tuple> {
@Override public void load(
LongWritable recordNum, WritableRecord record,
MutationContext<LongWritable, Tuple, NullWritable, Tuple> context) throws IOException {
TCVertex vertex = new TCVertex();
vertex.setId((LongWritable) record.get(0));
String[] edges = record.get(1).toString().split(",");
for (int i = 0; i < edges.length; i++) { try {
long destID = Long.parseLong(edges[i]);
vertex.addEdge(new LongWritable(destID), NullWritable.get());
} catch(NumberFormatException nfe) { System.err.println("Ignore " + nfe);
}
}
context.addVertexRequest(vertex);
}
}
public static void main(String[] args) throws IOException { if (args.length < 2) {
System.out.println("Usage: <input> <output>"); System.exit(-1);
}
GraphJob job = new GraphJob();
job.setGraphLoaderClass(TCVertexReader.class);
job.setVertexClass(TCVertex.class);
```

```
job.addInput(TableInfo.builder().tableName(args[0]).build());
job.addOutput(TableInfo.builder().tableName(args[1]).build());
long startTime = System.currentTimeMillis();
job.run();
System.out.println("Job Finished in " + (System.currentTimeMillis() - startTime) / 1000.0 + " seconds");
}
}
```

1.9.6.10. GraphLoader

The following example describes how to compile a graph job program to load data of different types. It mainly covers how GraphLoader and VertexResolver are used together to build the graph.

Example:

```
import java.io.IOException;
import com.aliyun.odps.conf.Configuration;
import com.aliyun.odps.data.TableInfo;
import com.aliyun.odps.graph.ComputeContext;
import com.aliyun.odps.graph.GraphJob;
import com.aliyun.odps.graph.GraphLoader;
import com.aliyun.odps.graph.Vertex;
import com.aliyun.odps.graph.VertexResolver;
import com.aliyun.odps.graph.MutationContext;
import com.aliyun.odps.graph.VertexChanges;
import com.aliyun.odps.graph.Edge;
import com.aliyun.odps.io.LongWritable;
import com.aliyun.odps.io.WritableComparable;
import com.aliyun.odps.io.WritableRecord;
/**
* A MaxCompute Graph job uses MaxCompute tables as the input. Assume that a job has two input tables, on
e storing vertices and the other storing edges.
* The format of the table storing vertices is as follows:
* +------------------------+
* VertexID | VertexValue |
* +------------------------+
* | id0| 9|
* +------------------------+
* | id1| 7|
* +------------------------+
* | id2| 8|
* +------------------------+
```

```
*
* The format of the table storing edges is as follows:
* +-----------------------------------+
* VertexID | DestVertexID| EdgeValue|
* +-----------------------------------+
* | id0| id1| 1|
* +-----------------------------------+
* | id0| id2| 2|
* +-----------------------------------+
* | id2| id1| 3|
* +-----------------------------------+
*
* The two preceding tables show that id0 has two outgoing edges pointing to id1 and id2. id2 has an outgoin
g edge pointing to id1, and id1 has no outgoing edges.
*
* For data of this type, in GraphLoader::load(LongWritable, Record, MutationContext), > MutationContext#a
ddVertexRequest(Vertex) can be used to add vertices to the graph, while link MutationContext#addEdgeReq
uest(WritableComparable,Edge) can be used to add edges to the graph. In link VertexResolver#resolve(Writa
bleComparable, Vertex, VertexChanges, boolean), vertices and edges added in the load() method are combin
ed to a vertex object, which is used as the returned value and added to the graph for participating in comput
ation.
*
**/
public class VertexInputFormat {
private final static String EDGE_TABLE = "edge.table";
/**
* Resolve a record to vertices and edges. Each record indicates a vertex or an edge based on its source.
*
* Enter a record to generate key-value pairs as you process com.aliyun.odps.mapreduce.Mapper#map. The k
eys are vertex IDs, and the values are vertices or edges written based on the context. These key-value pairs a
re summarized based on vertex IDs using LoadingVertexResolver.
*
* Note: Vertices or edges added here are requests sent based on the record content, and are not used in com
putation. Only vertices or edges added using VertexResolver participate in computation.
**/
public static class VertexInputLoader extends
GraphLoader<LongWritable, LongWritable, LongWritable, LongWritable> {
private boolean isEdgeData;
/**
* Configure VertexInputLoader.
*
```

```
* @param conf
* Indicate the configured parameters of a job. These parameters are configured in the MAIN function of Grap
hJob, or set on the console.
* @param workerId
* Indicate the serial number of the operating worker. It starts from 0 and can be used to build a unique verte
x ID.
* @param inputTableInfo
* Indicate information about the input table loaded to the current worker. The information can be used to d
etermine the type of current input data (record format).
**/
@Override
public void setup(Configuration conf, int workerId, TableInfo inputTableInfo) {
isEdgeData = conf.get(EDGE_TABLE).equals(inputTableInfo.getTableName());
}
/**
* Based on the record content, resolve corresponding edges and send a request to add them to the graph.
*
* @param recordNum
* Indicate the record serial number, which starts from 1 and is separately counted in each worker.
* @param record
* Indicate the record in the input table. It contains three columns, indicating the first vertex, last vertex, and
edge weight.
* @param context
* Indicate the context for adding resolved edges to the graph.
**/
@Override public void load(
LongWritable recordNum, WritableRecord record,
MutationContext<LongWritable, LongWritable, LongWritable, LongWritable> context) throws IOException {
if (isEdgeData) {
/**
* Data comes from the table that stores edges.
*
* 1. The first column indicates the first vertex ID.
**/
LongWritable sourceVertexID = (LongWritable) record.get(0);
/**
* 2. The second column indicates the last vertex ID.
**/
LongWritable destinationVertexID = (LongWritable) record.get(1);
/**
* 3. The third column indicates the edge weight.
```

```
* 3. The third column indicates the edge weight.
**/
LongWritable edgeValue = (LongWritable) record.get(2);
/**
* 4. Create an edge that consists of the last vertex ID and edge weight.
**/
Edge<LongWritable, LongWritable> edge = new Edge<LongWritable, LongWritable>( destinationVertexID, ed
geValue);
/**
* 5. Send a request to add an edge to the first vertex.
**/
context.addEdgeRequest(sourceVertexID, edge);
/**
* 6. If each record indicates a bidirectional edge, repeat steps 4 and 5. Edge<LongWritable, > LongWritable> e
dge2 = new
* Edge<LongWritable, LongWritable>( sourceVertexID, edgeValue);
* context.addEdgeRequest(destinationVertexID, edge2);
**/
} else {
/**
* Data comes from the table that stores vertices.
*
* 1. The first column indicates the vertex ID.
**/
LongWritable vertexID = (LongWritable) record.get(0);
/**
* 2. The second column indicates the vertex value.
**/
LongWritable vertexValue = (LongWritable) record.get(1);
/**
* 3. Create a vertex that consists of the vertex ID and vertex value.
**/
MyVertex vertex = new MyVertex();
/**
* 4. Initialize the vertex.
**/
vertex.setId(vertexID); vertex.setValue(vertexValue);
/**
* 5. Send a request for adding a vertex.
**/
context.addVertexRequest(vertex);
```

```
}
}
}
/**
* Summarize key-value pairs generated using GraphLoader::load(LongWritable, Record, > MutationContext), which is similar to
* Reduce in com.aliyun.odps.mapreduce.Reducer. For the unique vertex > ID, all actions such as
* adding or deleting vertices or edges for the ID are stored in VertexChanges.
*
* Note: Not only conflicting vertices or edges added by using the load() method are called. (A conflict occurs when multiple same vertex objects or duplicate edges are added.)
* All IDs requested to be generated using the load() method are called.
**/
public static class LoadingResolver extends
VertexResolver<LongWritable, LongWritable, LongWritable, LongWritable> {
/**
* Process a request for adding/deleting vertices or edges for an ID.
*
* VertexChanges has four APIs, which correspond to the four APIs of MutationContext:
* VertexChanges::getAddedVertexList() corresponds to
* MutationContext::addVertexRequest(Vertex).
* In the load() method, if vertex objects with the same ID are requested to be added, such vertex objects are collected to the returned list.
* VertexChanges::getAddedEdgeList() corresponds to
* MutationContext::addEdgeRequest(WritableComparable, Edge)
* If edge objects with the same first vertex ID are requested to be added, such edge objects are collected to t he returned list.
* VertexChanges::getRemovedVertexCount() corresponds to
* MutationContext::removeVertexRequest(WritableComparable)
* If vertices with the same ID are requested to be deleted, the number of total deletion requests is returned.
* VertexChanges#getRemovedEdgeList() corresponds to
* MutationContext#removeEdgeRequest(WritableComparable, WritableComparable)
* If edge objects with the same first vertex ID are requested to be deleted, such edge objects are collected to the returned list.
*
* By processing ID changes, you can state whether the ID participates in computation using the returned val ue. If the returned vertex is not NULL,
* the ID participates in subsequent computation. If the returned vertex is NULL, the ID does not participate i n subsequent computation.
*
* @param vertexId
```

```
* Indicate the ID of the vertex to be added, or the ID of the first vertex of the edge to be added.
* @param vertex
* Indicate an existing vertex object. Its value is always NULL in the data loading phase.
* @param vertexChanges
* Indicate the set of vertices or edges to be added/deleted for the ID.
* @param hasMessages
* Indicate whether the ID has any input messages. Its value is always false in the data loading phase.
**/
@Override
public Vertex<LongWritable, LongWritable, LongWritable, LongWritable> resolve( LongWritable vertexId,
Vertex<LongWritable, LongWritable, LongWritable, LongWritable> vertex, VertexChanges<LongWritable, Lo
ngWritable, LongWritable, LongWritable> vertexChanges, boolean hasMessages) throws IOException {
/**
* 1. Obtain the vertex object for computation.
**/
MyVertex computeVertex = null;
if (vertexChanges.getAddedVertexList() == null
|| vertexChanges.getAddedVertexList().isEmpty()) { computeVertex = new MyVertex(); computeVertex.setId(v
ertexId);
} else {
/**
* Each record indicates a unique vertex in the table that stores vertices.
**/
computeVertex = (MyVertex) vertexChanges.getAddedVertexList().get(0);
}
/**
* 2. Add the edge, which is requested to be added to the vertex, to the vertex object. If the data is a possible
duplicate, perform deduplication based on the algorithm needs.
**/
if (vertexChanges.getAddedEdgeList() ! = null) {
for (Edge<LongWritable, LongWritable> edge : vertexChanges.getAddedEdgeList()) { computeVertex.addEdg
e(edge.getDestVertexId(), edge.getValue());
}
}
/**
* 3. Return the vertex object and add it to the final graph for computation.
**/
return computeVertex;
}
}
/**
```

```
/
* Determine actions of the vertex that participates in computation.
*
**/
public static class MyVertex extends
Vertex<LongWritable, LongWritable, LongWritable, LongWritable> {
/**
* Write the vertex edge to the result table based on the format of the input table. Ensure that the format and
data of the input and output tables are the same.
*
* @param context
* Indicate the runtime context.
* @param messages
* Indicate the input message.
**/
@Override
public void compute(
ComputeContext<LongWritable, LongWritable, LongWritable, LongWritable> context, Iterable<LongWritabl
e> messages) throws IOException {
/**
* Write the vertex ID and value to the result table that stores vertices.
**/
context.write("vertex", getId(), getValue());
/**
* Write the vertex edge to the result table that stores edges.
**/
if (hasEdges()) {
for (Edge<LongWritable, LongWritable> edge : getEdges()) { context.write("edge", getId(), edge.getDestVerte
xId(),
edge.getValue());
}
}
/**
* Perform one round of iteration.
**/
voteToHalt();
}
}
/**
* @param args
* @throws IOException
```

```
*/
public static void main(String[] args) throws IOException {
if (args.length < 4) { throw new IOException(
"Usage: VertexInputFormat <vertex input> <edge input> <vertex output> <edge output>");
}
/**
* GraphJob is used to configure Graph jobs.
*/
GraphJob job = new GraphJob();
/**
* 1. Specify input graph data and the table that stores edges.
*/
job.addInput(TableInfo.builder().tableName(args[0]).build());
job.addInput(TableInfo.builder().tableName(args[1]).build());
job.set(EDGE_TABLE, args[1]);
/**
* 2. Specify the data loading mode, and resolve the records to edges. Similar to Map, the generated key is th
e vertex ID, and the value is the edge.
*/
job.setGraphLoaderClass(VertexInputLoader.class);
/**
* 3. Specify the data loading phase, and generate the vertex that participates in computation. Similar to Red
uce, edges generated by Map are combined to a vertex.
*/
job.setLoadingVertexResolverClass(LoadingResolver.class);
/**
* 4. Specify actions of the vertex that participates in computation. The vertex.compute() method is used for
each round of iteration.
*/
job.setVertexClass(MyVertex.class);
/**
* 5. Specify the output table of the Graph job, and write the computation result to the result table.
*/
job.addOutput(TableInfo.builder().tableName(args[2]).label("vertex").build());
job.addOutput(TableInfo.builder().tableName(args[3]).label("edge").build());
/**
* 6. Submit the job for execution.
*/
job.run();
}
}
```

1.10. Java SDK

MaxCompute provides Java SDK with a variety of APIs to support development on MaxCompute.

For more inforamtion about the APIs, see *MaxCompute Developer Guide*.

1.11. PyODPS

1.11.1. Overview

Although you can implement most MaxCompute development by executing SQL statements, you need to use Python in complex business scenarios and custom UDF scenarios.

PyODPS is the Python SDK of MaxCompute. It provides simple and convenient Python programming interfaces, basic operations on MaxCompute objects, and the DataFrame framework. It allows you to easily analyze data on MaxCompute.

1.11.2. Quick start

This topic describes how to use a PyODPS node in DataWorks for development. The following procedure is for reference only.

1. Create a PyODPS node.
   i. Create a business flow.

      Right-click **Business Flow** below **Data Analytics** and choose **Create Workflow** from the shortcut menu.

   ii. Create a node.

      Right-click **Data Analytics** and choose **Create Data Analytics Node > PyODPS**.
2. Edit the PyODPS node.

i. Write the program code.

The following code is for reference only:

```
import time          # Similar to Java, module import is required before an additional SDK is called.
import datetime      # In this example, only the print function is used.
import base64
import hashlib
import httplib
import json
import sys
import csv
from odps import ODPS      # To call an SDK related to MaxCompute, you must import this module.
def main():
  print"Hello World"     # Provide the output in the log file.
if __name__ == "__main__":   # The main entry of the program.
  main()
```

ii. Run the code.

After you edit the code, click the Run icon. You can view the running results in the **Runtime Log** section.

The first code snippet is completed. The main entry of the code is determined based on `if __name__ == "__main__"`. This statement takes effect only when the preceding script is run directly (name = main). It does not take effect when it is referenced as a module by other code files (name = Python file name).

1.11.3. Installation instructions

If you can access the Internet, we recommend that you use the Python package installer PIP to install PyODPS. For more information, see PIP installation instructions. If you want to speed up the download, we recommend that you use Alibaba Cloud images.

Prerequisites

Before you install PyOPDS, make sure that the following requirements are met:

- The Setuptools version is 3.0 or later.
- The Requests version is 2.4.0 or later.

Installation commands for reference:

```
pip install setuptools>=3.0
pip install requests>=2.4.0
```

Installation suggestions

We recommend that you install the following tools to speed up Tunnel upload:

- Greenlet. Recommended version: 0.4.10 or later.
- Cython. Recommended version: 0.19.0 or later.

Installation commands for reference:

```
pip install greenlet>=0.4.10  # Optional. It accelerates Tunnel upload.
pip install cython>=0.19.0  # Optional. It is not recommended if you use a Windows operating system.
```

> **Note** If you use a Windows operating system, make sure that you have installed Visual C++ and Cython of correct versions. Otherwise, you cannot speed up Tunnel upload.

Installation procedure

Run the following command to install PyODPS:

```
pip install pyodps
```

Run the following command to check whether the installation is complete:

```
python -c "from odps import ODPS"
```

If the Python version is not the default, you can run the following command to switch to the default version after you have installed PIP:

```
/home/tops/bin/python2.7 -m pip install setuptools>=3.0  # Replace the version of Setuptools with the actual version.
```

1.11.4. Platform instructions

1.11.4.1. Overview

PyODPS can be called as a data development node on a data development platform such as DataWorks. The platform provides a PyODPS running environment and supports scheduling and execution. You do not need to manually create a MaxCompute object. To migrate from a platform to a locally deployed PyODPS environment, see the instructions in the next topic.

1.11.4.2. Use local PyODPS

If you need to debug PyODPS locally or the resources on the platform where PyODPS is deployed cannot meet your requirements, you can deploy a local PyODPS environment.

You must install PyODPS first. For information about how to install it, see Installation instructions.

After you have installed PyODPS, you must manually create the MaxCompute object that was previously created on the platform. Then, execute the following statement on the platform to generate a statement template required by the MaxCompute object and manually modify the code:

```
print("\nfrom odps import ODPS\no = ODPS(%r, '<access-key>', %r, '<endpoint>')\n" % (o.account.access_id
, o.project))
```

> **Note** You need to replace **access-key** and **endpoint** with valid values. For information about how to obtain the values, see the corresponding topics in *MaxCompute Developer Guide*.

Then, place the modified code at the beginning of all code.

1.11.4.3. Use PyODPS in DataWorks

Create a workflow node

Set Node Type to PYODPS.

MaxCompute entry

The PyODPS node in DataWorks contains a global variable odps or o, which is the MaxCompute entry. You do not need to manually define the MaxCompute entry.

```
print(o.exist_table('pyodps_iris'))
```

Execute SQL statements

For more information, see SQL.

> **Note** By default, InstanceTunnel is disabled in DataWorks, and instance.open_reader is executed by using the Result interface. In this case, a maximum of 10,000 data records can be read. After InstanceTunnel is enabled, you can execute reader.count to obtain the number of data records. If you need to obtain all data iteratively, you must disable the limit on the data volume.

You can execute the following statements to enable InstanceTunnel and disable the limit:

```
options.tunnel.use_instance_tunnel = True
options.tunnel.limit_instance_tunnel = False  # Disable the limit on the data volume.
with instance.open_reader() as reader:
  # Use InstanceTunnel to read all data.
```

You can also add `tunnel=True` and `limit=False` to open_reader to enable InstanceTunnel and disable the limit on the data volume for the current open_reader operation.

```
with instance.open_reader(tunnel=True, limit=False) as reader:
# The current open_reader operation is executed by using InstanceTunnel and all data can be read.
```

> **Note** If you do not enable InstanceTunnel, the format of the obtained data may be incorrect.

DataFrame

- Execute DataFrame.

  To execute DataFrame in DataWorks, you must explicitly call automatically executed methods, such as execute and head.

```
from odps.df import DataFrame
iris = DataFrame(o.get_table('pyodps_iris'))
for record in iris[iris.sepal_width < 3].execute(): # Call an automatically executed method to process each record.
```

  To call an automatically executed method for data display, set `options.interactive` to True.

```
from odps import options
from odps.df import DataFrame
options.interactive = True # Set options.interactive to True at the beginning of the code.
iris = DataFrame(o.get_table('pyodps_iris'))
print(iris.sepal_width.sum()) # The method is executed immediately when the system displays information.
```

- Display details.

  To display details, you must set `options.verbose`. By default, this parameter is set to True in DataWorks. The system displays details such as the LogView URL while running.

Obtain scheduling parameters.

Different from SQL nodes in DataWorks, a PyODPS node does not replace strings such as **${param_name}** in the code. Instead, it adds a dict parameter named `args` to the global variable. You can obtain the scheduling parameters in dict. This way, the Python code is not affected. For example, if you set `ds=${yyyymmdd}` under **Schedule > Parameter** in DataWorks, you can run the following commands to obtain the parameter value:

```
print('ds=' + args['ds'])
ds=yyyymmdd
```

> **Note** You can run the following command to obtain the partition named **ds=${yyyymmdd}**:
>
> ```
> o.get_table('table_name').get_partition('ds=' + args['ds'])
> ```

Limits on functions

Functions may be limited in the following aspects due to the lack of packages such as matplotlib:

- The use of the plot function of DataFrame is affected.
- User defined functions (UDFs) of DataFrame can be executed only after they are submitted to

MaxCompute. As required by the Python sandbox, you can only use pure Python libraries and the NumPy library to execute UDFs. Other third-party libraries such as pandas cannot be used.

- However, you can use the NumPy and pandas libraries pre-installed in DataWorks to execute non-UDFs. You are not allowed to use other third-party libraries that contain binary code.

For compatibility reasons, `options.tunnel.use_instance_tunnel` is set to **False** in DataWorks by default. If you want to enable `InstanceTunnel` globally, you must set this parameter to **True**.

For implementation reasons, the Python atexit package is not supported. You need to use the try-finally structure to implement related functions.

Limits on usage

- The Python version of a PyODPS node is 2.7.
- Locally processed data obtained by a PyODPS node cannot exceed 50 MB, and the memory space occupied by the node cannot exceed 1 GB. Otherwise, the system stops tasks in the node. Do not write unnecessary Python data processing code in PyODPS tasks.
- Writing and debugging code in DataWorks is inefficient. We recommend that you install an IDE locally to write code.
- To prevent excess pressure on the gateway of DataWorks, the memory usage and CPU utilization are limited when PyODPS is used in DataWorks. The limits are managed by DataWorks. If the system displays **Got killed**, the memory usage exceeds the limit and the system stops the related processes. Therefore, we do not recommend you perform local data operations. However, the limits on the memory usage and CPU utilization do not apply to SQL and DataFrame tasks (except to_pandas) that are initiated by PyODPS.

1.11.5. Basic operations

1.11.5.1. Overview

PyODPS provides basic operations for MaxCompute objects. You can use Python-compliant programming methods to perform operations on MaxCompute.

1.11.5.2. Projects

You can use the `get_project` method of a MaxCompute object to obtain a project.

```
project = o.get_project('my_project') # Obtain a specific project.
project = o.get_project()         # Obtain the default project.
```

If the my_project parameter is not specified, the default project is obtained.

You can use the `exist_project` method to check whether a project exists.

1.11.5.3. Tables

Basic operations

You can call `list_tables` for a MaxCompute object to list all tables in a project.

```
for table in o.list_tables():
# Process each table.
```

You can call `exist_table` to check whether a table exists and call `get_table` to obtain the table.

```
t = o.get_table('dual')
t.schema
odps.Schema {
 c_int_a           bigint
 c_int_b           bigint
 c_double_a        double
 c_double_b        double
 c_string_a        string
 c_string_b        string
 c_bool_a          boolean
 c_bool_b          boolean
 c_datetime_a      datetime
 c_datetime_b      datetime
}
t.lifecycle
-1
print(t.creation_time)
2014-05-15 14:58:43
t.is_virtual_view
False
t.size
1408
t.comment
'Dual Table Comment'
t.schema.columns
[<column c_int_a, type bigint>,
 <column c_int_b, type bigint>,
 <column c_double_a, type double>,
 <column c_double_b, type double>,
 <column c_string_a, type string>,
 <column c_string_b, type string>,
 <column c_bool_a, type boolean>,
 <column c_bool_b, type boolean>,
 <column c_datetime_a, type datetime>,
 <column c_datetime_b, type datetime>]
t.schema['c_int_a']
<column c_int_a, type bigint>
t.schema['c_int_a'].comment
'Comment of column c_int_a'
```

You can obtain a table from another project by specifying the project parameter.

```
t = o.get_table('dual', project='other_project')
```

Create a table schema

You can initialize a table in two ways:

- Initialize a table based on table columns and available partitions.

```
from odps.models import Schema, Column, Partition
columns = [Column(name='num', type='bigint', comment='the column'),
      Column(name='num2', type='double', comment='the column2')]
partitions = [Partition(name='pt', type='string', comment='the partition')]
schema = Schema(columns=columns, partitions=partitions)
schema.columns
[<column num, type bigint>,
 <column num2, type double>,
 <partition pt, type string>]
schema.partitions
[<partition pt, type string>]
schema.names  # Obtain the names of non-partition fields.
['num', 'num2']
schema.types  # Obtain the types of non-partition fields.
[bigint, double]
```

- Initialize a table by calling `Schema.from_lists`. This method is easier to call, but you cannot directly set the comments of columns and partitions.

```
schema = Schema.from_lists(['num', 'num2'], ['bigint', 'double'], ['pt'], ['string'])
schema.columns
[<column num, type bigint>,
 <column num2, type double>,
 <partition pt, type string>]
```

Create a table

You can use a table schema to create a table.

```
table = o.create_table('my_new_table', schema)
table = o.create_table('my_new_table', schema, if_not_exists=True)  #The table is created only if no table wi
th the same name exists.
table = o.create_table('my_new_table', schema, lifecycle=7)  # Set the lifecycle.
```

You can also use a comma-connected string in the "field name, field type" format to create a table. This method is easier.

```
table = o.create_table('my_new_table', 'num bigint, num2 double', if_not_exists=True)
# To create a partitioned table, you can pass in (table field list, partition field list).
table = o.create_table('my_new_table', ('num bigint, num2 double', 'pt string'), if_not_exists=True)
```

By default, when you create a table, you can only use the BIGINT, DOUBLE, DECIMAL, STRING, DATETIME, BOOLEAN, MAP, and ARRAY data types. If you need to use other data types, such as TINYINT and STRUCT, you can set `options.sql.use_odps2_extension` to True. Example:

```
from odps import options
options.sql.use_odps2_extension = True
table = o.create_table('my_new_table', 'cat smallint, content struct<title:varchar(100), body string>')
```

Synchronize table updates

After another program updates a table, such as its schema, you can call the `reload` method to synchronize the update.

```
table.reload()
```

Record

A record refers to a single row in a table. You can call new_record for the table object to create a record.

```
t = o.get_table('mytable')
r = t.new_record(['val0', 'val1']) # The number of values must be equal to the number of fields in the table sc
hema.
r2 = t.new_record() # You can leave the value empty.
r2[0] = 'val0' # Set a value based on an offset.
r2['field1'] = 'val1' # Set a value based on a field name.
r2.field1 = 'val1' # Set a value based on an attribute.
print(record[0]) # Obtain the value at position 0.
print(record['c_double_a']) # Obtain a value based on a field.
print(record.c_double_a) # Obtain a value based on an attribute.
print(record[0: 3]) # Perform slicing operations.
print(record[0, 2, 3]) # Obtain values at multiple positions.
print(record['c_int_a', 'c_double_a']) # Obtain values based on multiple fields.
```

Obtain table data

You can obtain table data in three ways:

- Call `head` to retrieve up to the first 10,000 data records in a table. Example:

```
t = odps.get_table('dual')
for record in t.head(3):
    print(record[0]) # Obtain the value at position 0.
    print(record['c_double_a']) # Obtain a value based on a field.
    print(record[0: 3]) # Perform slicing operations.
    print(record[0, 2, 3]) # Obtain values at multiple positions.
    print(record['c_int_a', 'c_double_a']) # Obtain values based on multiple fields.
```

- Use `open_reader` for a table object to open a reader and read the table data. You can open the reader with or without a WITH clause.

```
# Open the reader with a WITH clause:
with t.open_reader(partition='pt=test') as reader:
    count = reader.count
    for record in reader[5:10] # You can execute this line multiple times until all records are read. The numb
er of records is specified by count. You can change it to parallel-operation code.
        # Process a record.
# Open the reader without a WITH clause:
reader = t.open_reader(partition='pt=test')
count = reader.count
for record in reader[5:10] # You can execute this line multiple times until all records are read. The number
of records is specified by count. You can change it to parallel-operation code.
    # Process a record.
```

- Use the `read_table` method for a MaxCompute object to obtain table data. Example:

```
for record in o.read_table('test_table', partition='pt=test'):
# Process a record.
```

Write data to a table.

Similar to `open_reader`, you can use `open_writer` for a table object to open a writer and write data to a table. Example:

```
# Open the writer with a WITH clause:
with t.open_writer(partition='pt=test') as writer:
records = [[111, 'aaa', True],          # A list can be used.
      [222, 'bbb', False],
      [333, 'ccc', True],
      [444, 'Chinese', False]]
writer.write(records)  # records can be iterable objects.
with t.open_writer(partition='pt1=test1,pt2=test2') as writer: #Write data in multi-level partitioning mode.
records = [t.new_record([111, 'aaa', True]),  # Record objects can be used.
      t.new_record([222, 'bbb', False]),
      t.new_record([333, 'ccc', True]),
      t.new_record([444, 'Chinese', False])]
writer.write(records)
with t.open_writer(partition='pt=test', blocks=[0, 1]) as writer:  # Two blocks are enabled.
   writer.write(0, gen_records(block=0))
   writer.write(1, gen_records(block=1))  # The two write operations can be performed in parallel based on t
he multithreading technique. Each block is independent.
# Open the writer without a WITH clause:
writer = t.open_writer(partition='pt=test', blocks=[0, 1])
writer.write(0, gen_records(block=0))
writer.write(1, gen_records(block=1))
writer.close()  # You must close the writer. Otherwise, the written data may be incomplete.
```

If the specified partition does not exist, use the create_partition parameter to create a partition. Example:

```
with t.open_writer(partition='pt=test', create_partition=True) as writer:
  records = [[111, 'aaa', True],          # A list can be used.
        [222, 'bbb', False],
        [333, 'ccc', True],
        [444, 'Chinese', False]]
  writer.write(records)  # records can be iterable objects.
```

You can also use the `write_table` method for a MaxCompute object to write data. Example:

```
records = [[111, 'aaa', True],          # A list can be used.
      [222, 'bbb', False],
      [333, 'ccc', True],
      [444, 'Chinese', False]]
o.write_table('test_table', records, partition='pt=test', create_partition=True)
```

> **Note**
>
> - Each time you call write_table, MaxCompute generates a file on the server. This operation is time-consuming. If too many files are generated, the efficiency of subsequent queries will be reduced. Therefore, we recommend that you write multiple records at a time or provide a Generator object when you use the write_table method.
> - When you use `write_table`, new data will be appended to existing data. PyODPS does not provide options to overwrite existing data. You need to manually remove the data that you want to overwrite. For a non-partitioned table, you must call `table.truncate()`. For a partitioned table, you need to delete partitions first.

Delete a table

```
o.delete_table('my_table_name', if_exists=True) # Delete a table if the table exists.
t.drop() # The drop function can be directly executed if a table object exists.
```

Create a DataFrame object

PyODPS provides a DataFrame framework, which allows you to conveniently query and manage MaxCompute data. You can use `to_df` to convert a table to a DataFrame object.

```
table = o.get_table('my_table_name')
df = table.to_df()
```

Table partitions

- Basic operations

  Check whether a table is partitioned:

  ```
  if table.schema.partitions:
   print('Table %s is partitioned.' % table.name)
  ```

  Iterate over all the partitions in a table:

  ```
  for partition in table.partitions:
      print(partition.name)
  for partition in table.iterate_partitions(spec='pt=test'):
  # Iterate over subpartitions.
  ```

  Check whether a specific partition exists:

  ```
  table.exist_partition('pt=test,sub=2019')
  ```

  Obtain a specific partition:

```
partition = table.get_partition('pt=test')
 print(partition.creation_time)
2019-09-18 22:22:27
 partition.size
0
```

- Create a partition.

```
t.create_partition('pt=test', if_not_exists=True)  # Create the partition if it does not exist.
```

- Delete a partition.

```
t.delete_partition('pt=test', if_exists=True)  # Delete the partition if it exists.
partition.drop()  # Use the drop method to delete the partition object if it exists.
```

Data upload and download channels

MaxCompute Tunnel is the data channel of MaxCompute. You can use it to upload data to or download data from MaxCompute.

> **Note** We recommend that you use the write and read interfaces of tables instead of the Tunnel interface. In a Cython environment, PyODPS compiles C programs during installation to accelerate the Tunnel upload and download.

- Upload example:

```
from odps.tunnel import TableTunnel
table = o.get_table('my_table')
tunnel = TableTunnel(odps)
upload_session = tunnel.create_upload_session(table.name, partition_spec='pt=test')
with upload_session.open_record_writer(0) as writer:
  record = table.new_record()
  record[0] = 'test1'
  record[1] = 'id1'
  writer.write(record)
  record = table.new_record(['test2', 'id2'])
  writer.write(record)
upload_session.commit([0])
```

- Download example:

```
from odps.tunnel import TableTunnel
tunnel = TableTunnel(odps)
download_session = tunnel.create_download_session('my_table', partition_spec='pt=test')
with download_session.open_record_reader(0, download_session.count) as reader:
  for record in reader:
# Process each record.
```

Note PyODPS currently does not allow you to upload external tables.

1.11.5.4. SQL

PyODPS supports MaxCompute SQL queries and provides methods to read execution results.

You can use the `execute_sql` and `run_sql` methods to create task instances.

Note The commands that are executable in the MaxCompute console may not be executed as SQL statements in MaxCompute. Use other methods to execute non-DDL/DML statements. For example, use the `run_security_query` method to execute GRANT/REVOKE statements, and use the `run_xflow` or `execute_xflow` method to execute PAI commands.

Execute SQL statements

```
o.execute_sql('select * from dual')  # Run the SQL statement in synchronous mode. Blocking continues until execution of the SQL statement is completed.
instance = o.run_sql('select * from dual')  # Run the SQL statement in asynchronous mode.
print(instance.get_logview_address())  # Obtain the LogView address.
instance.wait_for_success()  # Blocking continues until execution of the SQL statement is completed.
```

Configure runtime parameters

You can configure runtime parameters by setting the `hints` parameter. The type of this parameter is DICT.

```
o.execute_sql('select * from pyodps_iris', hints={'odps.sql.mapper.split.size': 16})
```

If you set the `sql.settings` parameter globally, you need to configure runtime parameters each time you execute the statement.

```
from odps import options
options.sql.settings = {'odps.sql.mapper.split.size': 16}
o.execute_sql('select * from pyodps_iris')  # The hints parameter is automatically set based on global settings.
```

Obtain SQL query results

You can directly call the `open_reader` method to obtain SQL query results. In the following example, structured data is returned.

```
with o.execute_sql('select * from dual').open_reader() as reader:
  for record in reader:
  # Process each record.
```

When the `DESC` command is executed, you can use `reader.raw` to obtain the raw SQL query results.

```
with o.execute_sql('desc dual').open_reader() as reader:
print(reader.raw)
```

If `options.tunnel.use_instance_tunnel` is set to True when you use `open_reader`, PyODPS calls Instance Tunnel by default. Otherwise, PyODPS calls the old Result interface. However, if you are using an earlier version of MaxCompute or an error occurs when PyODPS calls Instance Tunnel, PyODPS generates an alert and automatically downgrades the call object to the old Result interface. You can identify the cause of the downgrade based on the alert information. If the result of Instance Tunnel does not meet your expectation, set this option to False. When you call `open_reader`, you can specify a Result interface by setting the tunnel parameter.

```
# Call Instance Tunnel.
with o.execute_sql('select * from dual').open_reader(tunnel=True) as reader:
  for record in reader:
  # Process each record.
# Call the Result interface.
with o.execute_sql('select * from dual').open_reader(tunnel=False) as reader:
  for record in reader:
  # Process each record.
```

By default, PyODPS does not limit the amount of data that can be read from an instance. For protected projects, the amount of data that can be downloaded by using Tunnel is limited. If `options.tunnel.limit_instance_tunnel` is not set, the limit is automatically enabled. The number of data entries that can be downloaded is limited based on project configurations. Generally, a maximum of 10,000 data entries can be downloaded. You can add a limit option to the `open_reader` method or set `options.tunnel.limit_instance_tunnel` to True to manually limit the amount.

If your MaxCompute version only supports the old Result interface and you need to read all data, you can export the SQL query results to another table and then use the table read interface to read data. This may be limited by project security settings.

In PyODPS V0.7.7.1 and later, you can use `open_reader` to call Instance Tunnel to obtain all data.

```
instance = o.execute_sql('select * from movielens_ratings limit 20000')
with instance.open_reader() as reader:
  print(reader.count)
  # for record in reader: Traverse the 20,000 data records. In this example, only 10 data records are obtained based on data slicing.
  for record in reader[:10]:
    print(record)
```

Set alias

During runtime, if the resource referenced by a UDF changes dynamically, you can use the old resource name as the alias of the current resource. This way, you do not need to delete the UDF or create a UDF.

```
from odps.models import Schema
myfunc = '''\
from odps.udf import annotate
from odps.distcache import get_cache_file
@annotate('bigint->bigint')
class Example(object):
  def __init__(self):
    self.n = int(get_cache_file('test_alias_res1').read())
  def evaluate(self, arg):
    return arg + self.n
'''
res1 = o.create_resource('test_alias_res1', 'file', file_obj='1')
o.create_resource('test_alias.py', 'py', file_obj=myfunc)
o.create_function('test_alias_func',
          class_type='test_alias.Example',
          resources=['test_alias.py', 'test_alias_res1'])
table = o.create_table(
  'test_table',
  schema=Schema.from_lists(['size'], ['bigint']),
  if_not_exists=True
)
data = [[1, ], ]
# Write a row of data that contains only one value: 1.
o.write_table(table, 0, [table.new_record(it) for it in data])
with o.execute_sql(
  'select test_alias_func(size) from test_table').open_reader() as reader:
  print(reader[0][0])
res2 = o.create_resource('test_alias_res2', 'file', file_obj='2')
# Use the name of the resource whose content is 1 as the alias of the resource whose content is 2. You do no
t need to modify the UDF or resource.
with o.execute_sql(
  'select test_alias_func(size) from test_table',
  aliases={'test_alias_res1': 'test_alias_res2'}).open_reader() as reader:
  print(reader[0][0])
```

Execute SQL statements in an interactive environment

In IPython and Jupyter, SQL plug-ins can be used to execute SQL statements and parameterized queries are supported.

Set biz_id

Occasionally, when an SQL statement is executed, biz_id must be submitted. Otherwise, an error occurs. In this case, you can set biz_id in the global options to troubleshoot the error.

```
from odps import options
options.biz_id = 'my_biz_id'
o.execute_sql('select * from pyodps_iris')
```

1.11.5.5. Task instances

Tasks, such as SQL tasks, are the basic computing unit of MaxCompute.

Basic operations

Tasks are implemented as MaxCompute instances. You can call `list_instances` to obtain all instances in a project, `exist_instance` to check whether an instance exists, and `get_instance` to obtain an instance.

```
for instance in o.list_instances():
  print(instance.id)
  o.exist_instance('my_instance_id')
```

You can call the `stop` method for an instance or call `stop_instance` at the MaxCompute entry to stop an instance.

Obtain the LogView address of a task

You can call `get_logview_address` to obtain the LogView address of an SQL task.

```
# Obtain the LogView address based on an existing instance object.
instance = o.run_sql('desc pyodps_iris')
print(instance.get_logview_address())
# Obtain the LogView address based on an instance ID.
instance = o.get_instance('20160426055209945g9k5pvyi2')
print(instance.get_logview_address())
```

For an XFlow task, you must enumerate its subtasks and then obtain the LogView address of each subtask.

```
instance = o.run_xflow('AppendID', 'algo_public', {'inputTableName': 'input_table', 'outputTableName': 'output_table'})
for sub_inst_name, sub_inst in o.get_xflow_sub_instances(instance).items():
  print('%s: %s' % (sub_inst_name, sub_inst.get_logview_address()))
```

Obtain the status of a task instance

An instance can be in the **Running**, **Suspended**, or **Terminated** state. You can obtain the status from the status attribute. You can call the `is_terminated` method to check whether the execution of the current instance is completed and call the `is_successful` method to check whether the execution is successful. If the task is running or fails, False is returned for both methods.

```
instance = o.get_instance('2016042605520945g9k5pvyi2')
instance.status
<Status.TERMINATED: 'Terminated'>
  from odps.models import Instance
  instance.status == Instance.Status.TERMINATED
  True
  instance.status.value
  'Terminated'
```

You can call the `wait_for_completion` method to ask the system to return the status until the instance execution is completed. The `wait_for_success` method functions similarly. The difference is that if the execution fails, an exception is reported.

Subtask operations

A running instance may contain one or more subtasks, which are called Tasks. Note that Task here does not refer to the basic computing unit of MaxCompute.

You can call the `get_task_names` method to obtain the names of all Tasks.

```
instance.get_task_names()
['SQLDropTableTask']
```

After obtaining a Task name, you can call `get_task_result` to obtain the execution result of the Task. You can also call `get_task_results` to obtain the execution result of each Task in the form of a dictionary.

```
instance = o.execute_sql('select * from pyodps_iris limit 1')
instance.get_task_names()
['AnonymousSQLTask']
instance.get_task_result('AnonymousSQLTask')
'"sepallength","sepalwidth","petallength","petalwidth","name"\n5.1,3.5,1.4,0.2,"Iris-setosa"\n'
instance.get_task_results()
OrderedDict([('AnonymousSQLTask', "sepallength","sepalwidth","petallength","petalwidth","name"\n5.1,
3.5,1.4,0.2,"Iris-setosa"\n')])
```

You can call `get_task_progress` to obtain the current running progress of a Task when the task instance is running.

```
while not instance.is_terminated():
  for task_name in instance.get_task_names():
    print(instance.id, instance.get_task_progress(task_name).get_stage_progress_formatted_string())
    time.sleep(10)
20190519101349613gzbzufck2 2019-05-19 18:14:03 M1_Stg1_job0:0/1/1[100%]
```

1.11.5.6. Resources

PyODPS mainly supports file and table resources.

Resources commonly apply to UDFs and MapReduce on MaxCompute.

You can call `list_resources` to list all resources, `exist_resource` to check whether a resource exists, and `delete_resource` to delete a resource. You can also call the `drop` method to delete a resource.

File resources

Files of basic file types and the .py, .jar, and .archive types are supported.

- Create a file resource

  You can create a file resource by specifying a resource name, a file type, and a file-like or string object. Example:

  ```
  resource = odps.create_resource('test_file_resource', 'file', file_obj=open('/to/path/file')) # Use a file-like object.
  resource = odps.create_resource('test_py_resource', 'py', file_obj='import this') # Use a string object.
  ```

- Read and modify a file resource

  You can call the `open` method for a file resource or call `open_resource` at the MaxCompute entry to open a file resource. The opened object is a file-like object. Similar to the `open` method built in Python, file resources also support various opening modes. Example:

  ```
  with resource.open('r') as fp: # Open the file in read mode.
    content = fp.read() # Read all content.
    fp.seek(0) # Return to the beginning of the resource.
    lines = fp.readlines() # Read multiple lines.
    fp.write('Hello World') # Error. Data cannot be written into a file in read mode.
  with odps.open_resource('test_file_resource', mode='r+') as fp: # Open the file in read/write mode.
    fp.read()
    fp.tell() # Current position
    fp.seek(10)
    fp.truncate() # Truncate the file to the specified length.
    fp.writelines(['Hello\n', 'World\n']) # Write multiple lines into the file.
    fp.write('Hello World')
    fp.flush() # Manually calling the method will submit the update to MaxCompute.
  ```

PyODPS supports the following opening modes:

- r: read mode. The file can be opened but data cannot be written into it.
- w: write mode. Data can be written into the file, but data in it cannot be read. Note that the file content is cleared first if the file is opened in write mode.
- a: append mode. Data can be added to the end of the file.
- r+: read/write mode. You can read and write data from and to the file.
- w+: This mode is similar to r+, but the file content is cleared first.
- a+: This mode is similar to r+, but data can only be written to the end of the file.

In PyODPS, file resources can be opened in binary mode. For example, some compressed files must be opened in binary mode. **rb** indicates that a file is opened in binary read mode, and **r+b** indicates that a file is opened in binary read/write mode.

Table resources

- Create a table resource

```
o.create_resource('test_table_resource', 'table', table_name='my_table', partition='pt=test')
```

- Update a table resource

```
table_resource = o.get_resource('test_table_resource')
table_resource.update(partition='pt=test2', project_name='my_project2')
```

- Obtain a table and a partition

```
table_resource = o.get_resource('test_table_resource')
table = table_resource.table
print(table.name)
partition = table_resource.partition
print(partition.spec)
```

- Read and write data

```
table_resource = o.get_resource('test_table_resource')
with table_resource.open_writer() as writer:
  writer.write([0, 'aaaa'])
  writer.write([1, 'bbbbb'])
  with table_resource.open_reader() as reader:
    for rec in reader:
      print(rec)
```

1.11.5.7. Functions

You can create UDFs and use them in MaxCompute SQL.

Basic operations

You can call `list_functions` of a MaxCompute object to obtain all functions in the project. You can call `exist_function` to check whether a function exists and call `get_function` to obtain a function.

Create a function

```
# Reference resources in the current project.
resource = o.get_resource('my_udf.py')
function = o.create_function('test_function', class_type='my_udf.Test', resources=[resource])
# Reference resources in another project.
resource2 = o.get_resource('my_udf.py', project='another_project')
function2 = o.create_function('test_function2', class_type='my_udf.Test', resources=[resource2])
```

Delete a function

```
o.delete_function('test_function')
function.drop()  # Call the drop method if the function exists.
```

Update a function

You can call the `update` method to update a function.

```
function = o.get_function('test_function')
new_resource = o.get_resource('my_udf2.py')
function.class_type = 'my_udf2.Test'
function.resources = [new_resource, ]
function.update()  # Update the function.
```

1.11.6. DataFrame

PyODPS provides an interface similar to pandas called PyODPS DataFrame. This interface operates on MaxCompute tables and makes full use of the capabilities of MaxCompute. You can also change the data source from MaxCompute tables to pandas DataFrame, so that the same code can be executed on pandas.

This topic describes how to create and perform operations on DataFrame objects and how to use DataFrame to process data. For the complete DataFrame document, see DataFrame.

DataFrame object operations

The following example demonstrates how to create a DataFrame object. It is for reference only.

> **Note** The data used in the example is downloaded from movielens 100K. You can download the data as needed.

Assume that the following three tables already exist: pyodps_ml_100k_movies (movie-related data), pyodps_ml_100k_users (user-related data), and pyodps_ml_100k_ratings (rating-related data).

1. If no MaxCompute object is provided in the runtime environment, you must create an object.

```
from odps import ODPS
o = ODPS('**your-access-id**', '**your-secret-access-key**',
    project='**your-project**', endpoint='**your-end-point**')
```

2. You only need to import a Table object to create a DataFrame object.

```
from odps.df import DataFrame
users = DataFrame(o.get_table('pyodps_ml_100k_users'))
```

3. You can use the dtypes attribute to view the fields of DataFrame and the types of these fields.

```
users.dtypes
odps.Schema {
 user_id        int64
 age            int64
 sex            string
 occupation     string
 zip_code       string
}
```

4. You can use the `head` method to obtain the first N data records for quick data preview. Example:

```
users.head(10)
   user_id  age sex  occupation zip_code
0        1   24   M  technician    85711
1        2   53   F       other    94043
2        3   23   M      writer    32067
3        4   24   M  technician    43537
4        5   33   F       other    15213
5        6   42   M   executive    98101
6        7   57   M administrator    91344
7        8   36   M administrator    05201
8        9   29   M     student    01002
9       10   53   M      lawyer    90703
```

5. You can add a filter on the fields if you do not want to view all of them.
   - Example:

```
users[['user_id', 'age']].head(5)
  user_id age
0     1  24
1     2  53
2     3  23
3     4  24
4     5  33
```

- You can also exclude several fields. Example:

```
users.exclude('zip_code', 'age').head(5)
  user_id sex occupation
0     1   M technician
1     2   F     other
2     3   M    writer
3     4   M technician
4     5   F     other
```

- When you exclude some fields, you may want to obtain new columns through computation. For example, add the sex_bool attribute and set it to True if sex is M. Otherwise, set it to False.

```
users.select(users.exclude('zip_code', 'sex'), sex_bool=users.sex == 'M').head(5)
  user_id age occupation sex_bool
0     1  24 technician    True
1     2  53     other    False
2     3  23    writer     True
3     4  24 technician    True
4     5  33     other    False
```

6. Obtain the numbers of male and female users.

```
users.groupby(users.sex).agg(count=users.count())
  sex count
0   F   273
1   M   670
```

7. To divide users by occupation, obtain the first 10 occupations that have the largest population, and sort the occupations in descending order of population.

```
df = users.groupby('occupation').agg(count=users['occupation'].count())
df.sort(df['count'], ascending=False)[:10]
   occupation  count
0     student    196
1       other    105
2    educator     95
3  administrator     79
4    engineer     67
5   programmer     66
6    librarian     51
7      writer     45
8   executive     32
9   scientist     31
```

Alternatively, you can use the `value_counts` method. Note that the number of records returned by this method is limited by `options.df.odps.sort.limit`.

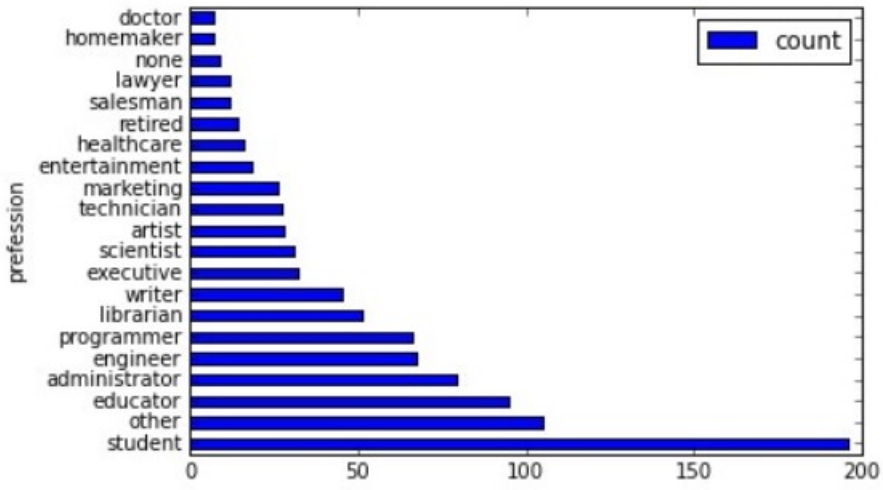
```
users.occupation.value_counts()[:10]
   occupation  count
0     student    196
1       other    105
2    educator     95
3  administrator     79
4    engineer     67
5   programmer     66
6    librarian     51
7      writer     45
8   executive     32
9   scientist     31
```

8. Show data in a more intuitive graph.

```
%matplotlib inline
```

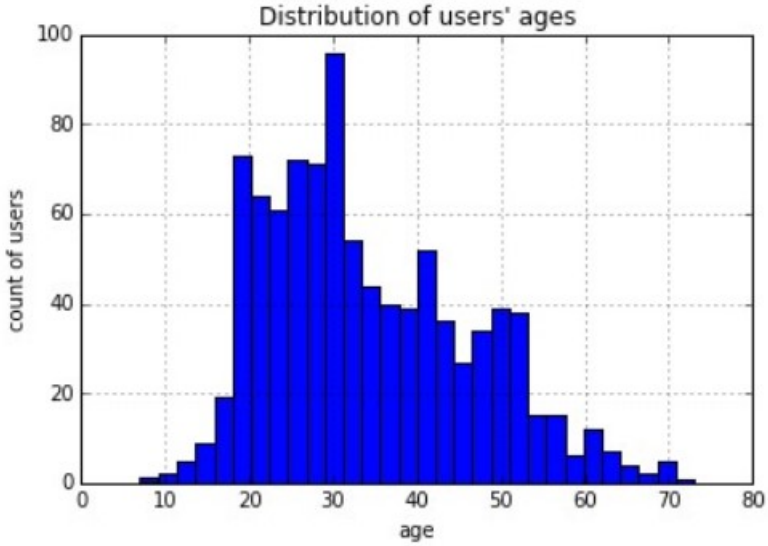
9. Use a horizontal column chart to visualize data.

```
users['occupation'].value_counts().plot(kind='barh', x='occupation', ylabel='prefession')
<matplotlib.axes._subplots.AxesSubplot at 0x10653cfd0>
```



10. Divide users into 30 groups by age and view the histogram of age distribution.

```
users.age.hist(bins=30, title="Distribution of users' ages", xlabel='age', ylabel='count of users')
<matplotlib.axes._subplots.AxesSubplot at 0x10667a510>
```



11. Use `join` to join the three tables and save them as a new table.

```
movies = DataFrame(o.get_table('pyodps_ml_100k_movies'))
ratings = DataFrame(o.get_table('pyodps_ml_100k_ratings'))
o.delete_table('pyodps_ml_100k_lens', if_exists=True)
lens = movies.join(ratings).join(users).persist('pyodps_ml_100k_lens')
lens.dtypes
odps.Schema {
 movie_id                int64
 title                   string
 release_date            string
 video_release_date      string
 imdb_url                string
 user_id                 int64
 rating                  int64
 unix_timestamp          int64
 age                     int64
 sex                     string
 occupation              string
 zip_code                string
}
```

12. Divide users aged 0 to 80 into eight age groups.

```
labels = ['0-9', '10-19', '20-29', '30-39', '40-49', '50-59', '60-69', '70-79']
cut_lens = lens[lens, lens.age.cut(range(0, 81, 10), right=False, labels=labels).rename('age_group')]
```

13. View the first 10 data records of a single age in a group.

```
cut_lens['age_group', 'age'].distinct()[:10]
  age_group age
0     0-9   7
1   10-19   10
2   10-19   11
3   10-19   13
4   10-19   14
5   10-19   15
6   10-19   16
7   10-19   17
8   10-19   18
9   10-19   19
```

14. View the total rating and average rating of users in each age group.

```
cut_lens.groupby('age_group').agg(cut_lens.rating.count().rename('total_rating'), cut_lens.rating.mean().rename('avg_rating'))
  age_group avg_rating total_rating
0     0-9 3.767442     43
1   10-19 3.486126   8181
2   20-29 3.467333   39535
3   30-39 3.554444   25696
4   40-49 3.591772   15021
5   50-59 3.635800   8704
6   60-69 3.648875   2623
7   70-79 3.649746   197
```

DataFrame data processing

The following example demonstrates how to process DataFrame data. It is for reference only.

> **Note** The data used in the example is downloaded from Iris dataset. You can download the data as needed.

1. Create a test data table.

   Use the table management feature of DataWorks to create a table, and then click **DDL mode**.

   Enter the CREATE TABLE statement and submit the table. Example:

   ```
   CREATE TABLE `pyodps_iris` (
     `sepallength` double COMMENT 'sepallength(cm)',
     `sepalwidth` double COMMENT 'sepalwidth(cm)',
     `petallength` double COMMENT 'petallength(cm)',
     `petalwidth` double COMMENT 'petalwidth(cm)',
     `name` string COMMENT 'name'
   );
   ```

2. Upload test data.

   Click the **Import** icon.

   Enter the table name and upload the downloaded dataset.

   Select **By Location** and click Import.

3. Create a PyODPS node to store and run code.
4. Enter the code and click the Run icon. You can view the result in the **Runtime Log** section in the lower pane.

   Code details:

```
from odps.df import DataFrame
from odps.df import output
iris = DataFrame(o.get_table('pyodps_iris')) #Create the DataFrame object iris from the MaxCompute ta
ble.
print iris.head(10)
print iris.sepallength.head(5) # Display part of the iris content.
# Use a user defined function to calculate the sum of two columns of iris.
print iris.apply(lambda row: row.sepallength + row.sepalwidth, axis=1, reduce=True, types='float').rena
me('sepaladd').head(3)
# Specify the output name and type of the function.
@output(['iris_add', 'iris_sub'], ['float', 'float'])
def handle(row):
# Use the yield keyword to return multiple rows of results.
  yield row.sepallength - row.sepalwidth,row.sepallength + row.sepalwidth
  yield row.petallength - row.petalwidth,row.petallength + row.petalwidth
# Display the results of the first five rows. axis=1 indicates that the axis of the column extends horizonta
lly.
print iris.apply(handle,axis=1).head(5)
```

1.11.7. User experience enhancement

1.11.7.1. Command line

PyODPS provides an enhanced command line tool.

You can perform the following steps to configure and call the tool:

1. Import the PyODPS enhancement tool:

   ```
   from odps.inter import setup, enter, teardown
   ```

2. Configure your account:

   ```
   setup('**your-access_id**', '**your-access-key**', '**your-project**', endpoint='**your-endpoint**')
   ```

   > **Note**
   > - If you do not specify the room parameter, the default room is used.
   > - After you have configured an account, you do not need to enter the account information again upon the next logon.

3. You can then call the enter method to create a Room object in any Python interactive interface.

```
room = enter()
o = room.odps
o.get_table('dual')
odps.Table
 name: odps_test_sqltask_finance.`dual`
 schema:
  c_int_a          : bigint
  c_int_b          : bigint
  c_double_a       : double
  c_double_b       : double
  c_string_a       : string
  c_string_b       : string
  c_bool_a         : boolean
  c_bool_b         : boolean
  c_datetime_a     : datetime
  c_datetime_b     : datetime
```

Note The MaxCompute object is not automatically updated when you change the setup of the room. You need to call `enter()` again to retrieve the new Room object.

After you have configured an account and called objects, you can store, retrieve, or delete objects in the room or delete the entire room.

- You can store commonly used MaxCompute tables or resources in the room. Example:

```
room.store('stored-table', o.get_table('dual'), desc='Simple stored table example')
```

- You can call the `display` method to display the stored objects as a table. Example:

```
room.display()
```

default name	desc
stored-table	Simple stored table example
iris	Iris dataset

- You can use `room['stored-table']` or `room.iris` to retrieve the stored objects. Example:

```
room['stored-table']
odps.Table
 name: odps_test_sqltask_finance.`dual`
 schema:
  c_int_a          : bigint
  c_int_b          : bigint
  c_double_a       : double
  c_double_b       : double
  c_string_a       : string
  c_string_b       : string
  c_bool_a         : boolean
  c_bool_b         : boolean
  c_datetime_a     : datetime
  c_datetime_b     : datetime
```

- You can call the `drop` method to delete objects in the room.

```
room.drop('stored-table')
room.display()
default name      desc
iris      Iris dataset
```

- You can call `teardown()` to delete a room. When no parameter is specified, the default room is deleted.

```
teardown()
```

1.11.7.2. IPython

PyODPS provides the IPython plug-in to facilitate MaxCompute operations.

IPython enhancement

Some commands are provided for command line enhancement.

- You can run the following code to load the plug-in:

```
%load_ext odps
%enter
```

Result:

```
<odps.inter.Room at 0x11341df10>
```

- In this case, the global `o` and `odps` variables can be retrieved. You can run the `o.get_table` or `odps.get_table` command to call a table.

```
o.get_table('dual')
odps.get_table('dual')
```

Result:

```
odps.Table
 name: odps_test_sqltask_finance.`dual`
 schema:
  c_int_a          : bigint
  c_int_b          : bigint
  c_double_a       : double
  c_double_b       : double
  c_string_a       : string
  c_string_b       : string
  c_bool_a         : boolean
  c_bool_b         : boolean
  c_datetime_a     : datetime
  c_datetime_b     : datetime
```

- Run the following command to display the stored objects as a table:

```
%stores
```

Result:

default name	desc
iris	Iris dataset

Object name completion

PyODPS enhances the code completion feature that is provided by IPython. When you write statements such as o.get_xxx, the object name is automatically completed. In the following examples, <tab> is used to denote pressing the Tab key. When you enter the statement and encounter <tab>, press the Tab key.

- Use the Tab key to complete the object name:

```
o.get_table(<tab>
```

- You can enter the first few characters of an object name and press the Tab key to complete it:

```
o.get_table('tabl<tab>
```

IPython auto-completes the table name that starts with tabl.

- This feature can also complete the names of objects in different projects. The syntax is as follows:

```
o.get_table(project='project_name', name='tabl<tab>
o.get_table('tabl<tab>', project='project_name')
```

- If multiple matching objects exist, IPython provides a list. `options.completion_size` specifies the maximum number of objects in the list. The default value is 10.

SQL statements

PyODPS provides a SQL plug-in to execute MaxCompute SQL statements.

- You can use `%sql` to execute a single-line SQL statement. Example:

```
In [*]: %sql select * from pyodps_iris limit 5
|==========================================|  1 / 1  (100.00%)     3s
Out[*]:
   sepallength  sepalwidth  petallength  petalwidth      name
0          5.1         3.5          1.4         0.2  Iris-setosa
1          4.9         3.0          1.4         0.2  Iris-setosa
2          4.7         3.2          1.3         0.2  Iris-setosa
3          4.6         3.1          1.5         0.2  Iris-setosa
4          5.0         3.6          1.4         0.2  Iris-setosa
```

- You can use `%%sql` to execute a multiple-line SQL statement. Example:

```
In [*]: %%sql
  ....: select * from pyodps_iris
  ....: where sepallength < 5
  ....: limit 5
  ....:
|==========================================|  1 / 1  (100.00%)     15s
Out[*]:
   sepallength  sepalwidth  petallength  petalwidth      name
0          4.9         3.0          1.4         0.2  Iris-setosa
1          4.7         3.2          1.3         0.2  Iris-setosa
2          4.6         3.1          1.5         0.2  Iris-setosa
3          4.6         3.4          1.4         0.3  Iris-setosa
4          4.4         2.9          1.4         0.2  Iris-setosa
```

- To execute parameterized SQL statements, you can use `:parameter` to specify the parameter. Example:

```
In [1]: %load_ext odps
In [2]: mytable = 'dual'
In [3]: %sql select * from :mytable
|==========================================|  1 / 1  (100.00%)      2s
Out[3]:
  c_int_a c_int_b c_double_a c_double_b c_string_a c_string_b c_bool_a \
0     0     0     -1203       0       0     -1203    True
 c_bool_b      c_datetime_a      c_datetime_b
0   False  2012-03-30 23:59:58  2012-03-30 23:59:59
```

- For SQL runtime parameters, you can use `%set` to set a global parameter or use SET within a SQLCell to set a local parameter. The following example sets a local parameter, which does not affect the global setting.

```
In [*]: %%sql
    set odps.sql.mapper.split.size = 16;
    select * from pyodps_iris;
```

- The following example sets a global parameter. Global settings apply to all subsequent SQL statements.

```
In [*]: %set odps.sql.mapper.split.size = 16
```

Upload pandas DataFrame to MaxCompute tables

PyODPS provides the following command to upload pandas DataFrame objects to MaxCompute tables:

You only need to use the `%persist` command. The first parameter df is the variable name. The second parameterpyodps_pandas_df is the MaxCompute table name.

```
import pandas as pd
import numpy as np
df = pd.DataFrame(np.arange(9).reshape(3, 3), columns=list('abc'))
%persist df pyodps_pandas_df
```

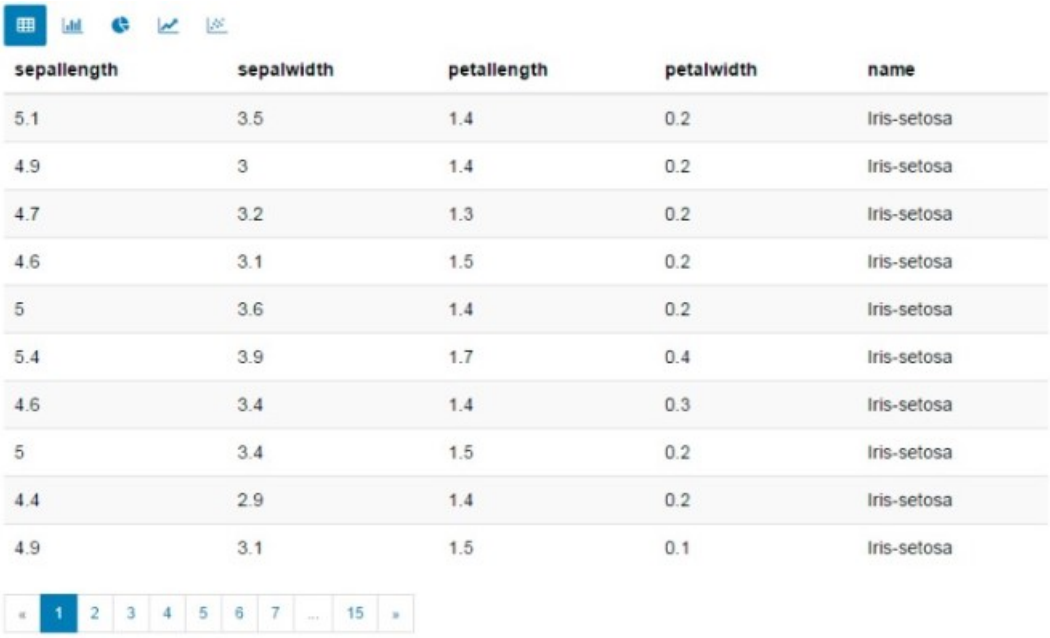
1.11.7.3. Jupyter Notebook

PyODPS enhances the result exploration and progress display features of Jupyter Notebook.

Result exploration

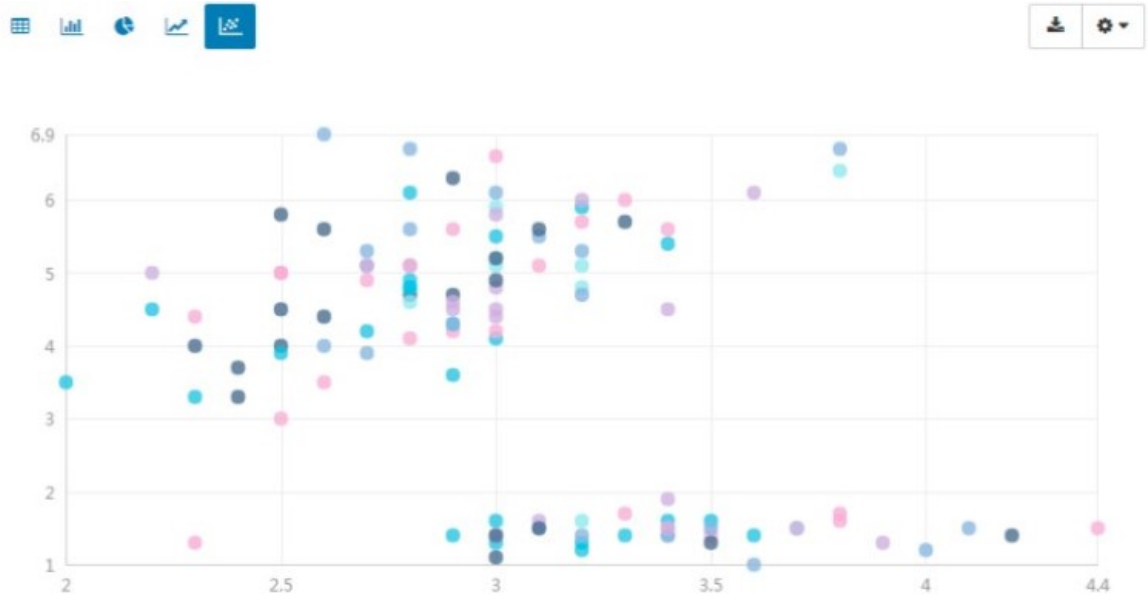
PyODPS provides a data exploration feature in Jupyter Notebook for SQLCell and DataFrame. You can use interactive data exploration tools to browse local data and create graphs.

1. If the execution result is a DataFrame object, PyODPS reads the result and displays it in a paged table. You can click a page number or the Previous or Next button to browse the data.

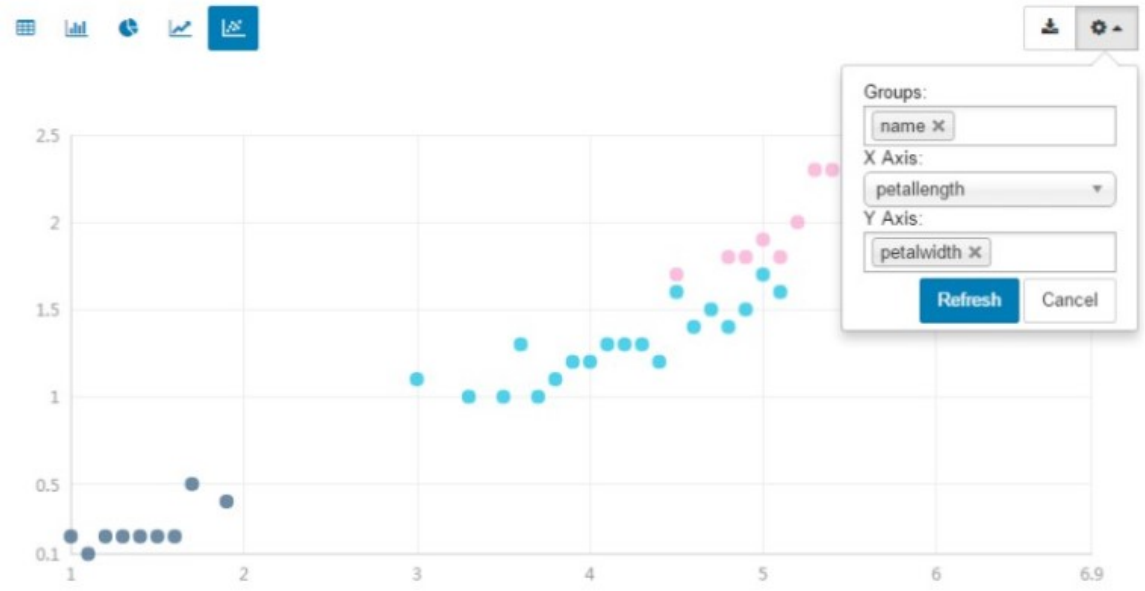


sepallength	sepalwidth	petallength	petalwidth	name
5.1	3.5	1.4	0.2	Iris-setosa
4.9	3	1.4	0.2	Iris-setosa
4.7	3.2	1.3	0.2	Iris-setosa
4.6	3.1	1.5	0.2	Iris-setosa
5	3.6	1.4	0.2	Iris-setosa
5.4	3.9	1.7	0.4	Iris-setosa
4.6	3.4	1.4	0.3	Iris-setosa
5	3.4	1.5	0.2	Iris-setosa
4.4	2.9	1.4	0.2	Iris-setosa
4.9	3.1	1.5	0.1	Iris-setosa

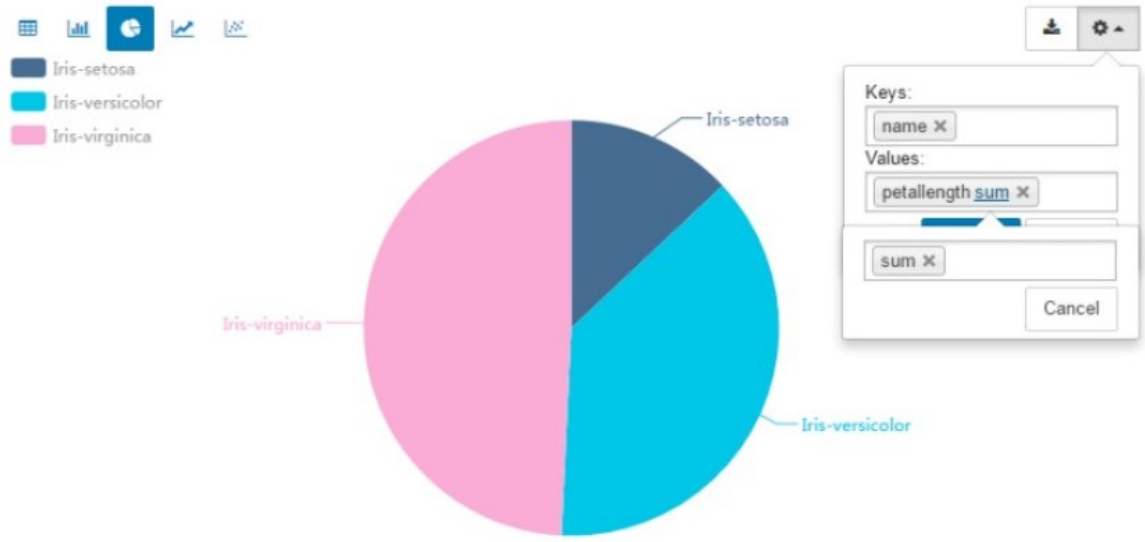
2. You can select other display modes on the top of the table to display the result in a column chart, pie chart, line chart, or scatter chart. The following figure shows a scatter chart created based on the default fields, which are the first three fields.



3. You can click the settings icon in the upper-right corner of a graph to modify the settings. For example, set Groups to **name**, X Axis to **petallength**, and Y Axis to **petalwidth**. The result is shown in the following graph. The **petallength-petalwidth** setting displays the data in a manner that is easy to understand.



For bar charts and pie charts, you can select an aggregate function for the value fields. The default aggregate function for column charts is `sum`, and that for pie charts is `count`. You can click the function name next to the value field name to select another function. For line charts, ensure that the values on the x-axis are not null. Otherwise, the graph may not display correctly.



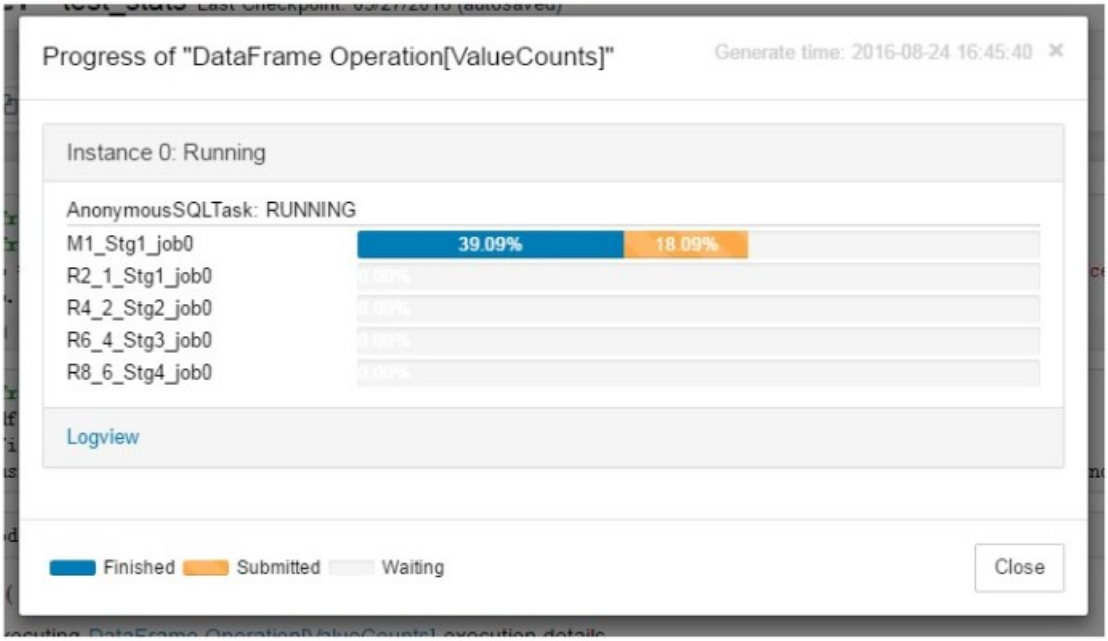
4. After you finish drawing the graph, click the **Download** icon to save it.

> **Note** Before you use this feature, ensure that you have installed pandas and ipywidgets.

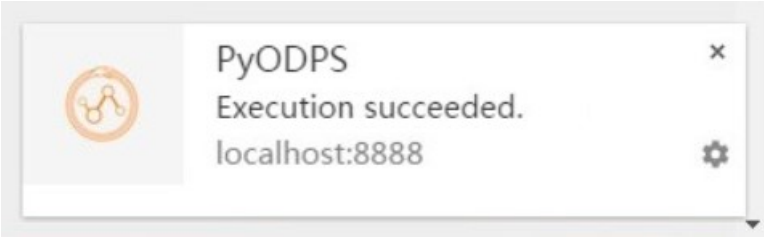
Progress display

The execution of large jobs takes extended periods of time. PyODPS provides progress bars to show the execution progress. When DataFrame jobs, machine learning jobs, or SQL statements that start with `%sql` are executed in Jupyter Notebook, a list of these jobs and their overall progress are displayed.

When you click a job name, a dialog box that displays the progress of each task in the job appears.



After the execution has been completed, a message that indicates whether the job is successful appears.



1.11.8. Configuration

PyODPS provides a series of configuration options. You can obtain them by using `odps.options`. Example:

```
from odps import options
# Set the lifecycle option, which specifies the lifecycle of all output tables.
options.lifecycle = 30
# Set the tunnel.string_as_binary option to True to use bytes instead of unicode to download data of the ST
RING type.
options.tunnel.string_as_binary = True
# When you execute PyODPS DataFrame on MaxCompute, you can refer to the following configuration to set
the limit to a relatively large value during a sort operation.
options.df.odps.sort.limit = 100000000
```

General configuration

Option	Description	Default value
end_point	The endpoint of MaxCompute.	None
default_project	The default project.	None
log_view_host	The hostname of LogView.	None
log_view_hours	The retention time of LogView (unit: hours).	24
local_timezone	The time zone used. True indicates local time, and False indicates UTC. The time zone of pytz can also be used.	None
lifecycle	The lifecycle of all tables.	None
temp_lifecycle	The lifecycle of temporary tables.	1
biz_id	The user ID.	None
verbose	Specifies whether to display logs.	False
verbose_log	The log receiver.	None
chunk_size	The size of the write buffer.	1496
retry_times	The number of request retries.	4
pool_connections	The number of cached connections in the connection pool.	10
pool_maxsize	The maximum capacity of the connection pool.	10

Option	Description	Default value
connect_timeout	The connection timeout period (unit: seconds).	5
read_timeout	The read timeout period (unit: seconds).	120
api_proxy	The API proxy server.	None
data_proxy	The data proxy server.	None
completion_size	The limit on the number of object completion listing items.	10
notebook_repr_widget	Specifies whether to use interactive graphs.	True
sql.settings	MaxCompute SQL runs global hints.	None
sql.use_odps2_extension	Specifies whether to enable MaxCompute 2.0 language extension.	False

Data upload and download configuration

Option	Description	Default value
tunnel.endpoint	The endpoint of Tunnel.	None
tunnel.use_instance_tunnel	Specifies whether to use Instance Tunnel to obtain execution results.	True
tunnel.limit_instance_tunnel	Specifies whether to limit the number of data records obtained by using Instance Tunnel.	None
tunnel.string_as_binary	Specifies whether to use bytes instead of unicode for data of the STRING type.	False

DataFrame configuration

Option	Description	Default value
interactive	Specifies whether DataFrame is used in an interactive environment.	Depends on the detection value.
df.analyze	Specifies whether to enable non-MaxCompute built-in functions.	True

Option	Description	Default value
df.optimize	Specifies whether to enable full DataFrame optimization.	True
df.optimizes.pp	Specifies whether to enable DataFrame predicate push optimization.	True
df.optimizes.cp	Specifies whether to enable DataFrame column pruning optimization.	True
df.optimizes.tunnel	Specifies whether to enable DataFrame tunnel optimization.	True
df.quote	Specifies whether to use `` to mark fields and table names in the backend of MaxCompute SQL.	True
df.libraries	The third-party library (resource name) that is used by DataFrame.	None
df.supersede_libraries	Specifies whether to use the self-uploaded NumPy to replace the version in the service.	False
df.odps.sort.limit	The default limit on the number of items added during a sort operation of DataFrame.	10000

Machine learning configuration

Option	Description	Default value
ml.xflow_settings	The XFlow execution configuration.	None
ml.xflow_project	The default XFlow project name.	algo_public
ml.use_model_transfer	Specifies whether to use ModelTransfer to obtain the model PMML.	False
ml.model_volume	The name of the volume used by ModelTransfer.	pyodps_volume

1.11.9. API overview

Links to PyODPS API documentation are provided below. You can see the parameter description and example of each function:

- Definitions

- DataFrame Reference

1.11.10. FAQ

How do I view the current PyODPS version?

Run the following commands:

```
import odps
print(odps.__version__)
```

How do I troubleshoot the "Project not found" error?

This problem is generally caused by incorrect endpoint configurations. You must check the configurations and rectify the problem. You also need to check whether the position of the MaxCompute object parameter is correct.

How do I manually specify a Tunnel endpoint?

You can create your MaxCompute object with the tunnel_endpoint parameter specified, as shown in the following code. Replace the content enclosed with asterisks (*) with actual parameter values and remove the asterisks (*).

```
from odps import ODPS
o = ODPS('**your-access-id**', '**your-secret-access-key**', '**your-default-project**',
    endpoint='**your-end-point**', tunnel_endpoint='**your-tunnel-endpoint**')
```

How do I troubleshoot the "project is protected" error reported while data is being read?

The project security policy does not allow you to read data from tables. To retrieve all the data, you can use the following solutions:

- Contact the project owner to add exception rules.
- Use DataWorks or other masking tools to mask the data and then export the data to an unprotected project before reading it.

To retrieve part of the data, you can use the following solutions:

- Use `o.execute_sql('select * from <table_name>').open_reader()` .
- Use `o.get_table('<table_name>').to_df()` in DataFrame.

I can only retrieve a maximum of 10,000 data records by executing SQL command open_reader. How do I retrieve more than 10,000 data records?

Use `create table as select ...` to save the SQL result to a table, and then use `table.open_reader` to read data.

How do I troubleshoot the "ODPSError: ODPS entrance should be provided" error reported when I upload pandas DataFrame to MaxCompute?

This error is reported because the global MaxCompute object cannot be found. Use one of the following methods to resolve this problem:

- If you use the room mechanism `%enter`, configure the global MaxCompute object.
- Call the `to_global` method for the MaxCompute object.
- Use the following MaxCompute parameter:

```
DataFrame(pd_df).persist('your_table', odps=odps)
```

How do I use max_pt in DataFrame?

Use the `odps.df.func` module to call built-in functions of MaxCompute. Example:

```
from odps.df import func
df = o.get_table('your_table').to_df()
df[df.ds == func.max_pt('your_project.your_table')]  # ds is a partition column.
```

How do I troubleshoot the "table lifecycle is not specified in mandatory mode" error reported when I use DataFrame to write data to a table?

Your project requires that every table be created with a lifecycle. Therefore, you must make the following configuration every time you run your own code:

```
from odps import options
options.lifecycle = 7  # You can also set this parameter to your expected lifecycle in days.
```

How do I traverse each row of data in PyODPS DataFrame?

PyODPS DataFrame currently does not support this feature. PyODPS DataFrame focuses on handling large volumes of data. Traversing data is inefficient.

We recommend that you use the apply or map_reduce method of DataFrame to parallelize your serial traverse operations.

If you confirm that data traversing is necessary in your scenario and that the cost is acceptable, you can use the `to_pandas` method to convert your DataFrame to pandas DataFrame, or you can store DataFrame as a table and use `read_table` or Tunnel to read data.

1.12. Java sandbox limits

MaxCompute MapReduce and UDF programs in distributed environments are run in Java sandboxes. The main programs of MapReduce are not subject to these limits.

The limits include:

- Local files cannot be accessed directly, and can only be accessed through APIs provided by MaxCompute MapReduce or Graph. You can access the resources specified by the resources option, such as files, JAR packages, and resource tables. You can use System.out and System.err to export logs and run the log command on the MaxCompute console to view log information.
- Direct access to the distributed file system is not allowed. You can only use MaxCompute MapReduce to Graph to access records of tables.
- JNI calls are not allowed.
- Java threads cannot be created, and Linux commands cannot be executed by sub-threads.
- Network access, including the operation of getting the local IP address, is prohibited.
- Java reflection restriction: The suppressAccessChecks permission is prohibited, so you cannot set a private attribute or method accessible to read private attributes or call private methods.

  Specifically, an access denied error is returned when you perform any of the preceding operations.

  Methods for accessing local files:

  java.io.File:

```
public boolean delete()
public void deleteOnExit()
public boolean exists()
public boolean canRead()
public boolean isFile()
public boolean isDirectory()
public boolean isHidden()
public long lastModified()
public long length()
public String[] list()
public String[] list(FilenameFilter filter)
public File[] listFiles()
public File[] listFiles(FilenameFilter filter)
public File[] listFiles(FileFilter filter)
public boolean canWrite()
public boolean createNewFile()
public static File createTempFile(String prefix, String suffix)
public static File createTempFile(String prefix, String suffix,File directory)
public boolean mkdir()
public boolean mkdirs()
public boolean renameTo(File dest)
public boolean setLastModified(long time)
public boolean setReadOnly()
java.io.RandomAccessFile:
RandomAccessFile(String name, String mode)
RandomAccessFile(File file, String mode)
java.io.FileInputStream:
```

```
FileInputStream(FileDescriptor fdObj)
FileInputStream(String name) FileInputStream(File file)
java.io.FileOutputStream:
FileOutputStream(FileDescriptor fdObj)
FileOutputStream(File file)
FileOutputStream(String name)
FileOutputStream(String name, boolean append)
java.lang.Class:
public ProtectionDomain getProtectionDomain()
java.lang.ClassLoader:
ClassLoader ()
ClassLoader(ClassLoader parent)
java. lang. Runtime:
public Process exec(String command)
public Process exec(String command, String envp[])
public Process exec(String cmdarray[])
public Process exec(String cmdarray[], String envp[])
public void exit(int status)
public static void runFinalizersOnExit(boolean value)
public void addShutdownHook(Thread hook)
public boolean removeShutdownHook(Thread hook)
public void load(String lib)
public void loadLibrary(String lib)
java.lang.System:
public static void exit(int status)
public static void runFinalizersOnExit(boolean value)
public static void load(String filename)
public static void loadLibrary( String libname)
public static Properties getProperties()
public static void setProperties(Properties props)
public static String getProperty(String key)
// Only some keys are accessible.
public static String getProperty(String key, String def)
// Only some keys are accessible.
public static String setProperty(String key, String value)
public static void setIn(InputStream in)
public static void setOut(PrintStream out)
public static void setErr(PrintStream err)
public static synchronized void setSecurityManager(SecurityManager s)
```

List of keys allowed by System.getProperty:

```
java.version
java.vendor
java.vendor.url
java.class.version
os.name os.version
os.arch
file.separator
path.separator
line.separator
java.specification.version
java.specification.vendor
java.specification.name
java.vm.specification.version
java.vm.specification.vendor
java.vm.specification.name
java.vm.version
java.vm.vendor
java.vm.name
file.encoding
user.timezone
java. lang. Thread:
Thread ()
Thread(Runnable target)
Thread(String name)
Thread(Runnable target, String name)
Thread(ThreadGroup group, ...)
public final void checkAccess()
public void interrupt()
public final void suspend()
public final void resume()
public final void setPriority (int newPriority)
public final void setName(String name)
public final void setDaemon(boolean on)
public final void stop()
public final synchronized void stop(Throwable obj)
public static int enumerate(Thread tarray[])
public void setContextClassLoader(ClassLoader cl)
java. lang. ThreadGroup:
ThreadGroup (String name)
ThreadGroup(ThreadGroup parent, String name)
```

```
public final void checkAccess()
public int enumerate(Thread list[])
public int enumerate(Thread list[], boolean recurse)
public int enumerate(ThreadGroup list[])
public int enumerate(ThreadGroup list[], boolean recurse)
public final ThreadGroup getParent()
public final void setDaemon(boolean daemon)
public final void setMaxPriority(int pri)
public final void suspend()
public final void resume()
public final void destroy()
public final void interrupt()
public final void stop()
java. lang. reflect. AccessibleObject:
public static void setAccessible (...)
public void setAccessible (...)
java.net. InetAddress:
public String getHostName ()
public static InetAddress[] getAllByName(String host)
public static InetAddress getLocalHost()
java.net.DatagramSocket:
public InetAddress getLocalAddress()
java.net.Socket:
Socket(...)
java.net.ServerSocket:
ServerSocket (...)
public Socket accept()
protected final void implAccept(Socket s)
public static synchronized void setSocketFactory(...)
public static synchronized void setSocketImplFactory(...)
java.net.DatagramSocket:
DatagramSocket (...)
public synchronized void receive(DatagramPacket p)
java.net.MulticastSocket:
MulticastSocket(...)
java.net.URL:
URL(...)
public static synchronized void setURLStreamHandlerFactory(...)
java.net.URLConnection
public static synchronized void setContentHandlerFactory(...)
public static void setFileNameMap(FileNameMap map)
```

```
java.net.HttpURLConnection:
public static void setFollowRedirects(boolean set)
java.net.URLClassLoader
URLClassLoader(...)
java.security.AccessControlContext:
public AccessControlContext(AccessControlContext acc, DomainCombiner combiner)
public DomainCombiner getDomainCombiner()
```

1.13. Volume lifecycle management

1.13.1. Overview

In the previous version of MaxCompute, a partition in a volume does not have a lifecycle and can exist forever. You have to manage the lifecycle of a volume. In some cases, user management of volume lifecycle may cause a problem. For example, if the account used to delete a partition is different from the account used to create the partition, the delete operation fails. The new feature of volume lifecycle management can solve this problem.

For more information about simple volume lifecycle management operations, see *Volume lifecycle operations*.

1.13.2. Volume lifecycle operations

Create a volume with a specified lifecycle

Example:

```
odps@ your_project>fs -mkv test_volume -lifecycle 7 "this is a test volume";
OK
```

Modify the lifecycle of a volume

Example:

```
odps@ your_project>fs -alter test_volume -lifecycle 3;
OK
```

View the lifecycle of a volume

Example:

```
odps@ your_project>fs -meta test_volume;
Comment: "this is a test volume"
Length: 0
File number: 0
Lifecycle: 3
OK
```

1.14. Spark on MaxCompute

1.14.1. Overview

Spark on MaxCompute is a solution developed by Alibaba Cloud to enable the seamless use of Spark on the MaxCompute platform. It supplements a wide variety of features to MaxCompute.

Spark on MaxCompute provides a native Spark user experience and offers native Spark components and APIs. Spark on MaxCompute can access MaxCompute data sources and enhance security for multi-tenant scenarios. Spark on MaxCompute can also act as a management platform to share resources, storage, and user systems between jobs and ensure high performance at a low cost. Spark can work with MaxCompute to create better and more efficient data processing solutions. Community Spark applications can run in **Spark on MaxCompute**.

Spark on MaxCompute has an independent data development node in DataWorks and supports data development in DataWorks.

1.14.2. Project resources

Before you use **Spark on MaxCompute**, you may need to pay attention to or download the following project resources:

- **Spark on MaxCompute** release package: Download the latest release package at Spark on MaxCompute.
- **Spark on MaxCompute** plugin: This is an open-source program. Download the plugin at Aliyun Cupid SDK.

After you prepare the preceding project resources, you need to complete environment configuration. Then, you can run related GitHub demos.

1.14.3. Environment settings

1.14.3.1. Decompress the Spark on MaxCompute release package

Download the latest version of the **Spark on MaxCompute** release package and decompress it. The structure of the decompressed folder is as follows:

```
.
|-- R
|-- RELEASE
|-- __spark_libs__.zip
|-- bin
|-- conf
|-- cupid
|-- derby.log
|-- examples
|-- jars
|-- logs
|-- metastore_db
|-- python
|-- sbin
|-- yarn
```

1.14.3.2. Set environment variables

Set required environment variables.

> **Note** The main environment variables are JAVA_HOME and SPARK_HOME.

Set JAVA_HOME

```
export JAVA_HOME=/path/to/jdk
export CLASSPATH=.:$JAVA_HOME/lib/dt.jar:$JAVA_HOME/lib/tools.jar
export PATH=$JAVA_HOME/bin:$PATH
```

Set SPARK_HOME

```
export SPARK_HOME=/path/to/spark_extracted_package
export PATH=$SPARK_HOME/bin:$PATH
```

If you use SparkR, install R in the */home/admin/R* directory. Then, run the following command to set the path:

```
export PATH=/home/admin/R/bin/:$PATH
```

If you use PySpark, install Python 2.7. Then, run the following command to set the path:

```
export PATH=/path/to/python/bin/:$PATH
```

1.14.3.3. Configure Spark-defaults.conf

The *$SPARK_HOME/conf* directory contains a file named spark-defaults.conf. Before you submit a Spark task to MaxCompute, you must configure your MaxCompute account in this file.

The following content is the default configuration in the file. You only need to enter your account information in the blanks.

```
# OdpsAccount Info Setting
spark.hadoop.odps.project.name=
spark.hadoop.odps.access.id=
spark.hadoop.odps.access.key=
spark.hadoop.odps.end.point=
#spark.hadoop.odps.moye.trackurl.host=
#spark.hadoop.odps.cupid.webproxy.endpoint=
spark.sql.catalogImplementation=odps
# spark-shell Setting
spark.driver.extraJavaOptions -Dscala.repl.reader=com.aliyun.odps.spark_repl.OdpsInteractiveReader -Dsc
ala.usejavacp=true
# SparkR Setting
# odps.cupid.spark.r.archive=/path/to/R-PreCompile-Package.zip
# Cupid Longtime Job
# spark.hadoop.odps.cupid.engine.running.type=longtime
# spark.hadoop.odps.cupid.job.capability.duration.hours=8640
# spark.hadoop.odps.moye.trackurl.dutation=8640
# spark.r.command=/home/admin/R/bin/Rscript
# spark.hadoop.odps.cupid.disk.driver.enable=false
spark.hadoop.odps.cupid.bearer.token.enable=false
spark.hadoop.odps.exec.dynamic.partition.mode=nonstrict
```

1.14.4. Quick start

This topic describes how to use **Spark on MaxCompute**.

1. Download the Spark package from Spark on MaxCompute and decompress the package.
2. Set environment variables.

   ```
   export SPARK_HOME=/path/to/spark-2.1.0-private-cloud-v3.1.0
   export JAVA_HOME=/path/to/java/
   ```

3. Set spark-defaults.conf.

   ```
   cp $SPARK_HOME/conf/spark-defaults.conf.template $SPARK_HOME/conf/spark-defaults.conf
   ```

   Edit $SPARK_HOME/conf/spark-defaults.conf by filling information in the blanks.

```
# OdpsAccount Info Setting
spark.hadoop.odps.project.name=
spark.hadoop.odps.access.id=
spark.hadoop.odps.access.key=
spark.hadoop.odps.end.point=
#spark.hadoop.odps.moye.trackurl.host=
#spark.hadoop.odps.cupid.webproxy.endpoint=
spark.sql.catalogImplementation=odps
# spark-shell Setting
spark.driver.extraJavaOptions -Dscala.repl.reader=com.aliyun.odps.spark_repl.OdpsInteractiveReader
-Dscala.usejavacp=true
# SparkR Setting
# odps.cupid.spark.r.archive=/path/to/R-PreCompile-Package.zip
# Cupid Longtime Job
# spark.hadoop.odps.cupid.engine.running.type=longtime
# spark.hadoop.odps.cupid.job.capability.duration.hours=8640
# spark.hadoop.odps.moye.trackurl.dutation=8640
# spark.r.command=/home/admin/R/bin/Rscript
# spark.hadoop.odps.cupid.disk.driver.enable=false
spark.hadoop.odps.cupid.bearer.token.enable=false
spark.hadoop.odps.exec.dynamic.partition.mode=nonstrict
```

4. Prepare spark-example.

```
git clone https://github.com/aliyun/aliyun-cupid-sdk.git
cd aliyun-cupid-sdk
mvn -T 1C clean install -DskipTests
```

5. Run SparkPi.

```
cd $SPARK_HOME
bin/spark-submit --master yarn-cluster --class com.aliyun.odps.spark.examples.SparkPi /path/to/aliyun
-cupid-sdk/examples/spark-examples/target/spark-examples_2.11-1.0.0-SNAPSHOT-shaded.jar
```

If you see the following output, your operation is successful. Other logs may be included in the output.

```
18/02/09 15:52:28 INFO Client: Application report for application_1518162700322_1635034099 (state: FINISH
ED)
18/02/09 15:52:28 INFO Client:
 client token: N/A
 diagnostics: N/A
 ApplicationMaster host: ***
 ApplicationMaster RPC port: ***
 queue: queue
 start time: 1518162732343
 final status: SUCCEEDED
 tracking URL: http://***:80/proxyview/jobview/?h=http://***:80/api&p=odps_smoke_test&i=201802090751
48695gbkp8e01&t=spark&id=application_1518162700322_1635034099&metaname=20180209075148695gbk
p8e01&token=YkhjNXJWZ0dvdzVScXVFQWpCQWMra1RSZHVFPSxPRFBTX09CTzoxMzY1OTM3MTUwNzcyMjEz
LDE1MTg0MjE5MzUseyJTdGF0ZW1lbnQiOlt7IkFjdGlvbiI6WyJvZHBzOlJlYWQiXSwiRWZmZWN0IjoiQWxsb3ciL
CJSZXNvdXJjZSI6WyJhY3M6b2RwczoqOnByb2plY3RzL29kcHNfc21va2VfdGVzdC9pbnN0YW5jZXMvMjAxODAy
MDkwNzUxNDg2OTVnYmtwOGUwMSJdfV0sIlZlcnNpb24iOiIxIn0=
 user: user
18/02/09 15:52:28 INFO ShutdownHookManager: Shutdown hook called
18/02/09 15:52:28 INFO ShutdownHookManager: Deleting directory /tmp/spark-d77416ad-79a8-49f7-931d-05
33663b5d85
```

1.14.5. Demo

This topic provides a demo on how to use Spark.

The demo is as follows:

1. Modify the configuration file.

   Decompress the Spark package, go to the *conf* directory, and modify the following configuration items in the configuration file spark-defaults.conf:

   ```
   spark.hadoop.odps.project.name=xxxx
   spark.hadoop.odps.access.id=xxxx
   spark.hadoop.odps.access.key=xxxx
   spark.hadoop.odps.end.point=http://service.xxxx.xxxx.xxxxx.qd-inc.com:80/api
   spark.hadoop.odps.cupid.distributedcache.mincopy=3
   spark.hadoop.odps.cupid.distributedcache.maxcopy=3
   spark.hadoop.odps.cupid.proxy.domain.name=jobview.xxxx.xxxx.xxxx.com
   spark.hadoop.odps.cupid.history.server.address=10.xx.xx.xx:18080
   ```

> **Note**
>
> - You can obtain the first four configuration items from the web_component.conf file in the */cloud/app/odps-service-console/CupidFrontendServer#/cupid_web_proxy/current/conf.local/* directory.
> - spark.hadoop.odps.cupid.proxy.domain.name: specifies the domain name of odps_jobview_server_dns. Remove sparkui at the beginning of the domain name.
> - spark.hadoop.odps.cupid.history.server.address: specifies the IP address of the AG machine. Add the port number 18080 to the end of the IP address.

2. Start the program.

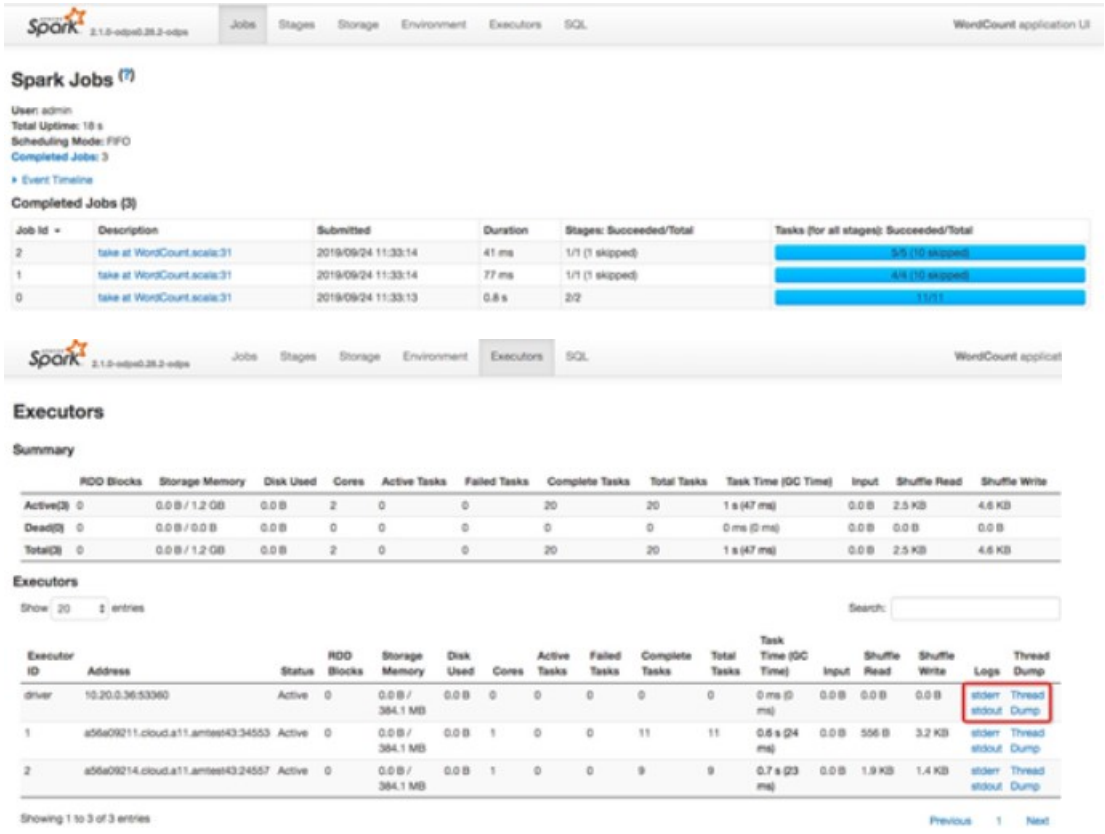
   Go to the directory where the Spark package is decompressed and run the following commands:

   ```
   bin/spark-submit
   --class com.aliyun.odps.spark.examples.WordCount --master yarn-cluster
   examples/spark-examples-2.0.0-SNAPSHOT-shaded.jar
   ```

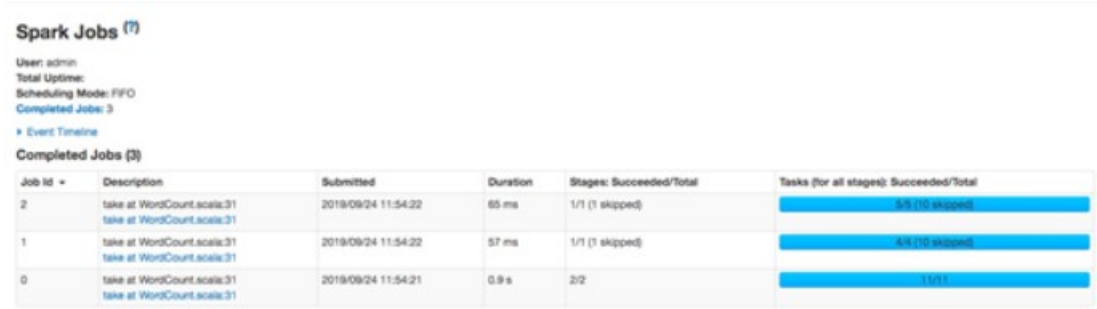
3. Access the link in the command output.

   LogView

SparkUI



Spark History



1.14.6. Common cases

1.14.6.1. WordCount example

Spark runs simple WordCount.

> **Note**
>
> You must download the GitHub project and compile the project before running the corresponding demos.
>
> ```
> git clone https://github.com/aliyun/aliyun-cupid-sdk.git
> -- Download a GitHub project.
> cd aliyun-cupid-sdk
> mvn -T 1C clean install -DskipTests
> -- Compile the GitHub project.
> ```
>
> After you complete the preceding steps, JAR packages are created. These JAR packages will be used to run the demos in this and the subsequent topics.

The following is the code for this example:

```
package com.aliyun.odps.spark.examples
import org.apache.spark.sql.SparkSession
object WordCount {
 def main(args: Array[String]) {
  val spark = SparkSession
   .builder()
   .appName("WordCount")
   .getOrCreate()
  val sc = spark.sparkContext
  try {
   sc.parallelize(1 to 100, 10).map(word => (word, 1)).reduceByKey(_ + _, 10).take(100).foreach(println)
  } finally {
   sc.stop()
  }
 }
}
```

Run the following command to submit the job:

```
bin/spark-submit \
--master yarn-cluster \
--class com.aliyun.odps.spark.examples.WordCount \
/path/to/aliyun-cupid-sdk/examples/spark-examples/target/spark-examples_2.11-1.0.0-
SNAPSHOT-shaded.jar
```

1.14.6.2. OSS access example

Spark can access OSS data.

Example:

```
package com.aliyun.odps.spark.examples.oss
import org.apache.spark.sql.SparkSession
object SparkUnstructuredDataCompute {
 def main(args: Array[String]) {
  val spark = SparkSession
    .builder()
    .appName("SparkUnstructuredDataCompute")
    .config("spark.hadoop.fs.oss.accessKeyId", "***")
    .config("spark.hadoop.fs.oss.accessKeySecret", "***")
    .config("spark.hadoop.fs.oss.endpoint", "oss-cn-hangzhou-zmf.aliyuncs.com")
    .getOrCreate()
  val sc = spark.sparkContext
  try {
    val pathIn = "oss://bucket/inputdata/"
    val inputData = sc.textFile(pathIn, 5)
    val cnt = inputData.count
    println(s"count: $cnt")
  } finally {
    sc.stop()
  }
 }
}
```

Run the following command to submit the job:

```
./bin/spark-submit
--jars cupid/hadoop-aliyun-package-3.0.0-alpha2-odps-jar-with-dependencies.jar
--class com.aliyun.odps.spark.examples.oss.SparkUnstructuredDataCompute
/path/to/aliyun-cupid-sdk/examples/spark-examples/target/spark-examples_2.11-1.0.0-SNAPSHOT-shaded.j
ar
```

1.14.6.3. MaxCompute table read/write example

Read/write a MaxCompute table and convert it to Spark RDD.

> **Notice** The project or table specified in the demo must exist or be changed to the specific project or table.

Example:

```
package com.aliyun.odps.spark.examples
import com.aliyun.odps.data.Record
import com.aliyun.odps.{ PartitionSpec, TableSchema}
import org.apache.spark.odps.OdpsOps
import org.apache.spark.sql.SparkSession
import scala.util.Random
object OdpsTableReadWrite {
 def main(args: Array[String]) {
  val spark = SparkSession
   .builder()
   .appName("OdpsTableReadWrite")
   .getOrCreate()
  val sc = spark.sparkContext
  val projectName = sc.getConf.get("odps.project.name")
  try {
   val odpsOps = new OdpsOps(sc)
   // read from normal table via rdd api
   val rdd_0 = odpsOps.readTable(
    projectName,
    "cupid_wordcount",
    (r: Record, schema: TableSchema) => (r.getString(0), r.getString(1))
   )
   //read from single partition column table via rdd api
   val rdd_1 = odpsOps.readTable(
    projectName,
    "dftest_single_parted",
    Array("pt=20160101"),
    (r: Record, schema: TableSchema) => (r.getString(0), r.getString(1), r.getString("pt"))
   )
   // read from multi partition column table via rdd api
   val rdd_2 = odpsOps.readTable(
    projectName,
    "dftest_parted",
    Array("pt=20160101,hour=12"),
    (r: Record, schema: TableSchema) => (r.getString(0), r.getString(1), r.getString("pt"), r.getString(3))
   )
```

```
    // read with multi partitionSpec definition via rdd api
    val rdd_3 = odpsOps.readTable(
     projectName,
     "cupid_partition_table1",
     Array("pt1=part1,pt2=part1", "pt1=part1,pt2=part2", "pt1=part2,pt2=part3"),
     (r: Record, schema: TableSchema) => (r.getString(0), r.getString(1), r.getString("pt1"), r.getString("pt2"))
    )
    // save rdd into normal table
    val transfer_0 = (v: Tuple2[String, String], record: Record, schema: TableSchema) => {
     record.set("id", v._1)
     record.set(1, v._2)
    }
    odpsOps.saveToTable(projectName, "cupid_wordcount_empty", rdd_0, transfer_0, true)
    // save rdd into partition table with single partition spec
    val transfer_1 = (v: Tuple2[String, String], record: Record, schema: TableSchema) => {
     record.set("id", v._1)
     record.set("value", v._2)
    }
    odpsOps.saveToTable(projectName, "cupid_partition_table1", "pt1=test,pt2=dev", rdd_0, transfer_1, tr
ue)
    // dynamic save rdd into partition table with multiple partition spec
    val transfer_2 = (v: Tuple2[String, String], record: Record, part: PartitionSpec, schema: TableSchema) => {
     record.set("id", v._1)
     record.set("value", v._2)
     val pt1_value = if (new Random().nextInt(10) % 2 == 0) "even" else "odd"
     val pt2_value = if (new Random().nextInt(10) % 2 == 0) "even" else "odd"
     part.set("pt1", pt1_value)
     part.set("pt2", pt2_value)
    }
    odpsOps.saveToTableForMultiPartition(projectName, "cupid_partition_table1", rdd_0, transfer_2, true)
   } catch {
    case ex: Exception => {
     throw ex
    }
   } finally {
    sc.stop
   }
  }
}
```

Run the following command to submit the job:

```
bin/spark-submit \
--master yarn-cluster \
--class com.aliyun.odps.spark.examples.OdpsTableReadWrite \
/path/to/aliyun-cupid-sdk/examples/spark-examples/target/spark-examples_2.11-1.0.0-SNAPSHOT-shaded.jar
```

You can use either of the following methods to adjust the MaxCompute table read concurrency:

- Modify the spark.hadoop.odps.input.split.size parameter. A larger value results in a smaller number of Map tasks. The default value is 256 MB.
- Set numPartition in OdpsOps.readTable. The value determines the number of Map tasks. The number is calculated based on spark.hadoop.odps.input.split.size.

1.14.6.4. MaxCompute Table Spark-SQL example

Use sqlContext to read/write a MaxCompute table.

> **Notice**
>
> - The project or table specified in the demo must exist or be changed to the specific project or table.
> - Spark-defaults.conf must contain the setting *spark.sql.catalogImplementation = odps*.

Example:

```
package com.aliyun.odps.spark.examples
import org.apache.spark.sql.SparkSession
object OdpsTableReadWriteViaSQL {
 def main(args: Array[String]) {
  // please make sure spark.sql.catalogImplementation=odps in spark-defaults.conf
  // to enable odps catalog
  val spark = SparkSession
   .builder()
   .appName("OdpsTableReadWriteViaSQL")
   .getOrCreate()
  val projectName = spark.sparkContext.getConf.get("odps.project.name")
  val tableName = "cupid_wordcount"
  // get a ODPS table as a DataFrame
  val df = spark.table(tableName)
  println(s"df.count: ${df.count()}")
  // Just do some query
  spark.sql(s"select * from $tableName limit 10").show(10, 200)
  spark.sql(s"select id, count(id) from $tableName group by id").show(10, 200)
  // any table exists under project could be use
  // productRevenue
  spark.sql(
   """
    |SELECT product,
    |    category,
    |    revenue
    |FROM
    | (SELECT product,
    |      category,
    |      revenue,
    |      dense_rank() OVER (PARTITION BY category
    |                  ORDER BY revenue DESC) AS rank
    | FROM productRevenue) tmp
    |WHERE rank <= 2
   """.stripMargin).show(10, 200)
  spark.stop()
 }
}
```

Run the following command to submit the job:

```
bin/spark-submit \
--master yarn-cluster \
--class com.aliyun.odps.spark.examples.OdpsTableReadWrite \
/path/to/aliyun-cupid-sdk/examples/spark-examples/target/spark-examples_2.11-1.0.0-SNAPSHOT-shaded.j
ar
```

1.14.6.5. MaxCompute self-developed Console mode example

For safety reasons, machines in MaxCompute can not be directly connected. Therefore, the yarn-clientmode in native Spark cannot be used. To enable interaction, the MaxCompute team developed a proprietary client mode.

Example:

```
package com.aliyun.odps.spark.examples
import com.aliyun.odps.cupid.client.spark.client.CupidSparkClientRunner
object SparkClientNormalFT {
 def main(args: Array[String]) {
  val cupidSparkClient = CupidSparkClientRunner.getReadyCupidSparkClient()
  val jarPath = args(0) //client-jobexamples jar path
  val sparkClientNormalApp = new SparkClientNormalApp(cupidSparkClient)
  sparkClientNormalApp.runNormalJob(jarPath)
  cupidSparkClient.stopRemoteDriver()
 }
}
```

Run the following command to submit the job:

```
java -cp \
/path/to/aliyun-cupid-sdk/examples/spark-examples/target/spark-examples_2.11-1.0.0-SNAPSHOT-shaded.j
ar:$SPARK_HOME/jars/* \
com.aliyun.odps.spark.examples.SparkClientNormalFT /path/to/aliyun-cupid-sdk/examples/client-jobexam
ples/target/client-jobexamples_2.11-1.0.0-SNAPSHOT.jar
```

1.14.6.6. MaxCompute Table PySpark example

Use PySpark to read/write MaxCompute tables.

Example:

```
from odps.odps_sdk import OdpsOps
from pyspark import SparkContext, SparkConf
from pyspark.sql import SQLContext, DataFrame
if __name__ == '__main__':
  conf = SparkConf().setAppName("odps_pyspark")
  sc = SparkContext(conf=conf)
  sql_context = SQLContext(sc)
  project_name = "cupid_testa1"
  in_table_name = "cupid_wordcount"
  out_table_name = "cupid_wordcount_py"
  normal_df = OdpsOps.read_odps_table(sql_context, project_name, in_table_name)
  for i in normal_df.sample(False, 0.01).collect():
    print i
  print "Read normal odps table finished"
  OdpsOps.write_odps_table(sql_context, normal_df.sample(False, 0.001), project_name, out_table_name)
  print "Write normal odps table finished"
```

Run the following command to submit the job:

```
spark-submit \
--master yarn-cluster \
--jars /path/to/aliyun-cupid-sdk/external/cupid-datasource/target/cupid-datasource_2.11-1.0.0-SNAPSHOT.
jar \
--py-files /path/to/aliyun-cupid-sdk/examples/spark-examples/src/main/python/odps.zip \
/path/to/aliyun-cupid-sdk/examples/spark-examples/src/main/python/odps_table_rw.py
```

1.14.6.7. Mllib example

We recommend that you use OSS for read/write operations in the Mllib model.

Example:

```
package com.aliyun.odps.spark.examples.mllib
import org.apache.spark.mllib.clustering.KMeans._
import org.apache.spark.mllib.clustering.{ KMeans, KMeansModel}
import org.apache.spark.mllib.linalg.Vectors
import org.apache.spark.sql.SparkSession
object KmeansModelSaveToOss {
 val modelOssDir = "oss://bucket/kmeans-model"
 def main(args: Array[String]) {
  //1. train and save the model
  val spark = SparkSession
   .builder()
   .appName("KmeansModelSaveToOss")
   .config("spark.hadoop.fs.oss.accessKeyId", "***")
   .config("spark.hadoop.fs.oss.accessKeySecret", "***")
   .config("spark.hadoop.fs.oss.endpoint", "***")
   .getOrCreate()
  val sc = spark.sparkContext
  val points = Seq(
   Vectors.dense(0.0, 0.0),
   Vectors.dense(0.0, 0.1),
   Vectors.dense(0.1, 0.0),
   Vectors.dense(9.0, 0.0),
   Vectors.dense(9.0, 0.2),
   Vectors.dense(9.2, 0.0)
  )
  val rdd = sc.parallelize(points, 3)
  val initMode = K_MEANS_PARALLEL
  val model = KMeans.train(rdd, k = 2, maxIterations = 2, runs = 1, initMode)
  val predictResult1 = rdd.map(feature => "cluster id: " + model.predict(feature) + " feature:" + feature.toArr
ay.mkString(",")).collect
  println("modelOssDir=" + modelOssDir)
  model.save(sc, modelOssDir)
  //2. predict from the oss model
  val modelLoadOss = KMeansModel.load(sc, modelOssDir)
  val predictResult2 = rdd.map(feature => "cluster id: " + modelLoadOss.predict(feature) + " feature:" + featu
re.toArray.mkString(",")).collect
  assert(predictResult1.size == predictResult2.size)
  predictResult2.foreach(result2 => assert(predictResult1.contains(result2)))
 }
}
```

Run the following command to submit the job:

```
./bin/spark-submit
--jars cupid/hadoop-aliyun-package-3.0.0-alpha2-odps-jar-with-dependencies.jar
--class com.aliyun.odps.spark.examples.mllib.KmeansModelSaveToOss
/path/to/aliyun-cupid-sdk/examples/spark-examples/target/spark-examples_2.11-1.0.0-SNAPSHOT-shaded.jar
```

1.14.6.8. PySpark interactive execution example

PySpark can only run on a host that can be directly connected to a computing cluster.

Install Python 2.7 and set the following path:

```
export PATH=/path/to/python/bin/:$PATH
```

Start command:

```
bin/pyspark --master yarn-client
```

Interactive execution:

```
df=spark.sql("select * from spark_user_data")
df.show()
```

1.14.6.9. Spark-shell interactive execution example (read tables)

Spark-shell can only run on a host that can be directly connected to a computing cluster.

Start command:

```
bin/spark-shell --master yarn
```

Interactive execution:

```
sc.parallelize(0 to 100, 2).collect
sql("show tables").show
sql("select * from spark_user_data").show(200,100)
```

1.14.6.10. Spark-shell interactive execution example (MLlib and OSS read/write)

Spark-shell can only run on a host that can be directly connected to a computing cluster.

Add the following configuration to conf/spark-defaults.conf:

```
spark.hadoop.fs.oss.accessKeyId=***
spark.hadoop.fs.oss.accessKeySecret=***
spark.hadoop.fs.oss.endpoint=***
```

Start command:

```
bin/spark-shell --master yarn --jars cupid/hadoop-aliyun-package-3.0.0-alpha2-odps-jar-with-dependencies.jar
```

Interactive execution:

```
import org.apache.spark.mllib.clustering.KMeans._
import org.apache.spark.mllib.clustering.{ KMeans, KMeansModel}
import org.apache.spark.mllib.linalg.Vectors
val modelOssDir = "oss://your_bucket/kmeans-model"
val points = Seq(
    Vectors.dense(0.0, 0.0),
    Vectors.dense(0.0, 0.1),
    Vectors.dense(0.1, 0.0),
    Vectors.dense(9.0, 0.0),
    Vectors.dense(9.0, 0.2),
    Vectors.dense(9.2, 0.0)
  )
val rdd = sc.parallelize(points, 3)
val initMode = K_MEANS_PARALLEL
val model = KMeans.train(rdd, k = 2, maxIterations = 2, runs = 1, initMode)
val predictResult1 = rdd.map(feature => "cluster id: " + model.predict(feature) + " feature:" + feature.toArray.mkString(",")).collect
println("modelOssDir=" + modelOssDir)
model.save(sc, modelOssDir)
val modelLoadOss = KMeansModel.load(sc, modelOssDir)
val predictResult2 = rdd.map(feature => "cluster id: " + modelLoadOss.predict(feature) + " feature:" + feature.toArray.mkString(",")).collect
assert(predictResult1.size == predictResult2.size)
predictResult2.foreach(result2 => assert(predictResult1.contains(result2)))
```

1.14.6.11. SparkR interactive execution example

SparkR can only be run on a host which can directly connect to a computing cluster. In addition, you must install R in the */home/admin/R* directory and set the path:

```
export PATH=/home/admin/R/bin/:$PATH
```

Start command:

```
bin/sparkR --master yarn -—archives . /R/R.zip
```

Interactive execution:

```
df <- as.DataFrame(faithful)
df
head(select(df, df$eruptions))
head(select(df, "eruptions"))
head(filter(df, df$waiting < 50))
results <- sql("FROM spark_user_data SELECT *")
head(results)
```

1.14.6.12. GraphX-PageRank example

Spark on MaxCompute supports native GraphX.

Example:

```
package com.aliyun.odps.spark.examples.graphx
import org.apache.spark.{ SparkConf, SparkContext}
import org.apache.spark.graphx._
import org.apache.spark.rdd.RDD
object PageRank {
 def main(args: Array[String]): Unit = {
  val conf = new SparkConf().setAppName("pagerank")
  val sc = new SparkContext(conf)
  // construct vertices
  val users: RDD[(VertexId, Array[String])] = sc.parallelize(List(
   "1,BarackObama,Barack Obama",
   "2,ladygaga,Goddess of Love",
   "3,jeresig,John Resig",
   "4,justinbieber,Justin Bieber",
   "6,matei_zaharia,Matei Zaharia",
   "7,odersky,Martin Odersky",
   "8,anonsys"
  ).map(line => line.split(",")).map(parts => (parts.head.toLong, parts.tail)))
  // construct edges
  val followers: RDD[Edge[Double]] = sc.parallelize(Array(
   Edge(2L, 1L, 1.0)
```

```
    Edge(4L,1L,1.0),
    Edge(1L,2L,1.0),
    Edge(6L,3L,1.0),
    Edge(7L,3L,1.0),
    Edge(7L,6L,1.0),
    Edge(6L,7L,1.0),
    Edge(3L,7L,1.0)
  ))
  // construct graph
  val followerGraph: Graph[Array[String], Double] = Graph(users, followers)
  // restrict the graph to users with usernames and names
  val subgraph = followerGraph.subgraph(vpred = (vid, attr) => attr.size == 2)
  // compute PageRank
  val pageRankGraph = subgraph.pageRank(0.001)
  // get attributes of the top pagerank users
  val userInfoWithPageRank = subgraph.outerJoinVertices(pageRankGraph.vertices) {
   case (uid, attrList, Some(pr)) => (pr, attrList.toList)
   case (uid, attrList, None) => (0.0, attrList.toList)
  }
  println(userInfoWithPageRank.vertices.top(5)(Ordering.by(_. _2. _1)).mkString("\n"))
 }
}
```

Run the following command to submit the job:

```
bin/spark-submit \
--master yarn-cluster \
--class com.aliyun.odps.spark.examples.graphx.PageRank \
/path/to/aliyun-cupid-sdk/examples/spark-examples/target/spark-examples_2.11-1.0.0-SNAPSHOT-shaded.j
ar
```

1.14.6.13. Spark Streaming - NetworkWordCount example

Spark on MaxCompute supports native Spark Streaming. To use NetworkWordCount, you need to install Netcat on your local host, and then run the following command:

```
$ nc -lk 9999
```

The input on the console then becomes the input of Spark Streaming.

Example:

```
package com.aliyun.odps.spark.examples.streaming
import org.apache.spark.SparkConf
import org.apache.spark.examples.streaming.StreamingExamples
import org.apache.spark.storage.StorageLevel
import org.apache.spark.streaming.{ Seconds, StreamingContext}
object NetworkWordCount {
 def main(args: Array[String]) {
  if (args.length < 2) {
   System.err.println("Usage: NetworkWordCount <hostname> <port>")
   System.exit(1)
  }
  StreamingExamples.setStreamingLogLevels()
  // Create the context with a 1 second batch size
  val sparkConf = new SparkConf().setAppName("NetworkWordCount")
  val ssc = new StreamingContext(sparkConf, Seconds(1))
  // Create a socket stream on target ip:port and count the
  // words in input stream of \n delimited text (eg. generated by 'nc')
  // Note that no duplication in storage level only for running locally.
  // Replication necessary in distributed scenario for fault tolerance.
  val lines = ssc.socketTextStream(args(0), args(1).toInt, StorageLevel.MEMORY_AND_DISK_SER)
  val words = lines.flatMap(_.split(" "))
  val wordCounts = words.map(x => (x, 1)).reduceByKey(_ + _)
  wordCounts.print()
  ssc.start()
  ssc.awaitTermination()
 }
}
```

Run the following command to submit the job:

```
bin/spark-submit \
--master local[4] \
--class com.aliyun.odps.spark.examples.streaming.NetworkWordCount \
/path/to/aliyun-cupid-sdk/examples/spark-examples/target/spark-examples_2.11-1.0.0-SNAPSHOT-shaded.j
ar localhost 9999
```

1.14.7. Maven dependencies

The GitHub project mentioned earlier can be used as your quick start template. For custom development, use the following pom.xml file.

Use Spark community edition 2.3.0 and ensure that the scope is provided.

```
<dependency>
  <groupId>org.apache.spark</groupId>
  <artifactId>spark-core_2.11</artifactId>
  <version>2.3.0</version>
  <scope>provided</scope>
</dependency>
```

The MaxCompute plugin has been released to the Maven warehouse. Add the following dependencies:

```
<dependency>
  <groupId>com.aliyun.odps</groupId>
  <artifactId>cupid-core_2.11</artifactId>
  <version>1.0.0</version>
  <scope>provided</scope>
</dependency>
<dependency>
  <groupId>com.aliyun.odps</groupId>
  <artifactId>cupid-client_2.11</artifactId>
  <version>1.0.0</version>
</dependency>
<dependency>
  <groupId>com.aliyun.odps</groupId>
  <artifactId>cupid-datasource_2.11</artifactId>
  <version>1.0.0</version>
</dependency>
```

The file list in the Maven warehouse is as follows:

- The core code of the Cupid platform encapsulates the Cupid task submission API and the parent-child process read/write table API.

  ```
  <dependency>
      <groupId>com.aliyun.odps</groupId>
      <artifactId>cupid-core_2.11</artifactId>
      <version>1.0.0</version>
  </dependency>
  ```

- The datasource encapsulates the spark-related MaxCompute table read/write API.

```
<dependency>
    <groupId>com.aliyun.odps</groupId>
    <artifactId>cupid-datasource_2.11</artifactId>
    <version>1.0.0</version>
```

- The SDK encapsulates the Cupid client mode.

```
<dependency>
    <groupId>com.aliyun.odps</groupId>
    <artifactId>cupid-client_2.11</artifactId>
    <version>1.0.0</version>
</dependency>
```

1.14.8. Special notes

1.14.8.1. Running modes

Spark on MaxCompute supports three running modes: Local, Cluster, and DataWorks.

Local mode

The Local mode is used to facilitate code debugging for applications. In Local mode, you can use **Spark on MaxCompute** the same way as native Spark in the community. Additionally, you can use Tunnel to read and write data from and to MaxCompute tables.

In this mode, you can use either an IDE or the command line to run Spark on MaxCompute. If you use this mode, you must add the `spark.master=local[N]` configuration. N indicates the CPU resources required to implement this mode.

To use Tunnel to read and write data from and to tables in Local mode, you must add the Tunnel configuration item to Spark-defaults.conf. Enter the endpoint based on the region and network environment where the MaxCompute project is located.

The following code provides an example on how to use the command line to run Spark on MaxCompute in this mode:

```
1.bin/spark-submit --master local[4] \
--class com.aliyun.odps.spark.examples.SparkPi \
${path to aliyun-cupid-sdk}/spark/spark-2.x/spark-examples/target/spark-examples_2.11-version-shaded.ja
r
```

Cluster mode

In Cluster mode, you need to specify the Main method as the entry point of a custom application. The Spark job ends when Main succeeds or fails. This mode is suited for offline jobs. You can use Spark on MaxCompute in this mode together with DataWorks to schedule jobs.

The following code provides an example on how to use the command line to run Spark on MaxCompute in this mode:

```
1.bin/spark-submit --master yarn-cluster \
-class SparkPi \
${ProjectRoot}/spark/spark-2.x/spark-examples/target/spark-examples_2.11-version-shaded.jar
```

DataWorks mode

You can run offline jobs of **Spark on MaxCompute** (in Cluster mode) in DataWorks to integrate and schedule the other types of nodes.

The following procedure is for reference only.

1. Upload the resources in the DataWorks business flow and click **Submit**.
2. In the created business flow, select **ODPS Spark** from **Data Analytics**.
3. Double-click the Spark node and define the Spark job.

   Select a Spark version, a development language, and a resource file. The resource file is the JAR file uploaded and published in the business flow.

   You can specify configuration items, such as the number of executors and memory size, for the job to be submitted.

   You also need to set `spark.hadoop.odps.cupid.webproxy.endpoint` to the endpoint of the region where the project is located, for example, http://service.cn.maxcompute.aliyun-inc.com/api.
4. You can manually run the Spark node to view the task operation log and obtain the URLs of LogView and JobView from the log for further analysis and diagnosis.
5. After you have defined the Spark job, you can orchestrate and schedule services of different types in the business flow.

1.14.8.2. Streaming tasks

MaxCompute also supports Spark Streaming. To support long-running tasks, add the following special configurations to spark-defaults.conf.

Compared with offline jobs, streaming jobs have additional configurations, which take effect immediately after they are completed in spark-defaults.conf.

```
spark.hadoop.odps.cupid.engine.running.type=longtime
-- Set the type to longtime so that the job will not be reclaimed.
spark.hadoop.odps.cupid.job.capability.duration.hours=25920
-- Set the duration.
spark.yarn.maxAppAttempts=10
-- Set the maximum number of retries for a failover.
spark.streaming.receiver.writeAheadLog.enable=true
-- Determine whether to enable the writeAheadLog mode. This mode prevents data loss but lowers the effici
ency.
```

1.14.8.3. Job diagnosis

After you submit a job, you need to check the job log to determine whether the job is submitted and executed properly. MaxCompute provides LogView and Spark Web UI for you to diagnose jobs.

Submit a job in Spark-submit mode. Logs are also generated when you use DataWorks to execute Spark tasks. Example:

```
cd $SPARK_HOME
bin/spark-submit --master yarn-cluster --class SparkPi /tmp/spark-2.x-demo/target/AliSpark-2.x-quickstart-1.0-SNAPSHOT-shaded.jar
```

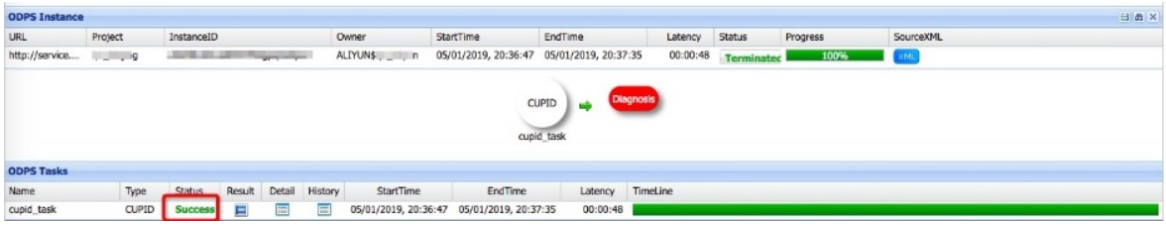
After the job is submitted, MaxCompute creates an instance and displays the LogView URL of the instance in the log.

```
19/01/05 20:36:47 INFO YarnClientImplUtil: logview url: http://logview.odps.aliyun.com/logview/?h=http://service.cn.maxcompute.aliyun.com/api&p=qn_beijing&i=xxx&token=xxx
Success criterion: <If the following output is displayed, the operation succeeded. Other logs may be included in the output.>
19/01/05 20:37:34 INFO Client:
  client token: N/A
  diagnostics: N/A
  ApplicationMaster host: 11.220.xxx.xxx
  ApplicationMaster RPC port: 30002
  queue: queue
  start time: 1546691807945
  final status: SUCCEEDED
  tracking URL: http://jobview.odps.aliyun.com/proxyview/jobview/?h=http://service.cn.maxcompute.aliyun-inc.com/api&p=project_name&i=xxx&t=spark&id=application_xxx&metaname=xxx&token=xxx
```

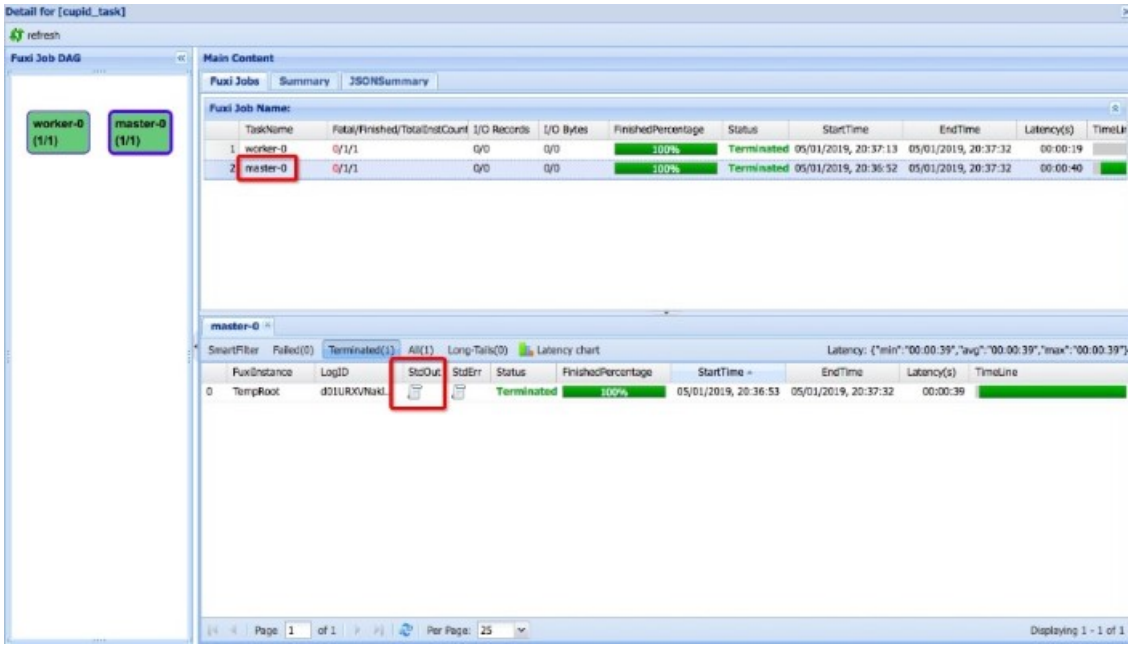
Use LogView to diagnose a job

Example:

1. View basic execution information about the task of the CUPID type in a browser based on the LogView URL.



2. Click the progress bar of the task whose **TaskName** is master-0. In the lower pane, click **All** and find TempRoot in the **FuxiInstance** column.



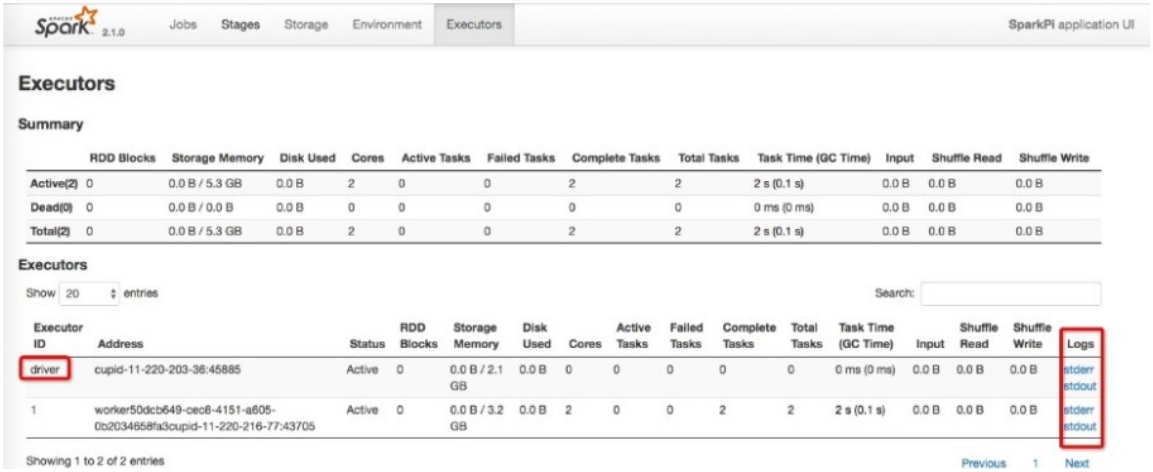
3. Click the icon in the **StdOut** column corresponding to TempRoot to view the output of SparkPi.

Use Spark Web UI to diagnose a job

The tracking URL in the log indicates that your job is submitted to the MaxCompute cluster. This URL is crucial because it is the URL of both Spark Web UI and History Server.

Example:

1. Access the URL in a browser to track the running status of your Spark job.



2. Click **stdout** in the Logs column corresponding to driver to view the output of the Spark job.

1.14.9. APIs supported by Spark

1.14.9.1. Spark Shell

Run the following commands to start the application.

```
$cd $SPARK_HOME
-- Access the spark directory.
<b>Start command</b>: <codeblock>bin/spark-shell --master yarn</codeblock>
-- Select a running mode and start the application.
```

Example:

```
sc.parallelize(0 to 100, 2).collect
sql("show tables").show
sql("select * from spark_user_data").show(200,100)
```

1.14.9.2. Spark R

Run the following commands to start the application:

```
$mkdir -p /home/admin/R && unzip . /R/R.zip -d /home/admin/R/
-- Create directory R and decompress R.zip in the directory.
$export PATH=/home/admin/R/bin/:$PATH
-- Set environment variables.
$bin/sparkR --master yarn --archives . /R/R.zip
-- Select a running mode and start the application.
```

Example:

```
df <- as.DataFrame(faithful)
df
head(select(df, df$eruptions))
head(select(df, "eruptions"))
head(filter(df, df$waiting < 50))
results <- sql("FROM spark_user_data SELECT *")
head(results)
```

1.14.9.3. Spark SQL

Run the following commands to start the application:

```
$cd $SPARK_HOME
-- Access the spark directory.
$bin/spark-sql --master yarn
-- Select a running mode and start the application.
```

Example:

```
show tables;
select * from spark_user_data limit 3;;
quit;
```

1.14.9.4. Spark JDBC

Run the following commands to start an application:

```
$sbin/stop-thriftserver.sh
-- Stop a thread.
$sbin/start-thriftserver.sh
-- Restart a thread.
$bin/beeline
-- Start an application.
```

Example:

```
! connect jdbc:hive2://localhost:10000/odps_smoke_test
show tables;
select * from mr_input limit 3;
! quit
```

1.14.10. Spark dynamic resource allocation

Background

Spark provides a large number of configuration items to implement a wide array of semantics. You can use the default values for most configuration items, but there are some items require manual configurations. Of these items, **spark.executor.instances** is the most complicated.

A value that is too small will cause operations to run slowly or fail, while a value that is too large will waste resources.

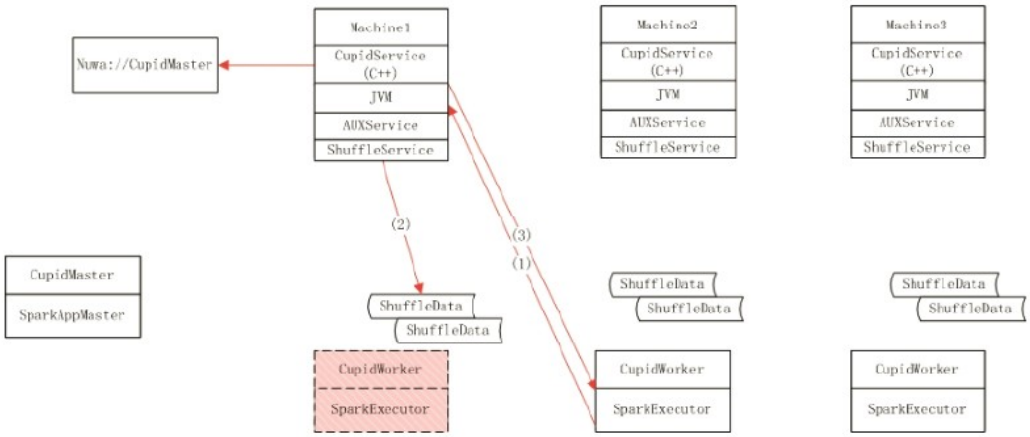
Even the optimal value based on full understanding of the data and logic is not reliable. For complex jobs, the number of executors required at different stages is different and different resources are required during the job execution process. Fixed configurations of resources will cause a waste. When long tail latency occurs, idle resources will be occupied by other executors even for simple jobs.

Solution

The best solution is to allocate resources as needed. Dynamic Resource Allocation (DRA) is such a solution. The CupidService developed by the Cupid team supports native DRA. Its implementation process is as shown in the following figure.

> **Note** For more information about the community native DRA and related configurations, see **Dynamic Resource Allocation** in Job Scheduling and **Dynamic Allocation** in Spark Configuration.

Implementation process



Enable DRA

You must add the following settings to enable DRA. You do not need to modify the code.

```
spark.hadoop.odps.cupid.shuffleservice.enable=true  // Required, the flag at the Cupid end.
spark.hadoop.odps.cupid.disk.driver.enable=true  // Required, the dependent item.
spark.dynamicAllocation.enabled=true // Required, the flag at the Spark end.
spark.shuffle.service.enabled=true // Required, the dependent item.
spark.shuffle.service.port=7338 // Required, the shuffle service port.
spark.authenticate=true // Required, authentication.
spark.dynamicAllocation.maxExecutors=128 // Optional, the maximum number of executors.
spark.dynamicAllocation.minExecutors=1 // Optional, the minimum number of executors.
spark.dynamicAllocation.initialExecutors=1 // Optional, the initial number of executors.
spark.dynamicAllocation.executorIdleTimeout=60s // Optional, the waiting period before idle executors are released.
```

When DRA is enabled, **spark.executor.instances** is optional and equivalent to `spark.dynamicAllocation.initialExecutors`.

1.14.11. FAQ

This topic describes the frequently asked questions about **Spark on MaxCompute**.

How do I migrate open-source Spark code to Spark on MaxCompute?

The migration method depends on whether the job needs to access MaxCompute tables or OSS:

- If the job does not need to access MaxCompute tables or OSS:

  Run the JAR package directly. Note that you must set the dependency on Spark or Hadoop to provided.

- If the job needs to access MaxCompute tables:

  Configure the related dependencies and re-package the application.

- If the job needs to access OSS:

  Configure the related dependencies and re-package the application.

How do I use Spark to access services in a VPC?

Currently, Spark does not allow access to services in a VPC. If you need to access a service in a VPC, submit a ticket to contact the MaxCompute team.

How do I troubleshoot the error indicating the ID and key provided by spark-defaults.conf are incorrect?

Error:

```
Stack:
com.aliyun.odps.OdpsException: ODPS-0410042:
Invalid signature value - User signature dose not match
```

Check whether the ID and key provided by spark-defaults.conf are consistent with the **AccessKey ID** and **AccessKey secret** obtained from the Apsara Stack console.

How do I troubleshoot the error indicating that I do not have permissions?

Error:

```
Stack:
com.aliyun.odps.OdpsException: ODPS-0420095:
Access Denied - Authorization Failed [4019], You have NO privilege 'odps:CreateResource' on {acs:odps:*:projects/*}
```

Contact the project owner to grant you the permissions to read and create resources.

How do I troubleshoot the error indicating that the project does not support Spark tasks?

Error:

```
Exception in thread "main" org.apache.hadoop.yarn.exceptions.YarnException: com.aliyun.odps.OdpsException: ODPS-0420095: Access Denied - The task is not in release range: CUPID
```

Check whether the **Spark on MaxCompute** service is provided in the region where the project is located. Check whether the configuration of Spark-defaults.conf is consistent with the requirements in the service documentation. If the Spark on MaxCompute service is provided in the region and the configuration of Spark-defaults.conf is correct, submit a ticket.

How do I handle the "No space left on device" error reported while a task is running?

Error:

```
No space left on device
```

Spark uses online storage to replace local storage. Shuffled data and overflow data of BlockManager are all stored online. Therefore, you must check the setting of the online storage space. The online storage space is specified by the `spark.hadoop.odps.cupid.disk.driver.device_size` parameter. The default space is 20 GB and the maximum space is 100 GB. If this error persists after you adjust the capacity to 100 GB, further analysis is needed.

The most common cause is data skew. During the shuffle and cache processes, data is centrally distributed in some blocks. In this case, you can decrease the number of concurrent tasks in each executor (spark.executor.cores) or increase the number of executors (spark.executor.instances).

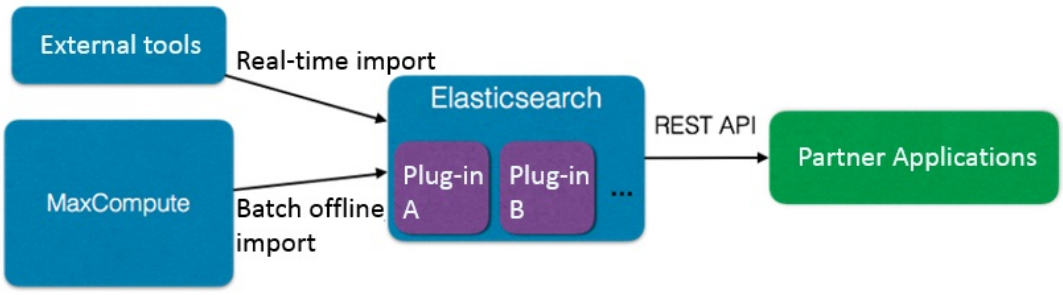
1.15. Elasticsearch on Maxcompute

1.15.1. Overview

Elasticsearch on MaxCompute is an enterprise-class full-text retrieval system developed by Alibaba Cloud for retrieving large volumes of data. It provides near-real-time (NRT) search performance for government agencies and enterprises. **Elasticsearch on MaxCompute** provides elastic full-text retrieval and supports native Elasticsearch APIs. Based on the APIs, it supports data import from heterogeneous data sources as well as cluster and service OAM. Based on the centralized scheduling and management capabilities of MaxCompute, Elasticsearch provides more efficient core services for retrieving large volumes of data.**Elasticsearch on MaxCompute** can also work with plugins available from the Elasticsearch open source community to provide a range of retrieval features.

You can import data to Elasticsearch on MaxCompute using external tools in real time or use MaxCompute to import offline data in batches. After indexing imported data, Elasticsearch on MaxCompute provides the retrieval service through the RESTful API. The following figure shows the usage of Elasticsearch on MaxCompute.

Elasticsearch on MaxCompute usage



1.15.2. Workflow

1.15.2.1. Overview

Elasticsearch on MaxCompute is based on the open source Elasticsearch. It can run the Elasticsearch service on MaxCompute clusters.

In the MaxCompute client, you can start and manage your Elasticsearch service as needed, including the number of nodes, disk space, memory size, and custom settings. The resources consumed by the Elasticsearch service are counted towards your MaxCompute instance quota.

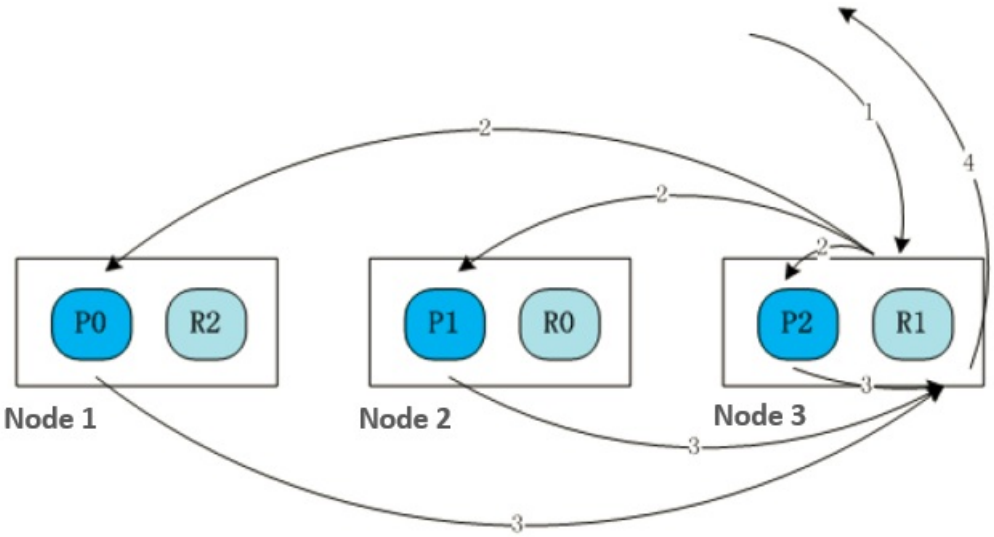
For the process of starting Elasticsearch, see the workflow chart in Typical practice of Elasticsearch.

The following topics describe the workflows of **Elasticsearch on MaxCompute** features.

1.15.2.2. Distributed retrieval workflow

The following figure shows the distributed retrieval workflow:

Distributed retrieval workflow



Each cluster consists of three nodes, as shown in the preceding figure. The index has three shards: P0, P1, and P2, which are distributed across three nodes. The shards work in 1:1 backup mode, so there are three replicas: R0, R1, and R2. The retrieval process is as follows:

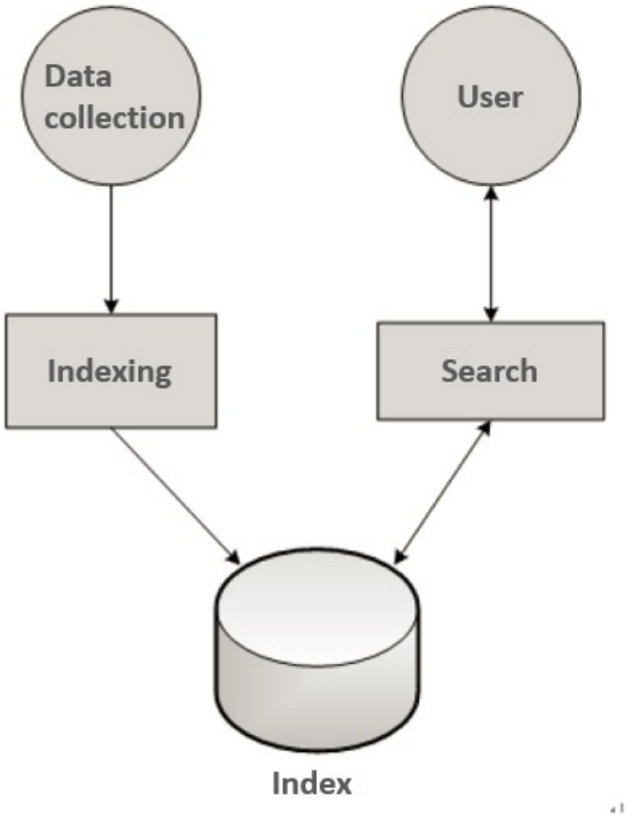
1. A user sends a retrieval request to node 3.
2. After receiving the request, node 3 sends a retrieval request (2) to P0, P1, and P2 based on the recorded index shard information.
3. The nodes where P0, P1, and P2 are located search for the requested information in the specified shards. Each node sends a retrieval result message (3) to node 3.
4. Node 3 combines the retrieval results from the other nodes, and returns a result to the user in an acknowledgment message (4).

Because multiple nodes perform data retrieval at the same time, the retrieval speed is improved. The performance of distributed retrieval increases with the number of nodes.

1.15.2.3. Full-text retrieval process

The following figure shows the full-text retrieval process.

Full-text retrieval process



The process is as follows:

1. The data collection module collects structured and unstructured data, converts the data into the field + value format, and submits the data to the index module.
2. The index module receives the data in the field + value format, performs segmentation and creates inverted indexes based on the predefined indexing method, and saves the indexes. The field type, indexing method, and segmentation rule are configured on the retrieval management page.
3. The search module receives and processes user requests. It parses the requests to obtain indexes, fields, and query statements. Then, the search module finds matching records from the inverted indexes.
4. The search module returns data that satisfies the user requirements, such as the sorting rule and quantity.

1.15.2.4. Authentication process

The authentication process is as follows:

1. **You try to log on to the Elasticsearch on MaxCompute** retrieval management or O&M platform. You are redirected to the authentication module. If you pass the authentication, you can access the platform. Otherwise, you are denied access to the platform.
2. The administrator can use the MaxCompute client to add Elasticsearch users and configure

permissions for the users.

3. When you try to access the index library through an API, the system implements authentication. You can search for or operate data in the index library only after passing the authentication.

1.15.3. Quick start

Before you start an Elasticsearch service, determine the following issues:

- **Node planning**: Determine the number of nodes required for each role in the Elasticsearch cluster. An Elasticsearch cluster has two roles by default, master and data. Each role is deployed on three nodes. You can add nodes to the cluster at any time.
- **Resource planning**: Determine the CPU, memory, and disk space resources required for each node. The resources configured for each node cannot be changed later. 8 GB memory and 20 GB disk space are allocated to each node by default.

  > **Note** Note that only 50% of the memory allocated to a data node is used for the JVM heap.

- **Elasticsearch configuration**: Determine the running configurations of Elasticsearch nodes, such as the queue size of bulk requests, and support for cross-domain HTTP requests.

After you determine the preceding issues, you can start your Elasticsearch service in the MaxCompute client.

The following example shows how to quickly start a small Elasticsearch cluster based on the default configuration. The name of the Elasticsearch service is es_first_cluster.

1. Download a MaxCompute client that supports Elasticsearch. Configure the AccessKey, project, and endpoint.

   > **Note** Note that the download link here provides a non-standard version of the MaxCompute client.

2. Start odpscmd and run the following command:

   ```
   server create es_first_cluster type elasticsearch_mdu;
   ```

   Wait for several minutes. If OK is returned, the Elasticsearch service is started successfully. Then, create an Elasticsearch user.

3. In odpscmd, run the following command to create an Elasticsearch user with the permission of all_access:

   ```
   server execute es_first_cluster create user admin with password 123456|all_access;
   ```

   If OK is returned, the Elasticsearch user is created.

4. Access the Elasticsearch service. Assuming that the service is started in a MaxCompute project named prj1, run the following command in odpscmd to view the Elasticsearch cluster information:

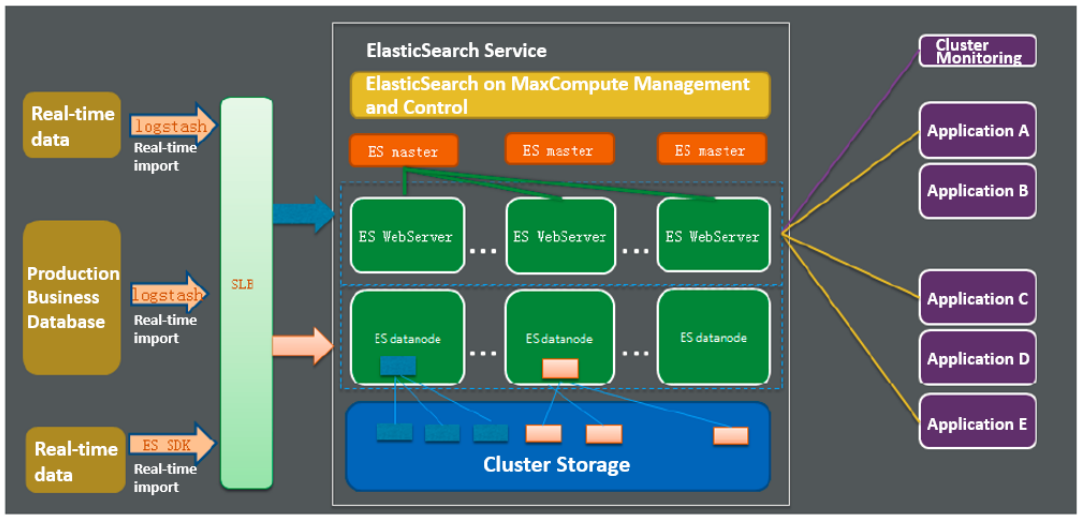
   ```
   curl -u admin:123456 http://search.aliyun.com:9200/prj1.es_first_cluster
   ```

> **Note** You can run the `server delete es_first_cluster` command to delete an Elasticsearch service. Note that this command **deletes data irrevocably**.

1.15.4. Support for Elasticsearch applications

1.15.4.1. ElasticSearch typical practice

Typical practice



Elasticsearch on MaxCompute allows you to start a set of Elasticsearch services on MaxCompute clusters by submitting a job. The project does not modify the native Elasticsearch code. **Elasticsearch on MaxCompute** works in the same way as the native Elasticsearch cluster.

1.15.4.2. Elasticsearch on MaxCompute support for VPC

Alibaba Cloud Elasticsearch on MaxCompute is an enterprise-class full-text retrieval system for retrieving massive amounts of data. To comply with data isolation and security requirements, **Elasticsearch on MaxCompute** provides support for Virtual Private Cloud (VPC) networks so that you can apply access policies at VPC level. (Elasticsearch VPC limits).

Elasticsearch on MaxCompute supports VPC networks in the following model:

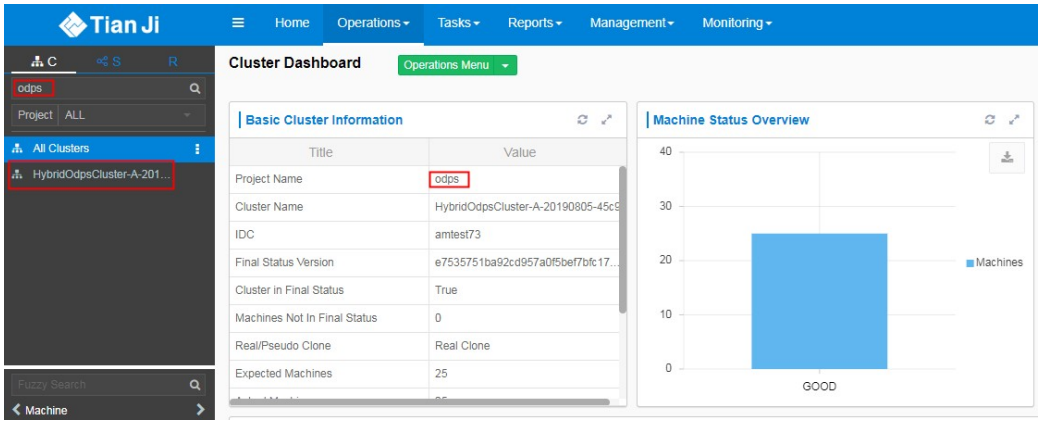
- Classic networks, VPC, and the Internet are isolated from each other. Users can access only the endpoints and virtual IP addresses (VIPs) on their networks.
- Projects without a whitelist of VPC IDs and IP addresses are accessible for users from valid domains over the three types of networks. A domain is valid only if its access request is acknowledged.
- When an ElasticSearch service instance is started in a MaxCompute project, they share the same VPCLIST, which is a whitelist of VPCs.
- Starting an ElasticSearch service instance occupies all resources by default. You must scale up the MaxCompute instance or scale down the ElasticSearch service instance if you start more ElasticSearch service instances.

Here is a specific use example. Starting one ElasticSearch service instance for each project is taken as the default practice when a MaxCompute VPC is deployed. You can start your Elasticsearch instances for your projects, apply for domain names and VIPs, and perform VPC health check in the Elasticsearch frontend.

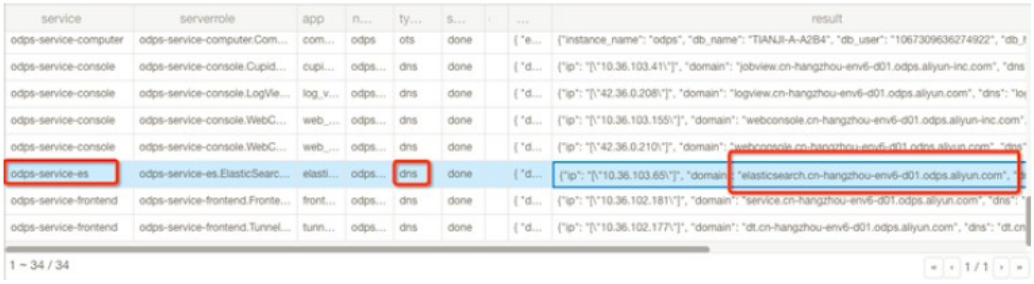
1.15.5. Special notes

1.15.5.1. Find the Elasticsearch service domain name

1. Log on to the Apsara Infrastructure Management Framework console. Choose Operations > Cluster Operations from the top navigation bar. In the left-side navigation pane, click the C tab and search for ODPS.



2. Navigate to the MaxCompute cluster resource usage page.
3. Find the Elasticsearch service domain name.



1.15.5.2. Import table data from MaxCompute to Elasticsearch

Before you can use **Elasticsearch on MaxCompute** to search for MaxCompute table data, you must import table data from MaxCompute to Elasticsearch clusters. MaxCompute MapReduce is designed to carry out the task of exporting data from MaxCompute to Elasticsearch. You can import data to Elasticsearch through simple configurations.

By utilizing the distributed dispatching capability of MaxCompute, you can easily control the concurrency. Besides, you can add the MapReduce job to the scheduled tasks on D2.

The data import process is as follows:

1. Download the JAR package of the MapReduce job.

2. Run the following command to add the JAR package to the MaxCompute resource files in the MaxCompute console:

```
add jar /PATH/TO/elasticsearch_output-1.0.0.jar
```

3. Create configuration file es_mr.conf in the following format for the MapReduce job:

```
<configuration>
 <property>
   <name>key1</name>
   <value>value1</value>
 </property>
 <property>
   <name>key2</name>
   <value>value2</value>
 </property>
</configuration>
```

4. Submit the MapReduce job in the MaxCompute console. Example:

```
jar -conf es_mr.conf -classpath /PATH/TO/elasticsearch_output-1.0.0.jar
    -resources elasticsearch_output-1.0.0.jar -Dworker_num=5
com.aliyun.odps.export.elasticsearch.mr.EsOutputJob <TABLE_NAME> [PARTITION_SPEC];
-- Five workers run concurrently to export data from <TABLE_NAME> [PARTITION_SPEC] to the Elasticsearch cluster.
```

The following table describes the parameters in the es_mr.conf file.

Parameters

Parameter	Example	Required	Default value	Description
es.resource	my_index/my_type	Yes	-	Index and type in the target Elasticsearch for imported data.
es.nodes	-	Yes	-	Elasticsearch endpoint.
es.nodes.client.only	true	No	false	Send data to client-only nodes only.
es.col.field.mapping	odps_col1:es_field1,odps_col3:es_field2	Yes	-	Mapping between the MaxCompute columns to be imported and the Elasticsearch fields.
es.batch.size.bytes	1 MB	No	1 MB	Batch data transfer size.
es.batch.size.entries	1000	No	1000	Number of data entries transferred each time.

Parameter	Example	Required	Default value	Description
es.net.http.auth.user	admin	No	-	Elasticsearch username.
es.net.http.auth.pass	123456	No	-	Elasticsearch password.
es.mapping.routing	field_routing	No	-	Routing field name, in the <CONSTANT> format for a constant.
es.mapping.id	field_id	No	-	id field of a document.

1.16. Flink on MaxCompute

In the current MaxCompute version, **Flink on MaxCompute** is only for trial use. The following demo only describes the trial features. For new features, see later versions.

Demo:

1. Modify the configuration file.

   Decompress the Flink package, go to the configuration file directory *conf*, and make the following modifications to the flink-conf.yaml file.

   ```
   project_name: xxxx
   access_id: xxxx
   access_key: xxxx
   end_point: xxxx
   odps.cupid.distributedcache.mincopy: 1
   odps.cupid.proxy.domain.name:xxxx
   #odps.task.major.version:
   cupid_v2
   ```

   > **Note**
   > - The first four configuration items can be obtained from the odps_config.ini file under the */home/admin/odps/odps_tools/clt/conf/* directory.
   > - odps.cupid.proxy.domain.name: specifies the domain name of odps_jobview_server_dns. Remove sparkui at the beginning of the domain name.

2. Start the program.

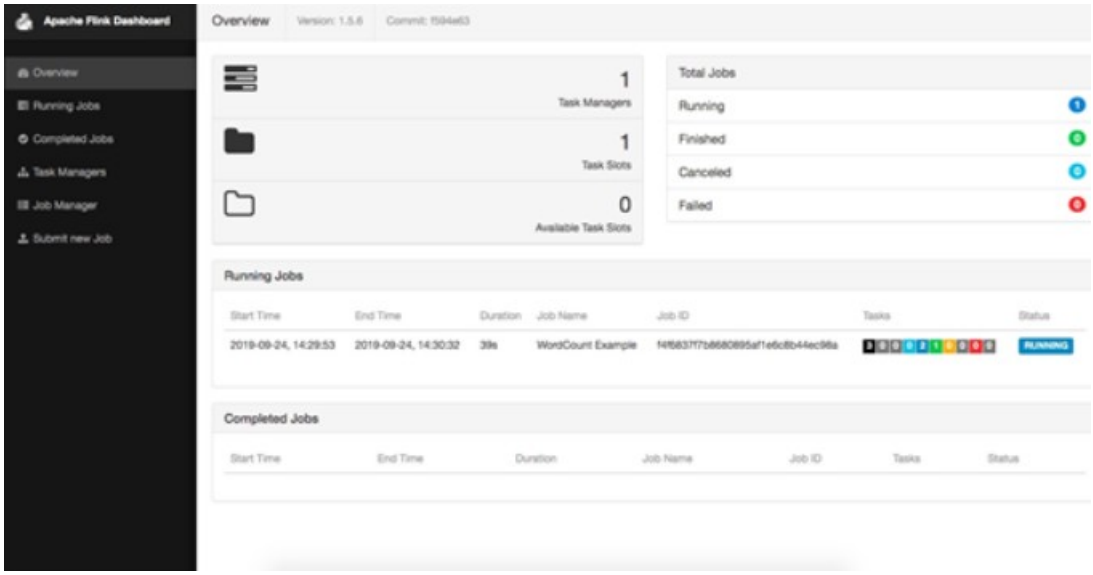
   Move flink-java-project-0.1.jar to the decompressed directory of Flink and run the following commands:

```
/bin/flink
run -c org.apache.flink.odps.WordCount -m yarn-cluster -yn 1
flink-java-project-0.1.jar --projectName odps_smoke_test --inputTable wc_in
--outputTable wc_out --sleepTime 100
```

3. Access the link in the command output.

   LogView

   Flink UI



1.17. Non-structured data access and processing (integrated computing scenarios)

1.17.1. Overview

MaxCompute SQL cannot directly process external data (such as non-structured data from OSS). Data must be imported to MaxCompute tables through relevant tools before computation. The MaxCompute team introduces the non-structured data processing framework to the MaxCompute system architecture to resolve this problem.

You can execute a simple DDL statement to create an external table in MaxCompute and associate MaxCompute tables with external data sources. This table can then act as an interface between MaxCompute and external data sources. You can fully use the computing capabilities of MaxCompute SQL to process data in the external table.

MaxCompute can process the following data sources by creating external tables:

- Internal data sources: OSS, Table Store, AnalyticDB, RDS, HDFS (Alibaba Cloud), and TDDL.
- External data sources: HDFS (open-source), MongoDB, and Hbase.

The following sections illustrate various data sources.

1.17.2. Internal data sources

1.17.2.1. OSS data source

1.17.2.1.1. Preface

As the core computing component of the Alibaba Cloud big data platform, MaxCompute provides powerful computing capabilities. It can schedule large amounts of nodes for parallel computing, and effectively manage failover and retry mechanisms in distributed computing. MaxCompute SQL implements different data processing logics through simple semantics. It is widely used within and outside Alibaba Group. It allows interoperability among different data sources and is significant for the integrated data ecology of Alibaba Cloud.

The following examples show how to access and process OSS unstructured data in MaxCompute.

1.17.2.1.2. Use the built-in extractor to read OSS data

1.17.2.1.2.1. Overview

You can use the MaxCompute built-in extractor to easily read OSS data in the specified format. You only need to create an external table as the source table for data query. For example, a CSV file is stored in OSS. The endpoint is oss-cn-shanghai-internal.aliyuncs.com, the bucket is oss-odps-test, and the file path is */demo/SampleData/CSV/AmbulanceData/vehicle.csv*. The following topics provide operation examples.

1.17.2.1.2.2. Create an external table

Run the following command to create an external table:

```
CREATE EXTERNAL TABLE IF NOT EXISTS ambulance_data_csv_external
(
vehicleId bigint,
recordId bigint,
patientId bigint,
calls bigint,
locationLatitute double,
locationLongtitue double,
recordTime string,
direction string
)
STORED BY 'com.aliyun.odps.CsvStorageHandler'
LOCATION 'oss://<*your-id*>:<*your-secret-key*>@oss-cn-shanghai-internal.aliyuncs.com/oss-odps-test/Demo/SampleData/CSV/AmbulanceData/';
```

Note

- com.aliyun.odps.CsvStorageHandler is a built-in StorageHandler for processing CSV files. It defines how to read and write CSV files. You only need to specify this name. The relevant logic is implemented by the system.
- LOCATION specifies an OSS directory. The system reads all files in the directory by default.
- An external table records only the corresponding OSS directory. When the table is deleted, OSS data stored in the directory specified by LOCATION is not deleted.

1.17.2.1.2.3. Query an external table

After an external table is created, you can use it in the same way you use a MaxCompute table.

The content of */demo/SampleData/CSV/AmbulanceData/vehicle.csv* is as follows:

```
1,1,51,1,46.81006,-92.08174,9/14/2017 0:00,S
1,2,13,1,46.81006,-92.08174,9/14/2017 0:00,NE
1,3,48,1,46.81006,-92.08174,9/14/2017 0:00,NE
1,4,30,1,46.81006,-92.08174,9/14/2017 0:00,W
1,5,47,1,46.81006,-92.08174,9/14/2017 0:00,S
1,6,9,1,46.81006,-92.08174,9/14/2017 0:00,S
1,7,53,1,46.81006,-92.08174,9/14/2017 0:00,N
1,8,63,1,46.81006,-92.08174,9/14/2017 0:00,SW
1,9,4,1,46.81006,-92.08174,9/14/2017 0:00,NE
1,10,31,1,46.81006,-92.08174,9/14/2017 0:00,N
```

Run the following command to submit a job, which calls a built-in CSV extractor to read data from OSS:

```
SELECT recordId, patientId, direction
FROM ambulance_data_csv_external
WHERE patientId > 25;
```

Command output:

```
+------------+------------+-----------+
| recordId | patientId | direction |
+------------+------------+-----------+
| 1 | 51 | S |
| 3 | 48 | NE |
| 4 | 30 | W |
| 5 | 47 | S |
| 7 | 53 | N |
| 8 | 63 | SW |
| 10 | 31 | N |
+------------+------------+-----------+
```

Note The system provides built-in CsvStorageHandler, TsvStorageHandler, and TextStorageHandler.

1.17.2.1.3. Custom extractors

1.17.2.1.3.1. Overview

If OSS data is in a complicated format that cannot be processed by the built-in extractor, you must customize an extractor to read data from OSS files. For example, a text file is stored in OSS. The file is not in the CSV format and the columns of records are separated by vertical bars (|). The file path is */demo/SampleData/CustomTxt/AmbulanceData/vehicle.csv*. The following topics provide operation examples.

1.17.2.1.3.2. Define StorageHandler

You can customize the data parsing logic. StorageHandler is the unified entrance of your custom logic. You can specify the types of custom extractors and outputers. StorageHandler provides only a simple definition. For example, you can implement SpeicalTextStorageHandler:

```
package com.aliyun.odps.udf.example.text;
public class SpeicalTextStorageHandler extends OdpsStorageHandler {
@Override
public Class&lt;? extends Extractor&gt; getExtractorClass() {
return TextExtractor.class;
}
@Override
public Class&lt;? extends Outputer> getOutputerClass() {
return TextOutputer.class;
}
}
```

Note Note that TextStorageHandler that is built in MaxCompute can process the data format in the preceding example (text separated by vertical bars (|)). This example is provided only to show you how to use the SDK to customize a StorageHandler (especially extractor) for processing uncommonly structured data.

1.17.2.1.3.3. Define an extractor

In the following example, TextExtractor is used to extract records from a text file, where the delimiter is imported as a parameter. TextExtractor can be used for all text files of the similar format.

```
/**
* Text extractor that extract schematized records from formatted plain-
text(csv, tsv etc.)
**/
public class TextExtractor extends Extractor {
private InputStreamSet inputs;
private String columnDelimiter;
private DataAttributes attributes;
private BufferedReader currentReader;
private boolean firstRead = true;
public TextExtractor() {
// Default to ",", this can be overwritten if a specific delimiter is
provided (via DataAttributes)
this.columnDelimiter = ",";
}
// No particular usage for execution context in this example
@Override
public void setup(ExecutionContext ctx, InputStreamSet inputs,
DataAttributes attributes) {
this.inputs = inputs;
```

```
this.inputs = inputs;
-- inputs specifies an InputStreamSet. An InputStream is returned each time next() is called. This InputStrea
m can read all the content of an OSS file.
this.attributes = attributes;
// Check if "delimiter" attribute is supplied via SQL query
String columnDelimiter = this.attributes.getValueByKey("delimiter");
-- The delimiter can be used as a parameter in DDL statements.
if ( columnDelimiter ! = null)
{
this.columnDelimiter = columnDelimiter;
}
// note: more properties can be inited from attributes if needed
}
@Override
public Record extract() throws IOException {
String line = readNextLine();
if (line == null) {
return null;
-- If NULL is returned, all records in the table have been read.
}
return textLineToRecord(line);
-- textLineToRecord splits a row into multiple columns using the delimiter. For the implementation process,
see Complete TextExtractor implementation.
-- extractor() returns a record that is extracted from OSS data.
}
@Override
public void close(){
// no-op
}
}
```

1.17.2.1.3.4. Compile and package code

You can compile and package Java code, and run the following command to upload it to MaxCompute. The procedure is the same as that for a normal Java UDF.

```
add jar odps-udf-example.jar;
```

1.17.2.1.3.5. Create an external table

After you upload a JAR package, you need to run the following command to create an external table. This command is similar to the one that you run before using a built-in extractor. The difference is that this command uses a custom StorageHandler.

```
CREATE EXTERNAL TABLE IF NOT EXISTS ambulance_data_txt_external
(
vehicleId int,
recordId int,
patientId int,
calls int,
locationLatitute double,
locationLongtitue double,
recordTime string,
direction string
)
STORED BY 'com.aliyun.odps.udf.example.text.SpeicalTextStorageHandler'
-- STORED BY specifies the class name of a custom StorageHandler.
WITH SERDEPROPERTIES('delimiter'='|')
-- SERDEPROPERITES can be used to specify parameters. These parameters are transferred to an extractor t
hrough DataAttributes.
LOCATION 'oss://<*your-id*>:<*your-secret-key*>@oss-cn-shanghai-internal.aliyuncs.com/oss-odps-test/D
emo/SampleData/CustomTxt/AmbulanceData/'
USING 'odps-udf-example.jar';
-- Specify the JAR package where the class definition is located.
```

1.17.2.1.3.6. Query an external table

The content of */demo/SampleData/CustomTxt/AmbulanceData/vehicle.csv* is as follows:

```
1|1|51|1|46.81006|-92.08174|9/14/2017 0:00|S
1|2|13|1|46.81006|-92.08174|9/14/2017 0:00|NE
1|3|48|1|46.81006|-92.08174|9/14/2017 0:00|NE
1|4|30|1|46.81006|-92.08174|9/14/2017 0:00|W
1|5|47|1|46.81006|-92.08174|9/14/2017 0:00|S
1|6|9|1|46.81006|-92.08174|9/14/2017 0:00|S
1|7|53|1|46.81006|-92.08174|9/14/2017 0:00|N
1|8|63|1|46.81006|-92.08174|9/14/2017 0:00|SW
1|9|4|1|46.81006|-92.08174|9/14/2017 0:00|NE
1|10|31|1|46.81006|-92.08174|9/14/2017 0:00|N
```

Run the following command to submit a job, which calls a custom extractor to read data from OSS:

```
SELECT recordId, patientId, direction
FROM ambulance_data_txt_external
WHERE patientId > 25;
```

Command output:

```
+------------+------------+-----------+
| recordId | patientId | direction |
+------------+------------+-----------+
| 1 | 51 | S |
| 3 | 48 | NE |
| 4 | 30 | W |
| 5 | 47 | S |
| 7 | 53 | N |
| 8 | 63 | SW |
| 10 | 31 | N |
+------------+------------+-----------+
```

1.17.2.1.4. Advanced usage

1.17.2.1.4.1. Use a custom extractor to read external unstructured data

The preceding topic describes how to use built-in and custom extractors to process text files such as .csv files that are stored in OSS. This topic describes how to use UDF extractors to process non-text files in OSS.

The following example shows how to process audio files (.wav files) in OSS.

1. Customize the SpeechSentenceSnrExtractor main logic. Use the SETUP API to read parameters, initialize the parameters, and import the audio processing model (by using the resource function).

```
public SpeechSentenceSnrExtractor(){
this.utteranceLabels = new HashMap&lt;String, UtteranceLabel&gt;();
}
@Override
public void setup(ExecutionContext ctx, InputStreamSet inputs,
DataAttributes attributes){
this.inputs = inputs;
this.attributes = attributes;
this.mlfFileName = this.attributes.getValueByKey(MLF_FILE_ATTRIBUTE_KEY);
String sampleRateInKHzStr =
this.attributes.getValueByKey(SPEECH_SAMPLE_RATE_KEY);
this.sampleRateInKHz = Double.parseDouble(sampleRateInKHzStr);
try {
// read the speech model file from resource and load the model into
memory
BufferedInputStream inputStream =
```

```
ctx.readResourceFileAsStream(mlfFileName);
loadMlfLabelsFromResource(inputStream);
inputStream.close();
} catch (IOException e) {
throw new RuntimeException("reading model from mlf failed with exception
" + e.getMessage());
}
}
@Override
public Record extract() throws IOException {
SourceInputStream inputStream = inputs.next();
if (inputStream == null){
return null;
}
// process one wav file to extract one output record [snr, id]
String fileName = inputStream.getFileName();
fileName = fileName.substring(fileName.lastIndexOf('/') + 1);
logger.info("Processing wav file " + fileName);
// infer id from speech file name
String id = fileName.substring(0, fileName.lastIndexOf('.'));
// read speech file into memory buffer
long fileSize = inputStream.getFileSize();
byte[] buffer = new byte[(int)fileSize];
int readSize = inputStream.readToEnd(buffer);
inputStream.close();
// compute the avg sentence snr from speech file
double snr = computeSnr(id, buffer, readSize);
// construct output record [snr, id]
Column[] outputColumns = this.attributes.getRecordColumns();
ArrayRecord record = new ArrayRecord(outputColumns);
record.setDouble(0, snr);
record.setString(1, id);
return record;
}
private void loadMlfLabelsFromResource(BufferedInputStream fileInputStream)
throws IOException {
// loading MLF label from resource, skipped here
}
// compute the snr of the speech sentence, assuming the input buffer
contains the entire content of a wav file
```

```
private double computeSnr(String id, byte[] buffer, int validBufferLen){
// computing the snr value for the wav file (supplied as byte buffer
array), skipped here
}
```

> **Note** The Extractor() API implements the reading and processing logic of audio files. It calculates the signal-to-noise ratio (SNR) of the read data based on the audio processing model and writes the result to a record in [snr, id] format.

2. Run the following commands to create an external table:

```
CREATE EXTERNAL TABLE IF NOT EXISTS speech_sentence_snr_external
(
sentence_snr double,
id string
)
STORED BY 'com.aliyun.odps.udf.example.speech.SpeechStorageHandler'
WITH SERDEPROPERTIES (
'mlfFileName'='sm_random_5_utterance.text.label' ,
'speechSampleRateInKHz' = '16'
)
LOCATION 'oss://<*your-id*>:<*your-secret-key*>@oss-cn-shanghai-internal.aliyuncs.com/oss-odps-test/dev/SpeechSentenceTest/'
USING 'odps-udf-example.jar,sm_random_5_utterance.text.label';
```

3. Run the following commands to read data from OSS:

```
SELECT sentence_snr, id
FROM speech_sentence_snr_external
WHERE sentence_snr > 10.0;
```

4. The command output is as follows:

```
-------------------------------------------------------------
| sentence_snr | id |
-------------------------------------------------------------
| 34.4703 | J310209090013_H02_K03_042 |
-------------------------------------------------------------
| 31.3905 | tsh148_seg_2_3013_3_6_48_80bd359827e24dd7_0 |
-------------------------------------------------------------
| 35.4774 | tsh148_seg_3013_1_31_11_9d7c87aef9f3e559_0 |
-------------------------------------------------------------
| 16.0462 | tsh148_seg_3013_2_29_49_f4cb0990a6b4060c_0 |
-------------------------------------------------------------
| 14.5568 | tsh_148_3013_5_13_47_3d5008d792408f81_0 |
-------------------------------------------------------------
```

Note By using the UDF extractor, you can run SQL statements to process multiple audio files in OSS in a distributed manner. Similarly, you can use the large-scale computation capabilities of MaxCompute to process unstructured data such as images and videos.

1.17.2.1.5. Data partitions

1.17.2.1.5.1. Overview

In the preceding topic, LOCATION is used to specify an OSS directory, which is associated with an external table. MaxCompute reads all data in the directory, including all files in the subdirectories. When there is a large volume of data in the directory, a full-text scan will cause extra I/O operations and processing time. There are two solutions:

- Reducing the data volume: You need to properly plan data storage addresses. Create multiple external tables for data from different parts, with the LOCATION of each external table pointing to a subset of data.
- Partitioning data: The external table, like an internal table, supports partitioning. You can create partitions to facilitate data management.

The following topics describe the partition feature of external tables.

1.17.2.1.5.2. Standard organization method and path format of partition data in OSS

Unlike the data in internal tables, data stored in external storage (such as OSS) cannot be managed in MaxCompute. If you need to use the partitioned table feature of MaxCompute, make sure that the data file paths in OSS are in the following format:

```
partitionKey1=value1\partitionKey2=value2\...
```

Example:

1. Your daily log files are stored in OSS, and you want to access some of the data from MaxCompute on a daily basis. If the log files are in the CVS format or a similar custom format, you can execute the following statement to create a partitioned external table:

```
CREATE EXTERNAL TABLE log_table_external (
click STRING,
ip STRING,
url STRING,
)
PARTITIONED BY (
year STRING,
month STRING,
day STRING
)
STORED BY 'com.aliyun.odps.CsvStorageHandler'
LOCATION 'oss://<ak_id>:<ak_key>@oss-cn-shanghai-internal.aliyuncs.com/oss-odps-test/log_data/';
```

> **Note** In the preceding example, the PARTITIONED BY clause is used to specify a partitioned external table. The partition keys are year, month, and day.

2. For the partitions to take effect, you must specify the OSS storage directory in the format shown in the preceding example. An example of a valid directory layout is as follows:

```
osscmd ls oss://oss-odps-test/log_data/
2017-09-14 08:03:35 128MB Standard oss://oss-odps-
test/log_data/year=2017/month=06/day=01/logfile
2017-09-14 08:04:12 127MB Standard oss://oss-odps-
test/log_data/year=2017/month=06/day=01/logfile. 1
2017-09-14 08:05:02 118MB Standard oss://oss-odps-
test/log_data/year=2017/month=06/day=02/logfile
2017-09-14 08:06:45 123MB Standard oss://oss-odps-
test/log_data/year=2017/month=07/day=10/logfile
2017-09-14 08:07:11 115MB Standard oss://oss-odps-
test/log_data/year=2017/month=08/day=08/logfile
...
```

> **Note** If you have uploaded offline data to OSS by using osscmd or other OSS tools, you can define the data path format. To ensure the partitioned external table feature operates normally, we recommend that the path where data is stored to is in the format specified in the previous example.

3. Then, you can execute the ALTER TABLE ADD PARTITION statement to import the partition information to MaxCompute. An example of the DDL statement is as follows:

```
ALTER TABLE log_table_external ADD PARTITION (year = '2017', month = '06', day = '01')
ALTER TABLE log_table_external ADD PARTITION (year = '2017', month = '06', day = '02')
ALTER TABLE log_table_external ADD PARTITION (year = '2017', month = '07', day = '10')
ALTER TABLE log_table_external ADD PARTITION (year = '2017', month = '08', day = '08')
...
```

4. When the data is ready and the partition information has been imported to MaxCompute, you can execute SQL statements to operate the partitions in the external table in OSS.
   - Execute the following statement to count the number of unique IP addresses in the log dated June 1, 2017:

     ```
     SELECT count(distinct(ip)) FROM log_table_external
     WHERE year = '2017' AND month = '06' AND day = '01';
     ```

     Note In the log_table_external directory that corresponds to an external table, only files in the *log_data/year=2017/month=06/day=01* subdirectory (logfile and To prevents unnecessary I/O operations, a full scan of the *log_data/* directory is not performed.

   - Similarly, you can execute the following statement to analyze data for the second half of 2017:

     ```
     SELECT count(distinct(ip)) FROM log_table_external
     WHERE year = '2017' AND month > '06';
     ```

     Note In this case, only the logs for the second half of 2017 stored in OSS are accessed.

1.17.2.1.5.3. Custom path of partition data in OSS

If you have historical data stored in OSS paths that are not in the partitionKey1=value1\partitionKey2=value2\... format, you can still access the data by using the MaxCompute partition feature. MaxCompute provides a way to import partitions through a custom path.

Example:

1. The data path only contains partition values (without partition keys). An example of the path layout is as follows:

```
osscmd ls oss://oss-odps-test/log_data_customized/
2017-09-14 08:03:35 128MB Standard oss://oss-odps-
test/log_data_customized/2017/06/01/logfile
2017-09-14 08:04:12 127MB Standard oss://oss-odps-
test/log_data_customized/2017/06/01/logfile. 1
2017-09-14 08:05:02 118MB Standard oss://oss-odps-
test/log_data_customized/2017/06/02/logfile
2017-09-14 08:06:45 123MB Standard oss://oss-odps-
test/log_data_customized/2017/07/10/logfile
2017-09-14 08:07:11 115MB Standard oss://oss-odps-
test/log_data_customized/2017/08/08/logfile
...
```

2. You can run the following statement to bind subdirectories to different partitions:

```
ALTER TABLE log_table_external ADD PARTITION (year = '2017', month = '06', day = '01')
LOCATION 'oss://<ak_id>:<ak_key>@oss-cn-shanghai-internal.aliyuncs.com/oss-odps-test/log_data_cu
stomized/2017/06/01/';
```

> **Note** The ADD PARTITION and LOCATION clauses are specified in the preceding example to bind the partitions to data paths. Even if the data storage path is not in the partitionKey1=value1\partitionKey2=value2\... format, you can still access the partition data in the subdirectory.

1.17.2.1.5.4. Access fully-customized non-partitioned data subsets

In certain situations, you might need to access a file subset in an OSS path, but files in this subset do not have any obvious regularity in terms of directory layout. The unstructured data processing framework of MaxCompute is able to handle this situation, but will not be discussed in this topic.

If you require advanced operations such as this, contact the MaxCompute technical team for support.

1.17.2.1.6. Output OSS data

1.17.2.1.6.1. Create an external table

To write data to OSS, you need to run the CREATE EXTERNAL TABLE statement to create an external table first. The process is the same as that of reading data from OSS. After the external table is created, you can run MaxCompute SQL statements such as INSERT INTO and INSERT OVERWRITE to write data to OSS. In the following example, the built-in TsvStorageHandler is used.

```
DROP TABLE IF EXISTS tpch_lineitem_tsv_external;
CREATE EXTERNAL TABLE IF NOT EXISTS tpch_lineitem_tsv_external
(
orderkey BIGINT,
suppkey BIGINT,
discount DOUBLE,
tax DOUBLE,
shipdate STRING,
linestatus STRING,
shipmode STRING,
comment STRING
)
STORED BY 'com.aliyun.odps.TsvStorageHandler'
LOCATION 'oss://<AK_id>:<AK_secret>@oss-cn-hangzhou-zmf.aliyuncs.com/oss-odps-test/tsv_output_fold
er/';
```

Note

The preceding DDL statement creates an external table named tpch_lineitem_tsv_external, and associates two external data dimensions with this external table.

- Data storage medium: LOCATION associates an OSS address with the external table. This address will be used to read or write data from or to the external table.
- Data storage format: StorageHandler is used to define the data access mode. In this example, MaxCompute built-in com.aliyun.odps.TsvStorageHandler is used to read or write data from or to TSV files. You can also use the MaxCompute SDK to define StorageHandlers.

1.17.2.1.6.2. Write data to a TSV text file by using an INSERT statement on an external table

After you associate a file in OSS with an external table, you can run a standard SQL INSERT OVERWRITE/INSERT INTO statement on the external table to write data to the OSS file. The source data can be either data stored in a MaxCompute internal table or external data that is imported to MaxCompute through an external table.

Note

- MaxCompute internal table: You can run an INSERT statement on an external table to write data from a MaxCompute internal table to an external storage medium.
- External data imported to MaxCompute through an external table: You can import external data to MaxCompute through an external table, use the data for computations, and then export the results to an external address or storage medium. For example, import Table Store data to MaxCompute and then export the data to OSS.

The following example assumes that you have a MaxCompute internal table named tpch_lineitem and want to export some of the data to OSS in the TSV format. After you create an external table, run the following INSERT OVERWRITE statements to export data:

```
INSERT OVERWRITE TABLE tpch_lineitem_tsv_external
SELECT l_orderkey, l_suppkey, l_discount, l_tax, l_shipdate, l_linestatus,
l_shipmode, l_comment
FROM tpch_lineitem
WHERE l_discount = 0.07 and l_tax = 0.01;
```

The preceding example selects eight columns from the rows in tcph_lineitem table that satisfy the conditions l_discount = 0.07 and l_tax = 0.01 and writes it to tpch_lineitem_tsv_external in OSS in the TSV format. After this operation is complete, you can view the corresponding TSV data file in OSS.

> **Notice**
>
> Data exported from MaxCompute to OSS is stored in a special file structure.
>
> - When you run INSERT INTO/OVERWRITE statements on an OSS address, all data is exported to the .odps folder at the specified LOCATION.
> - The .meta file in the .odps folder is an extra macro data file written by MaxCompute to record valid data in the current folder. Typically, if the INSERT operation is successful, all the data in the current folder is valid. You are only required to parse the macro data if a job fails.
> - If a job fails or is terminated, perform the INSERT OVERWRITE operation again until it is complete. This prevents parsing of the .meta file.
> - If you need to parse the .meta file, contact Alibaba Cloud technical team for support.

The number of files that are generated during MaxCompute built-in TSV/CSV processing is equal to the number of concurrent SQL stages. You can use the flexible semantics and configurations of MaxCompute to limit the number of generated files. In the preceding example, if you need to force a TSV file to be generated, you can append DISTRIBUTE BY l_discount to the INSERT OVERWRITE operation. Then, a reduce stage with only one reducer is added at last so that only one TSV file is output.

1.17.2.1.6.3. Write data to an unstructured file by using an INSERT statement on an external table

MaxCompute also provides Outputer APIs for data output. You can use the APIs to write user data to a custom unstructured data file through OutputStream. Further details are not covered in this topic.

If you have this requirement, contact the MaxCompute technical team for support.

1.17.2.1.6.4. Migrate data between different storage media with MaxCompute

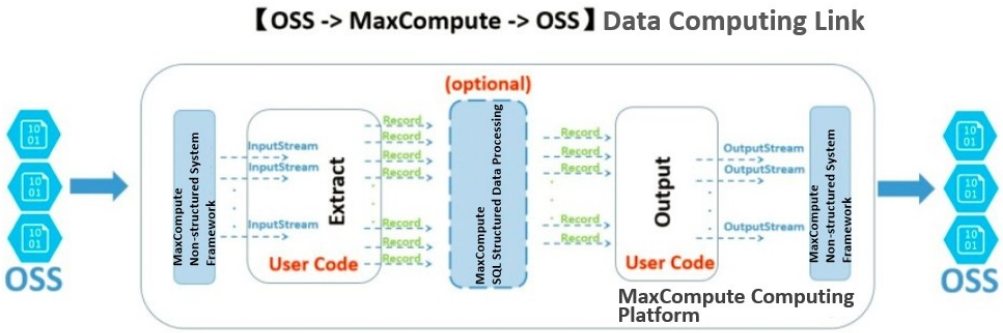
External tables act as an interface between MaxCompute and external storage media. External tables can be used to read or write data from or to various external storage media such as OSS and Table Store. Based on the external table feature, various data computing and storage links can be established. For example,

1. MaxCompute reads the OSS data associated with External Table A, and performs complicated computations. MaxCompute then outputs the results to the OSS address associated with External Table B.
2. MaxCompute reads the Table Store data associated with External Table A, and performs complicated computations. MaxCompute then outputs the results to the OSS address associated with External Table B.

> **Note** The preceding examples and data sources are scenarios with MaxCompute tables. The only difference is that the SELECT statement originates from an external table instead of a MaxCompute table.

Example:

By using MaxCompute as a central computing platform, you can import data from an OSS instance, and export that data to a different OSS instance (in a different location, or a different OSS account), as shown in the following figure.



From a data flow and processing logic standpoint, the unstructured data processing framework can be considered as a coupled data ingress and egress at both ends of the MaxCompute platform.

1. The external data (from an OSS instance) is converted based on the unstructured framework, and provided to the UDF API in the form of a Java InputStream class. The UDF extract logic is only required to read, parse, transform, and compute the data from the InputStream class, and return the data in the Record format used by MaxCompute.
2. Part of the returned records are used in the SQL logical operations on MaxCompute. These operations utilize the powerful SQL computation engine built into MaxCompute, and may generate new records.
3. The computed records are transferred to the UDF Output logic for further computation. Finally, the required information is extracted from the records, output through OutputStream, and written to the OSS instance.

> **Notice** You can perform any combination of the preceding steps based on your needs.

1.17.2.1.7. STS mode authorization for OSS

When you create an external table, the Location-based OSS access account supports plaintext input of the AccessKey ID and AccessKey secret, but the account information may be exposed. To prevent the leakage of account information, MaxCompute provides a more secure way to access OSS.

MaxCompute combines RAM and Security Token Service (STS) of Alibaba Cloud to resolve security issues of accounts. You can grant permissions in two ways:

- If the owners of MaxCompute and OSS use the same Alibaba Cloud account, you can authorize access to OSS with one click in the RAM console.
- Custom authorization is supported.
  i. You can log on to the RAM console and authorize access to OSS.

     Create a role named AliyunODPSDefaultRole or AliyunODPSRoleForOtherUser and set the policy content as follows:

```
-- If the owners of MaxCompute and OSS use the same account:
{
"Statement": [
{
 "Action": "sts:AssumeRole",
 "Effect": "Allow",
 "Principal": {
  "Service": [
   "odps.aliyuncs.com"
  ]
 }
}
],
"Version": "1"
}
-- If the owners of MaxCompute and OSS use different accounts:
{
"Statement": [
{
 "Action": "sts:AssumeRole",
 "Effect": "Allow",
 "Principal": {
  "Service": [
   "ID of the Alibaba Cloud account used by the owner of MaxCompute@odps.aliyuncs.com"
  ]
 }
}
],
"Version": "1"
}
```

ii. Set the AliyunODPSRolePolicy permission, which is the necessary permission for the role to access OSS.

```
{
"Version": "1",
"Statement": [
{
 "Action": [
  "oss:ListBuckets",
  "oss:GetObject",
  "oss:ListObjects",
  "oss:PutObject",
  "oss:DeleteObject",
  "oss:AbortMultipartUpload",
  "oss:ListParts"
 ],
 "Resource": "*",
 "Effect": "Allow"
}
]
}
--You can also add other permissions as required.
```

iii. Grant the AliyunODPSRolePolicy permission to the role.

> **Note** After authorization is complete, view the role details to obtain the RAM information of this role. You need to specify the RAM information when you create an OSS external table later.

1.17.2.2. Table Store data source

1.17.2.2.1. Preface

As the core computing component of the Alibaba Cloud big data platform, MaxCompute meets most distributed computing requirements within and outside Alibaba Group. As the entry of distributed data processing, MaxCompute SQL provides powerful support for quick processing and storage of large volumes (exabytes) of offline data. With the continuous expansion of big data business, many new data usage scenarios emerge. To adapt to the new scenarios, the MaxCompute computing framework is constantly evolving. Its powerful computation capabilities, originally designed to process internal data in special formats, have expanded to process external data sources in various formats. This topic describes in detail how to import data from Table Store to MaxCompute, implementing seamless interoperability between data sources.

Compared with traditional databases, NoSQL KV Store supports flexible schema, scalability and real-time response for applications such as online service. Alibaba Cloud Table Store is a large-scale NoSQL data storage service based on the Apsara system. It supports storage and real-time access of massive KV data. Table Store is widely used by all business units in Alibaba Group and the Alibaba Cloud ecosystem. In particular, Table Store features, such as row-level real-time update and override writing, are a supplement to the append-only operation of MaxCompute tables. As a storage-oriented service, Table Store does not provide sufficient computing capabilities to process large amounts of data concurrently. This makes it important to enable data interoperability between MaxCompute and Table Store.

The following examples show how to access and process Table Store data in MaxCompute.

1.17.2.2.2. MaxCompute reads and computes data in Table Store

1.17.2.2.2.1. Prerequisites and assumptions

This document assumes that you have basic knowledge of Table Store operations. If you are not familiar with Table Store or KV tables, we recommend that you first familiarize yourself with the basic concepts of Table Store (such as primary keys, partition keys, and attribute columns) before reading this topic.

1.17.2.2.2.2. Create an external table

External tables can act as interfaces between MaxCompute and Table Store: You can run a DDL statement (CREATE EXTERNAL TABLE) to import a table description in Table Store to the MaxCompute meta system. Then, you can process data in the Table Store table in the same way you process data in a MaxCompute table.

Example:

```
DROP TABLE IF EXISTS ots_table_external;
CREATE EXTERNAL TABLE IF NOT EXISTS ots_table_external
(
odps_orderkey bigint,
odps_orderdate string,
odps_custkey bigint,
odps_orderstatus string,
odps_totalprice double
)
STORED BY 'com.aliyun.odps.TableStoreStorageHandler'
-- com.aliyun.odps.TableStoreStorageHandler is a MaxCompute built-in StorageHandler for processing Tabl
e Store data. It defines the interaction between MaxCompute and Table Store. The relevant logic is impleme
nted by MaxCompute.
WITH SERDEPROPERTIES (
-- SERDEPROPERITES is an API that provides parameter options. Two options must be specified for TableSto
reStorageHandler: tablestore.columns.mapping and tablestore.table.name.
'tablestore.columns.mapping'=':o_orderkey, :o_orderdate, o_custkey,
o_orderstatus,o_totalprice',
-- tablestore.columns.mapping: This option is required. It describes the columns of Table Store tables that a
re accessed by MaxCompute, including primary key and attribute columns. Column names starting with a col
on (:) are primary key columns in Table Store tables. In this example, :o_orderkey and :o_orderdate are prim
ary key columns. The other column names specified are attribute columns. Table Store supports up to four
primary keys of the bigint or string type. The first primary key is the partition key. When you specify a mappi
ng, you must provide all primary key columns of the specified Table Store table. You do not have to specify a
ll the attribute columns, only those accessed by MaxCompute.
'tablestore.table.name'='ots_tpch_orders'
-- tablestore.table.name: This option is required. It describes the names of Table Store tables that are access
ed by MaxCompute. If you specify an invalid (nonexistent) Table Store table name, an error is returned and
MaxCompute does not create a Table Store table with this name.
)
LOCATION 'tablestore://<*your AK id*>:<*your AK secret key*>@odps-ots-dev.cn-
hangzhou.ots.aliyuncs.com';
-- The LOCATION clause specifies the Table Store information, including the instance name and endpoint.
```

Note The preceding example maps a Table Store table to a MaxCompute external table. The subsequent operations on the Table Store table can be performed through the external table.

1.17.2.2.2.3. Access Table Store data through an external table

After you follow the preceding example to create an external table, Table Store data is imported to MaxCompute. Then, you can access Table Store data by using MaxCompute SQL statements.

Example:

```
SELECT odps_orderkey, odps_orderdate, SUM(odps_totalprice) AS totalprice
FROM ots_table_external
WHERE odps_orderkey > 5000 AND odps_orderdate >20170725 AND odps_orderdate <20170910
GROUP BY odps_orderkey, odps_orderdate
HAVING totalprice> 2000;
```

> **Note** This example uses common MaxCompute SQL statements. Table Store access details are processed internally by MaxCompute.

If you need to use a copy of data for multiple computations, you can import the data from Table Store to a MaxCompute table (internal). This is more efficient than reading the data from Table Store every time.

Example:

```
CREATE TABLE internal_orders AS
SELECT odps_orderkey, odps_orderdate, odps_custkey, odps_totalprice
FROM ots_table_external
WHERE odps_orderkey > 5000 ;
```

> **Note** internal_orders is a common MaxCompute table that has all the features of a MaxCompute internal table. These features include efficient compressed column storage and complete meta. This table is stored in MaxCompute, so it can be accessed faster than an external table in Table Store. This feature is particularly suitable for hot data that is used for multiple computations.

1.17.2.2.3. Write data from MaxCompute to Table Store

Data interaction between MaxCompute and Table Store includes importing data from Table Store to MaxCompute for batch processing and exporting the data processing results from MaxCompute to Table Store. Table Store features such as real-time update and single-line overwrite allow you to quickly upload offline computing results to online applications. You can use MaxCompute SQL INSERT OVERWRITE statements to export data to Table Store.

> **Note** MaxCompute does not create external tables in Table Store. Before exporting data to a table in Table Store, make sure that the table has already been created in Table Store. Otherwise, an error is reported.

The following example assumes that you have created an external table named ots_table_external in MaxCompute. There is a table named ots_tpch_orders in Table Store. There is an internal table named internal_orders in MaxCompute. You want to process data in internal_orders before writing it to Table Store. For this purpose, you can run the following INSERT OVERWITE TABLE statement on the external table.

```
INSERT OVERWRITE TABLE ots_table_external
SELECT odps_orderkey, odps_orderdate, odps_custkey, CONCAT(odps_custkey,
'SHIPPED'), CEIL(odps_totalprice)
FROM internal_orders;
```

Note Table Store is a NoSQL storage medium that stores KV data. Data output from MaxCompute affects only the rows that contain the corresponding primary keys in the Table Store table. In addition, only the attribute columns in the external table was created are updated. The columns that are not included in the external table are not modified.

1.17.2.3. AnalyticDB data source

1.17.2.3.1. Overview

AnalyticDB updates or processes data. If both the data processed by AnalyticDB and the data in MaxCompute are used for computation, the data from AnalyticDB must be synchronized with the data from MaxCompute. To accomplish this, you can create an external table to access the AnalyticDB data.

The following example shows how MaxCompute accesses and processes AnalyticDB data.

1.17.2.3.2. Write data to AnalyticDB

1.17.2.3.2.1. Create an external table

Run the following command to create an external table:

```
set odps.sql.hive.compatible=true;
drop table if exists ads_table_external;
 CREATE EXTERNAL TABLE if not exists ads_table_external
 (
  c_int int ,
 c_tinyint tinyint ,
 c_boolean boolean ,
 c_smallint smallint ,
 c_biging bigint ,
 c_double double ,
 c_float float ,
 --c_time datetime ,
 c_date date ,
 c_timestamp datetime ,
 c_string string
 )
 STORED BY 'com.aliyun.odps.jdbc.JdbcStorageHandler'
 location 'jdbc:mysql:host:port/databasename? useSSL=false&user=${user}&password=${password}&table
=${tablename}'
 TBLPROPERTIES(
  'mcfed.mapreduce.jdbc.input.orderby'='c_int'
  )
;
```

Note The preceding command is for reference only.

1.17.2.3.2.2. Write and query data

After an external table is created, you can use it in the same way you would use a MaxCompute table. You can execute the **INSERT OVERWRITE | INTO** and **SELECT** statements to write data and query whether the write operation is successful respectively. For more information about the statements, see *DML statements* in *MaxCompute SQL*.

1.17.2.3.3. Read data from AnalyticDB

Run the following commands to read data from AnalyticDB:

```
set odps.sql.hive.compatible=true;
drop table if exists ads_read_external;
 CREATE EXTERNAL TABLE if not exists ads_read_external
(
  c_int int ,
 c_tinyint tinyint ,
 c_boolean boolean ,
 c_smallint smallint ,
 c_biging bigint ,
 c_double double ,
 c_float float ,
 --c_time datetime ,
 c_date date ,
 c_timestamp datetime ,
 c_string string
)
 STORED BY 'com.aliyun.odps.jdbc.JdbcStorageHandler'
 location 'jdbc:mysql:host:port/databasename? useSSL=false&user=${user}&password=${password}&table
=${tablename}'
 TBLPROPERTIES(
  'mcfed.mapreduce.jdbc.input.orderby'='c_int'
  )
;
-- Create an external table.
select * from ads_read;
-- Query and read data.
```

> **Note** The preceding commands are for reference only.

1.17.2.4. RDS data source

1.17.2.4.1. Overview

RDS updates or processes data. If both the data processed by RDS and the data in MaxCompute is used in computation, the data in RDS must be synchronized to MaxCompute. In this case, you can access the data in RDS by creating an external table.

The following examples show how MaxCompute accesses and processes RDS data.

> **Note** When you create an external table, the corresponding table may not exist in RDS. However, when you perform the SELECT or INSERT operation on external tables, you must create the corresponding tables in RDS first.

1.17.2.4.2. Write data to RDS

1.17.2.4.2.1. Create an external table

Run the following command to create an external table:

```
set odps.sql.hive.compatible=true;
drop table if exists rds_table_external;
 CREATE EXTERNAL TABLE if not exists rds_table_external
 (
  id bigint,
  name string,
  age tinyint
 )
 STORED BY 'com.aliyun.odps.jdbc.JdbcStorageHandler'
 location 'jdbc:mysql:host:port/databasename? useSSL=false&user=${user}&password=${password}&table
=${tablename}'
 TBLPROPERTIES(
  'mcfed.mapreduce.jdbc.input.orderby'='c_int'
  )
;
```

> **Note** The preceding command is for reference only.

1.17.2.4.2.2. Write and query data

After an external table is created, you can use it in the same way you use a MaxCompute table. You can execute the **INSERT OVERWRITE | INTO** and **SELECT** statements respectively to write data and query whether the write operation is successful. For more information about the INSERT OVERWRITE | INTO and SELECT statements, see *DML statements* in *MaxCompute SQL*.

1.17.2.4.3. Read data from RDS

Run the following commands to read data from RDS:

```
set odps.sql.hive.compatible=true;
drop table if exists rds_read_external;
 CREATE EXTERNAL TABLE if not exists rds_read_external
 (
  id int,
  name string,
  age int
 )
 STORED BY 'com.aliyun.odps.jdbc.JdbcStorageHandler'
 location 'jdbc:mysql:host:port/databasename? useSSL=false&user=${user}&password=${password}&table
=${tablename}'
 TBLPROPERTIES(
  'mcfed.mapreduce.jdbc.input.orderby'='c_int'
  )
;
-- Create an external table.
select * from rds_read;
-- Query and read data.
```

Note The preceding commands are for reference only.

1.17.2.5. HDFS data source (Alibaba Cloud)

1.17.2.5.1. Overview

Alibaba Cloud Hadoop Distributed File System (HDFS) is a distributed file system designed for Alibaba Cloud computing resources such as ECS and Container Service.

HDFS allows you to manage and access data in the same way as its open-source counterpart. HDFS features such as unlimited capacity, performance scale-out, single namespace, multi-tenancy, high reliability, and high availability, can be used without the need to modify existing big data analysis applications.

MaxCompute can interact with HDFS to jointly compute external tables.

HDFS supports multiple file formats, such as **text file**, **sequence file**, **RC file**, **Parquet**, and **AVRO**. The following example use **text file** to show how MaxCompute accesses and processes HDFS data.

1.17.2.5.2. Data processing for common tables

1.17.2.5.2.1. Write data to HDFS

1.17.2.5.2.2. Read data from HDFS

Run the following command to read data from HDFS after you upload the textfile file to HDFS:

```
set odps.sql.hive.compatible=true;
drop table if exists textfile_external_read;
CREATE external TABLE if not exists textfile_external_read
(
 c_int int ,
 c_tinyint tinyint ,
 c_boolean boolean ,
 c_smallint smallint ,
 c_biging bigint ,
 c_double double ,
 c_float float ,
 c_date date ,
 c_timestamp datetime ,
 c_string string
)
 ROW FORMAT SERDE 'org.apache.hadoop.hive.serde2.lazy.LazySimpleSerDe'
 WITH SERDEPROPERTIES ('field.delim'=',')
 STORED AS textfile
 location "mcfed:dfs://host:port/user/textfile"
-- host must be set as MountPointId.
-- /user/textfile is the file path. Replace it with the actual file path.
 TBLPROPERTIES(
  "mcfed.fs.dfs.impl"="com.alibaba.dfs.DistributedFileSystem"
);
-- Create an external table.
select * from textfile_external_read;
select count(*) from textfile_external_read;
select a.c_int,a.c_boolean,a.c_string,b.value from textfile_external_read a join dfstest b on a.c_int=b.id;
-- Query and read data.
```

Note The preceding command is for reference only.

1.17.2.5.3. Data processing for partitioned tables

Run the following commands to create an external table and process its data:

```
set odps.sql.hive.compatible=true;
drop table if exists textfile_partition;
CREATE external TABLE if not exists textfile_partition
(
 id string,
 name string
)
 partitioned by (date string)
 ROW FORMAT SERDE 'org.apache.hadoop.hive.serde2.lazy.LazySimpleSerDe'
 WITH SERDEPROPERTIES ('field.delim'=',')
 STORED AS textfile
 location "mcfed:dfs://host:port/user/partition/textfile/"
-- host must be set as MountPointId.
-- user/partition/textfile/ is the file path. Replace it with the actual file path.
 TBLPROPERTIES(
  "mcfed.fs.dfs.impl"="com.alibaba.dfs.DistributedFileSystem"
);
-- Create an external table.
alter table textfile_partition add partition (date='20190218');
alter table textfile_partition add partition (date='20190219');
-- Add partitions.
insert into table textfile_partition partition(date='20190218')select '1','cd' from (select count(*) from textfile
_partition)a;
insert into table textfile_partition partition(date='20190219')select '2','gh' from (select count(*) from textfile
_partition)a;
-- Write data to HDFS.
select * from textfile_partition;
select count(*) from textfile_partition;
select a.id,a.name,b.value from textfile_partition a join dfstest b on a.id=b.id;
-- Query and read data.
```

Note The preceding commands are for reference only.

1.17.2.6. TDDL data source

1.17.2.6.1. Overview

By encapsulating MySQL, TDDL provides features such as data partitioning, read/write splitting, and failover. In most cases, TDDL can be directly used to access MySQL databases. TDDL also provides Corona connection mode. Corona is a MySQL proxy that follows the standard MySQL protocol and can use JDBC to establish a connection.

MaxCompute can access MySQL databases of TDDL. Built-in StorageHandlers encapsulate native APIs provided by Hadoop such as org, Apache, Hadoop, MapReduce, lib, and db. MySQL JDBC is used for underlying data communication.

The following topics describe how MaxCompute accesses and processes TDDL data.

> **Notice** Among create, read, update, and delete (CRUD) operations, only the following operations are supported:
>
> - MaxCompute reads data from the external table created for a MySQL database.
> - MaxCompute writes data to the external table in the append mode.

1.17.2.6.2. Prerequisites

Because many features are disabled in the MaxCompute 2.0 by default, you must manually configure the following settings:

```
set odps.sql.hive.compatible=true;
-- You must configure this item for all DDL and DML statements to be used on TDDL external tables.
```

```
set odps.sql.udf.java.retain.legacy=false;
-- You must configure this item for all DDL and DML statements to be used on TDDL external tables.
```

```
set odps.sql.jdbc.splits.num=3;
-- Set the number of splits that MaxCompute reads from the MySQL database. Maximum value: 256. Default value: 1. You must configure this item for the SELECT operation on TDDL external tables.
```

```
set odps.sql.jdbc.reducer.num=3;
-- Set the number of concurrent instances that MaxCompute writes to the MySQL database. Maximum value: 256. Default value: 64. If the number of concurrent instances in the generated execution plan is smaller than this value, no changes are made. You must configure this item for the INSERT operation on TDDL external tables.
```

```
set odps.sql.hive.compatible=true;
-- Use an open-source community API to obtain and parse MySQL data types. You must configure this item for all DDL and DML statements to be used on TDDL external tables.
```

```
set odps.sql.type.system.odps2=true;
-- You must configure this item if new data types TINYINT, SMALLINT, INT, FLOAT, VARCHAR, TIMESTAMP, and BINARY are involved in SQL operations such as CREATE, SELECT, and INSERT.
```

1.17.2.6.3. Create a TDDL external table

1.17.2.6.3.1. Syntax

External tables can act as interfaces between MaxCompute and databases. The method used to process MySQL unstructured data in TDDL is similar to the method to access and process OSS unstructured data. First, you must execute the CREATE EXTERNAL TABLE statement to create an external table. The syntax is as follows:

```
-- Remember to add the corresponding SET statement.
DROP TABLE [IF EXISTS] <external_table_name>;
CREATE EXTERNAL TABLE [IF NOT EXISTS] <external_table_name>
(<column schemas>)
STORED BY 'com.aliyun.odps.jdbc.JdbcStorageHandler'
location 'jdbc:mysql://path_format'
TBLPROPERTIES(
 ...
);
```

Description:

- **column schema**: supports the following data types.

Data type mapping

MySQL type	MaxCompute type
TINYINT (unsigned)	TINYINT
SMALLINT (unsigned)	SMALLINT
INT (unsigned)	INT
BIGINT (unsigned)	BIGINT
BOOLEAN	BOOLEAN
FLOAT	FLOAT
DOUBLE	DOUBLE
VARCHAR	VARCHAR
TEXT	STRING
DATE	DATE
DATETIME	DATETIME

MySQL type	MaxCompute type
DECIMAL	DECIMAL (x, y) (The default precision is (10, 0). An error is returned when overflow occurs.)

Notice Because unsigned data types are not supported in MaxCompute, loss of precision may occur if unsigned types are specified.

- `setproject odps.sql.udf.strict.mode=true;` (strict mode, which is the default mode).
  - When reading external tables: MaxCompute can read the data if unsigned data is converted to signed data without loss of precision. A RuntimeException ("value out of range") error is reported if loss of precision occurs during data type conversion.
  - When writing external tables: MaxCompute does not check data types. You can specify the SQL mode to let MySQL produce desired data check actions. For more information about SQL mode settings and data check actions, see Server SQL Modes.
- `setproject odps.sql.udf.strict.mode=false;` (non-strict mode)
  - When reading external tables: MaxCompute can read unsigned data that has been converted to signed data without loss of precision. NULL is obtained if loss of precision occurs during data type conversion.
  - When writing external tables: MaxCompute does not check data types. You can specify the SQL mode to let MySQL produce desired data check actions.

- **STORED BY**: Only built-in StorageHandlers are supported. TDDL table field types must be within the range of supported data types in **column schema**.
- **LOCATION**: Three LOCATION formats are supported.

  1. Access a MySQL database through a JDBC connection string.

  ```
  jdbc:mysql://<user>:<password>@<host>/<databaseName>? useSSL=false&table=<tableName>
  ```

  user and password are the username and password of the JDBC connection string. host is the network address of the MySQL database. databaseName is the name of the MySQL database. tableName is the name of the MySQL table corresponding to the external table.

  2. Access the MySQL database of TDDL through Corona.

  ```
  jdbc:mysql://<user>:<password>@<host>/<databaseName>? useSSL=false&table=<tableName>
  ```

  3. Access the MySQL database of TDDL through an application name.

  ```
  jdbc:mysql://dummy_host? table=<tableName>
  ```

  tableName is the name of the MySQL table corresponding to the external table. You must specify `odps.federation.jdbc.tddl.appname` in the TBLPROPERTIES clause.

> **Notice**
>
> In the first location format, MaxCompute interacts with the database through JDBC. You must enter your username and password as plaintext data, which makes this location format less secure than others. Although usernames and passwords will be hidden when LogView or DESC EXTENDED TABLE is used in MaxCompute, we recommend that you use a separate DDL statement to create an external table before using the external table.
>
> For example, a project member with higher permissions can create an external table in MaxCompute. Other project members can then directly use the external table. This prevents project members with lower permissions from using the plaintext username and password, and prevents the plaintext password from being contained in SQL scripts.

- **TBLPROPERTIES**: includes the following items.
  - **odps.federation.jdbc.condition**: specifies the filter when MaxCompute reads data from a MySQL database. The difference between `odps.federation.jdbc.condition` and `select * from text_test_jdbc_write_external where condition` :

    Suppose the MySQL table contains 100 rows of data and you want to filter the data such that you obtain 10 rows. When you execute `odps.federation.jdbc.condition` , the MySQL table is filtered and MaxCompute only reads 10 rows from the external table. When you execute `select * from text_test_jdbc_write_external where condition` , MaxCompute reads 100 rows from the MySQL table, and then obtains 10 rows.
  - **odps.federation.jdbc.colmapping**: specified column name mapping. Example:

```
-- mysql schema:  mysqlId int
 -- MaxCompute create table
CREATE EXTERNAL TABLE if not exists table_external
(
odpsId1 int,
odpsId2 int
)
STORED BY ...
location ...
TBLPROPERTIES('odps.federation.jdbc.colmapping'='odpsId1:mysqlId, odpsId2:mysqlId');
```

  - **odps.federation.jdbc.insert.type**: specifies the insertion type when data is written into the MySQL database. The following data insertion types are supported: simpleInsert, insertOnDuplicateKeyUpdate, and replaceInto. By default, the insertion type is simpleInsert if this parameter is not specified.

    The INSERT statement executed in MaxCompute is parsed into the following SQL statements to update the database:

```
insert into sqlTable xxx values xxx;
 insert into sqlTable xxx values xxx on duplicate key update col1=values(col1), col2=values(col2);
 replace into sqlTable xxx values xxx;
```

- **odps.federation.jdbc.tddl.app.access.key**: the AccessKey ID for the authorized application.
- **odps.federation.jdbc.tddl.app.secret.key**: the AccessKey Secret for the authorized application.
- **odps.federation.jdbc.tddl.appname**: the application name of TDDL. Note that if you specify this value, MaxCompute uses the application name to access the MySQL database in TDDL SDK mode.

1.17.2.6.3.2. Example

The following example shows how to use the application name to access the MySQL database of TDDL. In this example, the application name is ODPS_TDDL_TEST_APP and the table name is odps_federation_localrun_write.

Example:

```
-- Remember to add the corresponding SET statement.
drop table if exists text_test_jdbc_external;
CREATE EXTERNAL TABLE if not exists text_test_jdbc_external
(
 colmapping tinyint, --c_tinyint tinyint,
 c_smallint smallint,
 c_int int,
 c_bigint bigint,
 c_utinyint tinyint,
 c_usmallint smallint,
 c_uint int,
 c_ubigint bigint,
 c_boolean tinyint,
 --c_float float,  -- in tddl, not recommend float and double type as it may lost precision
 --c_double double,
 c_string string,
 c_datetime datetime,
 c_decimal decimal
)
STORED BY 'com.aliyun.odps.jdbc.JdbcStorageHandler'
location 'jdbc:mysql://dummy_host? table=odps_federation_localrun_write'
TBLPROPERTIES(
'odps.federation.jdbc.insert.type'='simpleInsert',
'odps.federation.jdbc.condition'='c_boolean = 1 and c_int is not null and c_utinyint=127',
'odps.federation.jdbc.colmapping'='colmapping:c_tinyint',
'odps.federation.jdbc.tddl.appname'='ODPS_TDDL_TEST_APP',
'odps.federation.jdbc.tddl.app.access.key'='your tddl app access key',
'odps.federation.jdbc.tddl.app.secret.key'='your tddl app secret key');
```

1.17.2.6.4. Read data from an external table

For complex operations such as GROUP JOIN, we recommend that you import data from external table to MaxCompute tables before performing operations. This improves the efficiency of data computation. The following example shows how to import data from an associated MySQL external table to MaxCompute.

Create a MaxCompute table

Example:

```
CREATE TABLE if not exists text_test_jdbc_max_compute
(
 c_tinyint tinyint,
 c_smallint smallint,
 c_int int,
 c_bigint bigint,
 c_utinyint tinyint,
 c_usmallint smallint,
 c_uint int,
 c_ubigint bigint,
 c_boolean tinyint,
 --c_float float,
 --c_double double,
 c_string string,
 c_datetime datetime,
 c_decimal decimal
);
```

Import data to a MaxCompute table

Example:

```
-- Remember to add the SET statement.
insert OVERWRITE TABLE text_test_jdbc_odps select * from text_test_jdbc_read_external;
```

Relationship between creating an external table and importing data to a MaxCompute table

When you create an external table, only a data channel is established between MaxCompute and MySQL. MaxCompute does not store any MySQL data. If external table data is lost from the MySQL database, it will not be available in MaxCompute.

When data is imported to a MaxCompute table, the data is actually stored in the MySQL database. If imported data is lost from the MySQL database, it can be retrieved from the MaxCompute table.

1.17.2.6.5. Write data to an external table in the append mode

The column names and data types of the external table must be consistent with those of the database to ensure that the correct data is written to the eternal table. For more information about data check actions when loss of precision occurs during data type conversion, see the column schema parameter of Syntax.

An example of the command used is as follows:

```
-- Remember to add the SET statement.
insert INTO TABLE text_test_jdbc_external select * from text_test_jdbc_max_compute;
```

> **Note** For MySQL external tables, **insert INTO** mysql-external-table uses the same syntax as **insert OVERWRITE** mysql-external-table. No matter which statement is executed, data is appended to the table and you can use `ODPS.federation.jdbc.insert.type` to specify the data insertion type. For more information, see the **TBLPROPERTIES** parameter in Syntax. However, the preceding syntax notes are not applicable to MaxCompute tables.

1.17.3. External data sources

1.17.3.1. HDFS data source (open-source)

1.17.3.1.1. Overview

HDFS is the most widely used storage service in the open-source community. Most customers use HDFS at the underlying layer of their self-developed big data systems.

MaxCompute uses external tables to access HDFS data to facilitate data migration, interact with self-developed customer systems, and reduce the efforts and costs of customers.

HDFS supports multiple file formats, such as **text file**, **sequence file**, **RC file**, **Parquet**, and **AVRO**. The following example use **text file** to show how MaxCompute accesses and processes HDFS data.

1.17.3.1.2. Write data to HDFS

1.17.3.1.2.1. Create an external table

Run the following command to create an external table after the testfile script has been compiled:

```
set odps.sql.hive.compatible=true;
drop table if exists textfiletest;
 CREATE EXTERNAL TABLE if not exists textfiletest
(
 c_int int ,
 c_tinyint tinyint ,
 c_boolean boolean ,
 c_smallint smallint ,
 c_biging bigint ,
 c_double double ,
 c_float float ,
 --c_time datetime ,
 c_date date ,
 c_timestamp datetime ,
 c_string string
)
 STORED as TEXTFILE
 location 'hdfs://host:port/user/wbyy/';
-- File path /user/wbyy/ is for reference only. Replace it with the path to actually be accessed.
```

Note The preceding command is for reference only.

1.17.3.1.2.2. Write and query data

After an external table is created, you can use it in the same way you would use a MaxCompute table. You can execute the **INSERT OVERWRITE | INTO** and **SELECT** statements to write data and check whether the write operation is successful respectively. For more information about the statements, see *DML statements* in *MaxCompute SQL*.

1.17.3.1.3. Read data from HDFS

Run the following command to read data from HDFS after you compile the testfile script:

```
set odps.sql.hive.compatible=true;
drop table if exists testfile_read;
 CREATE EXTERNAL TABLE if not exists testfile_read
(
 c_int int ,
 c_tinyint tinyint ,
 c_boolean boolean ,
 c_smallint smallint ,
 c_biging bigint ,
 c_double double ,
 c_float float ,
 --c_time datetime ,
 c_date date ,
 c_timestamp datetime ,
 c_string string
)
 STORED as TEXTFILE
 location 'hdfs://host:port/user/wbyy/';
-- File path /user/wbyy/ is for reference only. Replace it with the path to actually be accessed.
-- Create an external table.
select * from testfile_read;
-- Query and read data.
```

Note The preceding command is for reference only.

1.17.3.2. MongoDB data source

1.17.3.2.1. Overview

ApsaraDB for MongoDB is a stable, reliable, and auto-scaling database service that is fully compatible with MongoDB protocols. MongoDB offers a full range of database solutions, such as disaster recovery, backup, restoration, monitoring, and alerting.

MaxCompute can interact with MongoDB for joint computation after you create external tables.

The following examples show how MaxCompute accesses and processes MongoDB data.

1.17.3.2.2. Prerequisites

You must first deploy MongoDB before creating an external table and processing MongoDB data.

1. Run the following command to enable the MongoDB service:

```
bin/mongod --dbpath=./db
```

2. Run the following command to start the MongoDB client:

```
bin/mongo --host=${host}
```

3. Run the following command to create a database:

```
use mongodb
```

4. Run the following command to create a username and password:

```
db.createUser({user: '${user}', pwd: '${password}', roles: [{role:'readWrite',db:'mongodb'}]})
```

5. Run the following command to check whether the operation is successful. A response of 1 indicates a successful operation.

```
db.auth('${user}', '${password}')
```

1.17.3.2.3. Write data to MongoDB

1.17.3.2.3.1. Create an external table

Run the following command to create a collection in MongoDB:

```
db.createCollection("${tablename}", { capped : true, autoIndexId : true, size : 6142800, max : 10000 } )
-- The values of the size and max parameters are for reference only. Replace them with the values to actually be used.
```

After the collection has been created, run the following command to create an external table:

```
set odps.sql.hive.compatible=true;
drop table if exists mongo_table_external;
CREATE external TABLE if not exists mongo_table_external
  (
   id string,
   name string
  )
  STORED BY 'com.mongodb.hadoop.hive.MongoStorageHandler'
  location "mcfed:mongodb://${user}:${password}@host:port/mongodb.${tablename}"
  TBLPROPERTIES(
    "mcfed.mongo.input.split_size"="2",
-- input.split_size value is for reference only. Replace them with the values to actually be used.
    "mcfed.location"="mongodb://${user}:${password}@host:port/mongodb.${tablename}",
    "mcfed.mongo.input.uri"="mongodb://${user}:${password}@host:port/mongodb.${tablename}",
    "mcfed.mongo.output.uri"="mongodb://${user}:${password}@host:port/mongodb.${tablename}"
);
```

> **Note** The preceding commands are for reference only.

1.17.3.2.3.2. Write and query data

After an external table is created, you can use it in the same way that you would use a MaxCompute table. You can execute the **INSERT OVERWRITE | INTO** and **SELECT** statements to write data and check whether the write operation is successful respectively. For more information about the statements, see *DML statements* in *MaxCompute SQL*.

1.17.3.2.4. Read data from MongoDB

Run the following command to read data from MongoDB after a row of data has been inserted into a created collection:

```
set odps.sql.hive.compatible=true;
drop table if exists mongo_read_external;
CREATE external TABLE if not mongo_read_external
  (
   id string,
   name string
  )
  STORED BY 'com.mongodb.hadoop.hive.MongoStorageHandler'
  location "mcfed:mongodb://${user}:${password}@host:port/mongodb.${tablename}"
  TBLPROPERTIES(
    "mcfed.mongo.input.split_size"="2",
-- The value of the input.split_size parameter is for reference only. Replace it with the value to actually be us
ed.
    "mcfed.location"="mongodb://${user}:${password}@host:port/mongodb.${tablename}",
    "mcfed.mongo.input.uri"="mongodb://${user}:${password}@host:port/mongodb.${tablename}"
);
-- Create an external table.
select * from mongo_external;
-- Query and read data.
```

> **Note** The preceding command is for reference only.

1.17.3.3. HBase data source

1.17.3.3.1. Overview

ApsaraDB for HBase is a distributed database based on Hadoop. It can store PBs of data and be used in scenarios requiring high-throughput random read/writes.

MaxCompute can interact with HBase for joint computation after you create external tables.

The following examples show how MaxCompute accesses and processes HBase data.

1.17.3.3.2. Write data to HBase

1.17.3.3.2.1. Create an external table

Run the following command to create an external table:

```
set odps.sql.hive.compatible=true;
drop table if exists hbase_table_external;
CREATE EXTERNAL TABLE if not exists hbase_table_external
(
id string,
cfa string
)
STORED BY 'org.apache.hadoop.hive.hbase.HBaseStorageHandler'
WITH SERDEPROPERTIES ('mcfed.hbase.table.name'='${table.name}','mcfed.hbase.columns.mapping'=':key,cf:a')
-- cf is the column family in the HBase table.
location 'hbase://host:port'
TBLPROPERTIES('hbase.table.name'='${table.name}','hbase.columns.mapping'=':key,cf:a', 'mcfed.zookeeper.session.timeout'='30', 'mcfed.hbase.client.retries.number'='1', "mcfed.hbase.zookeeper.quorum"="${host}", "mcfed.hbase.zookeeper.property.clientPort"="${port}");
-- The values of the zookeeper.session.timeout and hbase.client.retries.number parameters are for reference only. Replace them with the values to actually be used.
```

> **Note** The preceding command is for reference only.

1.17.3.3.2.2. Write and query data

After an external table is created, you can use it in the same way that you would use a MaxCompute table. You can execute the **INSERT OVERWRITE | INTO** and **SELECT** statements to write data and check whether the write operation is successful respectively. For more information about the statements, see *DML statements* in *MaxCompute SQL*.

1.17.3.3.3. Read data from HBase

Run the following commands to read data from HBase after you have created a table in the HBase client and inserted data into it:

```
set odps.sql.hive.compatible=true;
drop table if exists hbase_read_external;
CREATE EXTERNAL TABLE if not exists hbase_read_external
(
id string,
name string,
a string
)
STORED BY 'org.apache.hadoop.hive.hbase.HBaseStorageHandler'
WITH SERDEPROPERTIES ('mcfed.hbase.table.name'='${table.name}','mcfed.hbase.columns.mapping'=':key,
f1:name,f1:a')
-- f1 is the column family in the HBase table.
location 'hbase://host:port'
TBLPROPERTIES('hbase.table.name'='${table.name}','hbase.columns.mapping'=':key,f1:name,f1:a', 'mcfed.z
ookeeper.session.timeout'='30', 'mcfed.hbase.client.retries.number'='1', "mcfed.hbase.zookeeper.quorum"
="${host}", "mcfed.hbase.zookeeper.property.clientPort"="${port}");
-- The values of the zookeeper.session.timeout and hbase.client.retries.number parameters are for referenc
e only. Replace them with the values to actually be used.
-- Create an external table.
select * from hbase_read_external;
select count(*) from hbase_read_external;
select a.id,a.name from hbase_read_external a join hbase_test b on a.id=b.id;
-- Query and read data.
```

Note The preceding commands are for reference only.

1.18. Unstructured data access and processing (inside MaxCompute)

1.18.1. Overview

MaxCompute has the following problems when processing unstructured data: MaxCompute stores data as volumes and must export generated unstructured data to an external system for processing.

To alleviate these problems, MaxCompute uses external tables to enable connections between MaxCompute and various data types. MaxCompute uses external tables to read and write data volumes as well as process unstructured data from external sources such as OSS.

The following topics describe how MaxCompute accesses and processes volume unstructured data through external tables.

1.18.2. Create a volume external table

1.18.2.1. Syntax

You must execute the CREATE EXTERNAL TABLE statement to create an external table.

```
DROP TABLE [IF EXISTS] <external_table_name>;
CREATE EXTERNAL TABLE [IF NOT EXISTS] <external_table_name>
(<column schemas>)
[PARTITIONED BY (partition column schemas)]
STORED BY '<StorageHandler>'
[WITH SERDEPROPERTIES (
            'name'='value'
            )]
LOCATION 'volume://...'
[USING '<Resourcename>']
;
```

Description:

- **STORED BY**: Two built-in StorageHandlers `com.aliyun.odps.CsvStorageHandler` and `com.aliyun.odps.TsvStorageHandler` are supported. They can be used to read and write CSV files where the column delimiter is a comma and the row delimiter is `\n` or TSV files where the column delimiter is `\t` and the row delimiter is `\n`). If the built-in StorageHandlers cannot be used for some reason, you can build a custom StorageHandler.
- **WITH SERDEPROPERTIES**: specifies table attributes such as delimiters for a custom StorageHandler.
- **LOCATION**: the location format of the table.

  Format:

  ```
  volume://[project_name]/volume_name/partition_value
  ```

  Example:

  ```
  volume://test_project/volume_data/20190102
  ```

  project_name is optional. If **project_name** is not specified, the current project is used to obtain volume data after the DML SQL statement is executed. In the preceding example, if the current project is myproject, you can use the following location format:

  ```
  volume:///volume_data/20190102
  ```

> Notice
>
> - The location of a non-partitioned table must point to a volume partition, instead of the volume itself.
> - The location of a partitioned table must point to the volume itself.
> - The volume path cannot contain an equal sign (=) and does not support the default standard partition path *ds=2017071* that is used when a partition is created. The partition path must be customized. The custom partition path can be any path supported by the volume. For example, if the partition path is 20190102, the path combined with volume path can be *volume://test_project/volume_data/20190102*.

- **USING**: specifies the StorageHandler resource. To use a custom StorageHandler, you must first export the custom StorageHandler as a JAR package and then add it to MaxCompute as a JAR resource.

1.18.2.2. Use the built-in StorageHandler to create an external table

You can use the built-in StorageHandler to create a partitioned or non-partitioned table.

Create a non-partitioned table

Example:

```
DROP TABLE IF EXISTS volume_ext;
CREATE EXTERNAL TABLE volume_ext
(
key string,
value string
)
STORED BY 'com.aliyun.odps.CsvStorageHandler'--The built-in StorageHandler.
LOCATION 'volume://test_project/volume_data/20190102'
;
```

Create a partitioned table

Example:

```
DROP TABLE IF EXISTS volume_ext_pt;
CREATE EXTERNAL TABLE volume_ext_pt
(
key string,
value string
)
PARTITIONED BY (ds string)
STORED BY 'com.aliyun.odps.CsvStorageHandler'--The built-in StorageHandler.
LOCATION 'volume://test_project/volume_data'
;
ALTER TABLE volume_ext_pt DROP IF EXISTS PARTITION (ds="20190102");
ALTER TABLE volume_ext_pt ADD PARTITION (ds="20190102") LOCATION "volume://test_project/volume_da
ta/20190102";
```

1.18.2.3. Use a custom StorageHandler to create a table

When the built-in StorageHandlers are unable to meet the requirements of your business, you can customize a StorageHandler through Java and specify some attributes of the Volume external table which you want to process data through.

The following example shows how to use a custom StorageHandler to create an external table.

Assume that the data type is TEXT and the column delimiter is "|". You can perform the following steps to create an external table:

1. Use MaxCompute Studio or MaxCompute Eclipse development plug-in to customize various Java classes.
2. Export the JAR package. In this example, the package name is **odps-volume-example.jar**.
3. Run the following command to add the JAR package to MaxCompute as a resource:

   ```
   add jar odps-volume-example.jar -f;
   ```

4. Run the following commands to create an external table:

```
DROP TABLE IF EXISTS volume_ext;
CREATE EXTERNAL TABLE volume_ext
(
key string,
value string
)
STORED BY 'com.aliyun.odps.udf.example.text.TextStorageHandler'
WITH SERDEPROPERTIES (
            'delimiter'='|'
            )
LOCATION 'volume://myproject/volume_data/20190102'
USING 'odps-volume-example.jar'
  ;
```

Note After the external table is created, you can operate the volume data through the external table.

1.18.3. Access a volume external table

Volume external tables can be accessed in the same way that you would access a MaxCompute table. Example:

```
select key,value from volume_ext_pt where ds="20190102";
```

1.19. Multi-region cluster deployment on MaxCompute

1.19.1. Overview

MaxCompute supports multi-region cluster deployment.

The control clusters is deployed in a centralize manner and configures resources as well as manages compute tasks. The Compute cluster is deployed independently for each region and handles project creation and compute task delegation.

1.19.2. Characteristics of multi-region deployment

This topic describes the characteristics of multi-region deployment.

The multi-region deployment on MaxCompute has the following features:

- One MaxCompute service instance can manage multiple clusters that are located in different cities.

- Cross-cluster data interaction is implemented within the MaxCompute service, and cross-cluster data replication and synchronization are managed based on the actual configuration.
- Metadata is stored in a centralized manner. Therefore, the infrastructure requirements, such as network connections between different data centers, are relatively high.
- A unified account system is required.
- Big data application development systems, such as DataWorks, are used in all regions and clusters.
- You must change the mode of the current MaxCompute cluster to cross-cluster for multi-region deployment.

  > **Note** The conditions and limits on changing the cluster mode are as follows:
  >
  > - The network bandwidth must be sufficient for multi-region data synchronization and link redundancy.
  > - The central-region control cluster has a relatively high latency for basic services such as DNS and TableStore. We recommend that you deploy basic services in the same data center to keep the network latency within 5 ms.
  > - The network latency between the central-region control cluster and computing clusters in other regions must must be kept within 20 ms.
  > - Clocks must be synchronized between clusters in different cities and between machines in the same cluster.
  > - The network bandwidth must be sufficient for data replication among clusters.
  > - DNS is required.
  > - In order for cross-cluster servers to communicate on the same network, the clusters must have similar network bandwidth conditions, such as GE or 10GE.

- The operations, maintenance, deployment, and upgrade for multi-region deployment are different from those for a single cluster deployment. Multi-region deployment requires higher onsite operations and maintenance capabilities.

1.19.3. Instructions on multi-region deployment

This topic describes multi-region deployment.

The instructions to implement multi-region deployment are as follows:

- Computing tasks on MaxCompute are implemented in a cluster based on data distribution within the service. Cross-cluster replication and direct reads are performed based on the cluster configuration and distribution of data.
- Data replication and synchronization can be performed between different clusters by table or partition based on the actual cluster configuration.
- You must plan the relationship between the MaxCompute project and the cluster at the business layer. You can select one or multiple clusters for a single project.

  > **Note** If you select multiple clusters for a project, data replication is carried out among these clusters.

- If the project contains business that cannot implement cross-cluster computing, you can distribute data to different clusters and divide the computing tasks based on their distribution.

> **Note** Cross-cluster data replication and management requires management policies.

- The bandwidth between clusters in different remote data centers must be sufficient for data replication or read-only operations.
- Replication and read-only operations across clusters in MaxCompute involving large amounts of data will consume all of the bandwidth between the two clusters, as the two data centers share bandwidth.
- A cluster failure in the primary data center will affect the entire service because the primary data center stores information such as metadata and accounts.
- When the secondary data center fails, the project where data is stored on the cluster and the O&M of services are affected.

> **Note** If project data is independently stored in the primary data center, the failure of the secondary data center will not affect computing tasks of the project.

- In general scenarios, data is partitioned and replicated based on business characteristics, and computing tasks are performed based on data types in different clusters. The combined results of different MaxCompute tasks are applied.

1.19.4. Multi-region deployment examples

1.19.4.1. Table data synchronization between multiple clusters

This topic provides an example of table data synchronization between multiple clusters in a multi-region deployment scenario.

Prerequisites

- In the AdminConsole, you have selected two clusters and set one as the default cluster. An example of the operation is as follows:

> **Note**
>
> - In this example, for project multiregion, select AT-MDU-TEST and AT-5KN, with AT-MDU-TEST as the default cluster.
> - The URL of Apsara Stack MaxCompute AdminConsole is http://{odps_ag}:9090, which is port 9090 of MaxCompute AG.
> - Choose **ODPS Configuration > Project Management > Create Project**.

- Configure cross-cluster replication for the project. An example of the operation is as follows:
  i. Choose **ODPS Cconfiguration > Global Cross-cluster Replication Configuration** to go to the **Global Cross-cluster Replication Configuration** page.
  ii. In the Add Item part of the **InfoBetweenClusters** area, set key to **AT-5KN#AT-MDU-TEST**. Set availableBandwith and totalBandwith to **2000**. Then click **Add**.

iii. Choose **ODPS Configuration > Project Management**. Locate project multiregion and click **Cross-cluster Replication Configuration**.

iv. In the dialog box that appears, configure the parameters as follows:

v. Click **Save** and then click **Start Replication**.

Procedure

An example of the operation is as follows:

1. In the AG of the default cluster (AT-MDU-TEST), construct an upload tunnel data file in the directory of the same level as console, such as `echo "testtest" > uploaddata`.
2. Go to the console command line and run the following commands to create a table and insert data into the table:

```
use multiregion;
create table t1 (s string);
tunnel upload uploaddata t1;
```

3. Run the following command to check whether the data is inserted in the table:

```
select * from t1
```

4. In the AG of AT-MDU-TEST, view the Apsara Distributed File System directory for this table. Run the following command to check whether data exists in the directory:

```
pu ls product/aliyun/odps/multiregion/data/t1
```

5. On the AG in AT-5KN, view the Apsara Distributed File System directory for this table. Run the following command to check whether data exists in the directory:

```
pu ls /apsara/odps/mdutesting/multiregion/data/t1
```

6. If data is displayed after you perform both steps 4 and 5, the cross-cluster data synchronization operation is successful.

1.19.4.2. Query the status of data synchronization between primary and secondary clusters

This topic provides an example of how to query the status of data synchronization between the primary and secondary clusters in multi-region deployment scenarios.

Prerequisites

- In the AdminConsole, you have selected two clusters and set one as the default cluster. An example of the operation is as follows:

> Note
>
> - In this example, for project multiregion, select AT-MDU-TEST and AT-5KN, with AT-MDU-TEST as the default cluster.
> - The URL of Apsara Stack MaxCompute AdminConsole is http://{odps_ag}:9090, which is port 9090 of MaxCompute AG.
> - Choose **ODPS Configuration > Project Management > Create Project**.

- Configure cross-cluster replication for the project. An example of the operation is as follows:
  i. Choose **ODPS Cconfiguration > Global Cross-cluster Replication Configuration** to go to the **Global Cross-cluster Replication Configuration** page.
  ii. In the Add Item part of the **InfoBetweenClusters** area, set key to **AT-5KN#AT-MDU-TEST**. Set availableBandwith and totalBandwith to **2000**. Then click **Add**.

  iii. Choose **ODPS Configuration > Project Management**. Locate project multiregion and click **Cross-cluster Replication Configuration**.

  iv. In the dialog box that appears, configure the parameters as follows:

  v. Click **Save** and then click **Start Replication**.

Procedure

An example of the operation is as follows:

1. Write the bodychecksync configuration file for sending admintask.

```
<Instance>
 <Job>
  <Comment>
  </Comment>
  <Priority>1</Priority>
  <Tasks>
   <Admin>
   <Name>task_1</Name>
   <Comment>test</Comment>
   <Config>
    <Property>
     <Name>PROJECT</Name>
     <Value>multiregion</Value>
    </Property>
    <Property>
     <Name>CLUSTER</Name>
     <Value>AT-MDU-TEST</Value>
    </Property>
   </Config>
   <Command>GET_UNREPLICATED_OBJECTS</Command>
   </Admin>
  </Tasks>
  <DAG>
   <Comment/>
   <RunMode>Sequence</RunMode>
  </DAG>
 </Job>
</Instance>
```

2. Compile the header.

```
content-type: application/xml
```

3. Run the following command to send admintask:

```
CLTrelease/bin/odpscmd -e "http post  /projects/admin_task_project/instances -header=header -conte
nt=bodychecksync;"
```

4. Run the following command to check the instance execution results:

```
CLTrelease/bin/odpscmd  --project=admin_task_project -e "wait 20180711050550317gnege3ms2;"
```

5. Copy the Logview URL generated in the previous step, paste the URL in the address bar of your browser, and press Enter.

6. On the page that appears, click **Detail**. The status of data synchronization between the primary and secondary clusters is displayed.

1.19.4.3. Cross-region direct read

This topic provides cross-region direct read examples for multi-region deployment scenarios.

Cross-region direct read can be implemented with or without cross-cluster access.

> **Note** When cross-cluster access is not configured, cross-region direct read will take a longer amount of time to complete for large volumes of data.

Direct read when cross-cluster access is not configured

An example of the operation is as follows:

1. In the AdminConsole, create two projects: testmdu and testcross5kn.

   > **Note**
   > - In this example, for project testmdu, select AT-MDU-TEST and AT-5KN, with AT-MDU-TEST as the default cluster. For project testcross5kn, select only AT-5KN that serves as the default cluster.
   > - The URL of Apsara Stack MaxCompute AdminConsole is http://{odps_ag}:9090, which is port 9090 of MaxCompute AG.
   > - Choose **ODPS Configuration > Project Management > Create Project**.

2. Create tables for project testmdu and project testcross5kn respectively.

   ```
   create table testrep(s string );
   create table tablecross5kn (s string );
   ```

3. Construct some data for tables testep and tablecross5kn.
4. Run the following commands to read the table data on testmdu directly from testcross5kn:

   ```
   use testcross5kn;
   select * from testmdu.testrep;
   ```

   > **Note** If you can read the data, the cross-region direct read operation is successful.

Direct read when cross-cluster access is configured

An example of the operation is as follows:

1. In the AdminConsole, create two projects: testmdu and testcross5kn.

> **Note**
>
> - In this example, for project testmdu, select AT-MDU-TEST and AT-5KN, with AT-MDU-TEST as the default cluster. For project testcross5kn, select only AT-5KN that serves as the default cluster.
> - The URL of Apsara Stack MaxCompute AdminConsole is http://{odps_ag}:9090, which is port 9090 of MaxCompute AG.
> - Choose **ODPS Configuration > Project Management > Create Project**.

2. Create tables for project testmdu and project testcross5kn respectively.

```
create table testrep(s string );
create table tablecross5kn (s string );
```

3. Construct some data for tables testep and tablecross5kn.
4. Configure cross-cluster replication for project testmdu.

> **Note** Choose **ODPS Cconfiguration > Project Management**. Locate project testmdu and click **Cross-cluster Replication Configuration**.

5. Run the following command to read the table data on testmdu directly from testcross5kn:

```
use testcross5kn;
select * from testmdu.testrep;
```

> **Note** If you can read the data, the cross-region direct read operation is successful.

1.19.4.4. Cross-region JOIN

This topic provides an example of cross-region JOIN in multi-region deployment scenarios.

An example of the operation is as follows:

1. In the AdminConsole, create two projects: crosssregion and crossregion02.

> **Note**
>
> - In this example, for project crosssregion, select AT-MDU-TEST and AT-70N, with AT-MDU-TEST as the default cluster. For project crossregion02, select only AT-70N that serves as the default cluster.
> - The URL of Apsara Stack MaxCompute AdminConsole is http://{odps_ag}:9090, which is port 9090 of MaxCompute AG.
> - Choose **ODPS Configuration > Project Management > Create Project**.

2. Configure cross-cluster replication for project crosssregion.

> Note Choose ODPS Configuration > Project Management. Locate project crosssregion and click Cross-cluster Replication Configuration.

3. Create a table named business for project crosssregion.

```
create table business(bid bigint,name string,phone string,address string,region string);
```

4. Construct some data for the table.
5. Run the following command to import data into the table:

```
tunnel upload business business;
```

6. Create a table named product for project crossregion02.

```
create table if not exists product(pid bigint,name string,type string,color string,bid bigint);
```

7. Construct some data for the table.
8. Run the following command to import data into the table:

```
tunnel upload product product;
```

9. Run the following command in the console to obtain specific data from the preceding two tables:

```
select pro.pid,pro.name,pro.type,pro.color,bus.name,bus.phone from crossregion02.product pro join c
rosssregion.business bus on pro.bid=bus.bid where bus.region='Shanghai';
```

> Note If the specified data is returned, the cross-region JOIN operation is successful.

1.20. Security solution

1.20.1. Target users

This User Guide is intended for all owners and administrators of MaxCompute projects, and users interested in the MaxCompute multi-tenant data security system. The MaxCompute multi-tenant data security system includes:

- User authentication
- User and authorization management of projects
- Cross-project resource sharing
- Project protection

1.20.2. Quick start

Add a user and grant permissions to the user

Scenario: Jack is the administrator of the prj1 project. A new team member Alice, who already has an Alibaba Cloud account (alice@aliyun.com), applies to join the project. Alice applies for the following permissions: viewing table lists, submitting jobs, and creating tables.

The admin performs the following operations to add Alice to the project:

```
use prj1
add user aliyun$alice@aliyun.com;
-- Add a user.
grant List, CreateTable, CreateInstance on project prj1 to user aliyun$alice@aliyun.com
-- Grant permissions to the user.
```

Add a user and grant permissions to the user using an ACL

Scenario: Jack is the administrator of prj1. Three new members Alice, Bob, and Charlie join in as data reviewers. They require the following permissions: viewing table lists, submitting jobs, and reading the table userprofile.

The project administrator can use object-based ACL authorization in this scenario.

The operations are as follows:

```
use prj1
add user aliyun$alice@aliyun.com
-- Add a user.
add user aliyun$bob@aliyun.com
add user aliyun$charlie@aliyun.com
create role tableviewer
-- Create a role.
grant List, CreateInstance on project prj1 to role tableviewer; --Grant permissions to the role
-- Grant permissions to the role.
grant Describe, Select on table userprofile to role tableviewer
grant tableviewer to aliyun$alice@aliyun.com
-- Grant the tableviewer role to a user.
grant tableviewer to aliyun$bob@aliyun.com
grant tableviewer to aliyun$charlie@aliyun.com
```

Package and share resources

Scenario: Jack is the administrator of prj1. John is the administrator of prj2. Due to business requirements, Jack wants to share some resources of prj1 (such as datamining.jar and sampletable) to John's prj2. A user in prj2 (Bob) requires access to these resources. The prj2 administrator can configure an ACL or policy to automatically authorize prj2 users to access these resources, without the intervention of Jack.

The operations are as follows:

1. Prj1 administrator Jack creates a resource package in prj1.

```
use prj1
create package datamining
-- Create a package.
add resource datamining.jar to package datamining
-- Add resources to the package.
add table sampletable to package datamining
-- Add the table to the package.
allow project prj2 to install package datamining
-- Share the package to prj2.
```

2. Prj2 administrator Bob installs the package in prj2.

```
use prj2
install package prj1.datamining
-- Install the package.
describe package prj1.datamining
-- View the resource list of the package.
```

3. Configure automatic authorization for Bob on the package.

```
use prj2
grant Read on package prj1.datamining to user aliyun$bob@aliyun.com
-- Use an ACL to allow Bob to use the package.
```

> **Note** For more information about cross-project resource sharing, see Cross-project resource sharing.

Configure project protection

Scenario: Jack is the administrator of project prj1. This project contains sensitive data such as user IDs and shopping records. The project also stores many data mining algorithms to which the organization holds intellectual property rights. Jack wants to protect the sensitive data and algorithms in the project. He wants the data to be accessible only to users in the project. The data must not be able to flow out of the project.

The operations are as follows:

```
use prj1
set ProjectProtection=true
-- Enable project protection.
```

When project protection is enabled, data in the project can flow only within the project. Data cannot flow out. In some cases, for example, a user (Alice) requires to export data tables for business purposes. This operation is approved by the project administrator. MaxCompute provides two methods to export data from a protected project.

Method 1: Create an exception policy. For more information, see Data export methods when project protection is enabled.

1. Create a policy file. Create a policy file named */tmp/exception_policy.txt*. It only allows Alice to export t1 from prj1 using a SQL task. The policy is defined as follows:

```
{
"Version": "1",
"Statement": [{
"Effect":"Allow",
"Principal":"ALIYUN$alice@aliyun.com",
"Action":["odps:Describe","odps:Select"],
"Resource":"acs:odps:*:projects/prj1/tables/t1",
"Condition":{
"StringEquals": { "odps:TaskType":"SQL"
}
}
}]
```

2. Configure the exception policy.

```
use prj1
-- Enable project protection and configure an exception policy.
set ProjectProtection=true with exception /tmp/exception_policy.txt
```

> **Note** When you configure the exception policy, ensure that the principal cannot update the data resources or recreate an object with the same name (using DROP TABLE and CREATE TABLE). This prevents data leakage due to time-of-check to time-of-use (TOC2TOU).

Method 2: Configure trusted projects. Configure prj2 as a trusted project of prj1 to enable data flow from prj1 to prj2. For more information, see Data export methods when project protection is enabled.

```
use prj1
    add trustedproject prj2
```

> **Note** In MaxCompute, package-based resource sharing and project protection are mutually independent mechanisms that take effect at the same time, but their functions are mutually restrictive.

In MaxCompute, resource sharing has a higher priority than project protection. This means, if an object in a protected project is shared with other projects through the package mechanism, cross-project access to this object is not subject to the project protection rules.

1.20.3. User authentication

The main purpose of user authentication is to verify the identity of a request sender. Authentication typically includes:

- Verifying the true identity of a message sender
- Checking whether the message was tampered with before it is received.

1.20.4. Project user and authorization management

1.20.4.1. Overview

Projects are the foundation of the MaxCompute multi-tenant system and the basic units of data management and computing. When you create a project, you are automatically the project owner. All objects in the project, such as tables, instances, resources, and UDFs, belong to you. Objects in the project can only be accessed by the owner and users that are authorized by the owner.

This topic describes users, roles, and authorization management of projects. For example, Alice is the owner of test_project, and another user from Alice's project team requests to access the resources in test_project. Alice can use the methods described in this topic to perform user and authorization management. If a user that wants access to Alice's project is not from her project team, Alice can implement cross-project sharing. For more information, see Cross-project resource sharing.

1.20.4.2. User management

Add a user

If Alice (the project owner) decides to authorize another user, she must add the user to this project. Only users in a project can be authorized.

Run the following command to add a user:

```
add user <full_username>
-- Add a user to a project.
```

Remove a user

When a user leaves the project team, Alice needs to remove the user from the project. After a user is removed from the project, the user no longer has any access permissions on project resources.

Run the following command to remove a user from a project:

```
remove user <full_username>
-- Remove a user from a project.
```

Note

- After a user is removed, the user no longer has any access permissions on project resources.
- Before you remove a user who has been assigned a role, you must first revoke the role. For information about roles, see Role management.
- After a user is removed, the ACL authorization related to the user is retained. However, the policy authorization at the role level is revoked, and the policy authorization at the project level is retained. If the user is added to the project again, the previous ACL authorization of the user is re-activated.
- MaxCompute does not support complete removal of a user and the relevant authorization data.

1.20.4.3. Role management

A role is a collection of access permissions. A role can be used to assign the same permissions to a group of users. Role-based authorization can greatly simplify the authorization process and reduce authorization management costs. When granting permissions to users, you should consider using role-based authorization.

An admin role is automatically created when a project is created. This role is granted permissions to access all objects of the project, manage users and roles, and authorize users and roles. Compared with the project owner, the admin role cannot assign another user with the admin role, configure security rules for a project, or change the authentication model of the project. Permissions of the admin role cannot be modified.

The role management commands are as follows:

```
create role <rolename>
-- Create a role.
drop role <rolename>
-- Delete a role.
grant <rolename> to <username>
-- Assign a role to a user.
revoke <rolename> from <username>
-- Revoke the role of a user.
```

Note When you delete a role, MaxCompute checks whether there are users assigned with this role. If the role is assigned to users, the role fails to be deleted. To delete the role, you must revoke this role from all users.

1.20.4.4. ACL authorization actions

Authorization usually involves three elements: subject, object, and action. In MaxCompute, a subject is the user, there are various types of objects in a project, and actions are performed on objects. Different types of objects support different actions.

MaxCompute projects support the following object types and actions:

Object types and actions

Object	Action	Description
Project	**Read**	Check the information about the project itself (not including any objects of the project), such as CreateTime.
Project	**Write**	Update the information of the project itself (not including any objects of the project), such as Comments.
Project	**List**	View a list of all types of objects in the project.
Project	**CreateTable**	Create a table in the project.
Project	**CreateInstance**	Create an instance in the project.
Project	**CreateFunction**	Create a function in the project.
Project	**CreateResource**	Create resource in the project.
Project	**CreateJob**	Create a job in the project.
Project	**CreateVolume**	Create a volume in the project.
Project	**All**	All the permissions above.
Table	**Describe**	Read the metadata of the table.
Table	**Select**	Read the information of the table.
Table	**Alter**	Alter the metadata of the table; add or drop partitions.
Table	**Update**	Override or add data to the table.
Table	**Drop**	Drop the table.
Table	**All**	All the preceding permissions.
Function	**Read**	Read and execute permissions.
Function	**Write**	Update.
Function	**Delete**	Delete.
Function	**All**	All the preceding permissions.
Resource, instance, job, volume	**Read**	Read permissions.

Object	Action	Description
Resource, instance, job, volume	**Write**	Update permissions.
Resource, instance, job, volume	**Delete**	Delete permissions.
Resource, instance, job, volume	**All**	All the preceding permissions.

> **Note** In the preceding permissions, the CreateTable action of project objects, as well as the Select, Alter, Update, and Drop actions of table objects, must be used together with the CreateInstance action of project objects. Before using the preceding permissions to complete actions, you must assign the CreateInstance permission.

After adding users or creating roles, these users or roles should be authorized. The ACL authorization mechanism of MaxCompute is object-based. Authorization data (the access control list, or ACL) is considered as a sub-resource of an object). Therefore, ACL authorization can be performed only when the objects exist. When the objects are deleted, authorized permission data is automatically deleted.

The ACL of MaxCompute supports authorization using commands like SQL92-defined GRANT/REVOKE commands. Use the corresponding authorization commands to authorize existing project objects or revoke their authorization.

Command syntax:

```
grant actions on object to subject
revoke actions on object from subject
actions ::= action_item1, action_item2, ...
object ::= project project_name | table schema_name | instance inst_name | function func_name | resource r
es_name
subject ::= user full_username | role role_name
```

> **Note**
>
> The ACL authorization commands of MaxCompute do not support the [WITH GRANT OPTION] parameter. That is, when user A authorizes user B to access an object, user B cannot authorize user C to access the same object. Therefore, all authorization actions must be completed by users with at least one of the following identities:
>
> - Project owner
> - Users with the admin role in the project
> - Object creators in the project

ACL authorization example:

Scenario: Users alice@aliyun.com and bob@aliyun.com are new members of test_project. In test_project, they must submit jobs, create data tables, and view existing objects of the project. The administrator then takes the following authorization actions:

```
use test_project
-- Open a project.
security
add user aliyun$alice@aliyun.com
-- Add a user.
add user aliyun$bob@aliyun.com
-- Add a user.
create role worker
-- Create a role.
grant worker TO aliyun$alice@aliyun.com
-- Assign a role.
grant worker TO aliyun$bob@aliyun.com
-- Assign a role.
grant CreateInstance, CreateResource, CreateFunction, CreateTable, List ON PROJECT test_project TO ROLE
worke r
-- Authorize a role.
```

1.20.4.5. View permissions

MaxCompute allows you to view permissions in different dimensions. For example, you can view permissions of a specified user, permissions of a specified role, or the authorization list of a specified object.

View the permissions of a user

```
show grants
-- View the access permissions of the current user.
show grants for <username>
-- View the access permissions of a specified user. Only project owners and administrators can view the acce
ss permissions of a specified user.
```

View the permissions of a role

```
describe role <rolename>
-- View the access permissions granted to a specified role.
```

View the authorization list of an object

```
show acl for <objectName> [on type <objectType>]
-- View the authorization list of a specified object.
```

> **Note** If [on type <objectType>] is not specified, the default type is table.

MaxCompute uses characters A, C, D, and G to indicate the permissions of users or roles. The characters are described as follows:

- A: allow. Access is allowed.
- D: deny. Access is denied.
- C: condition. This is a conditional authorization. This character appears only in the policy authorization system. For more information, see Condition block structure.
- G: grant. You can grant permissions to this object.

Example:

```
odps@test_project> show grants for aliyun$odpstest1@aliyun.com
[roles]
dev
Authorization Type: ACL
[role/dev]
A projects/test_project/tables/t1: Select [user/odpstest1@aliyun.com]
A projects/test_project: CreateTable | CreateInstance | CreateFunction | List
A projects/test_project/tables/t1: Describe | Select
Authorization Type: Policy
[role/dev]
AC projects/test_project/tables/test_*: Describe
DC projects/test_project/tables/alifinance_*: Select [user/odpstest1@aliyun.com]
A projects/test_project: Create* | List
AC projects/test_project/tables/alipay_*: Describe | Select
Authorization Type: ObjectCreator
AG projects/test_project/tables/t6: All
AG projects/test_project/tables/t7: All
```

1.20.5. Cross-project resource sharing

1.20.5.1. Overview

You are the owner or administrator (admin role) of a project, and someone requests to access resources of your project. If the applicant is a member of your project team, we recommend that you use the user and authorization management features for your project. For more information, see User and authorization management of projects. If the applicant is not a member of your project team, you can use the package-based resource sharing feature described in this topic.

A package is used to share data and resources across projects. It can be used to implement cross-project user authorization. The following scenario describes a problem that can only be resolved effectively with the package mechanism.

Members of the Alifinance project need to access Alipay project data. The Alipay project administrator adds Alifinance project users to the Alipay project, and then grants the new users common permissions. For security concerns, the Alipay project administrator does not want to authorize every user of the Alifinance project team. A mechanism is required to allow the Alifinance project administrator to control access to the authorized objects.

By using the package feature, the Alipay project administrator can package the objects that the Alifinance team needs to access, and then allow the package to be installed in the Alifinance project. After installing the package, the Alifinance project administrator can decide whether to grant permissions on the package to users in the Alifinance project.

A package involves two subjects: package creator and package user. The package creator provides resources. The package creator packages the resources to be shared and the corresponding access permissions, and provides the package receiver with the permissions to install and use the package. The package user consumes the resources. After installing the package published by the package creator, the package user can directly access the resources.

The following topics describe the operations that can be performed by a package creator and package user.

1.20.5.2. Package usage

1.20.5.2.1. Operations for package creators

Create a package

Run the following commands to create a package:

```
create package <pkgname>
```

Delete a package

Run the following commands to drop a package:

```
delete package <pkgname>
```

Add a resource to be shared to the package

Run the following commands to add a resource to the package:

```
add project_object to package package_name [with privileges <privileges>]
remove project_object from package package_name
project_object ::= table table_name | instance inst_name | function func_name | resource res_name
privileges ::= action_item1, action_item2, ...
```

Note

- The types of supported objects exclude projects, so you cannot use a package to create objects in other projects.
- In addition to the objects, the operation permissions on the objects are also added to the package. When not passed [with privileges Privileges] When you specify an action permission, the default is read-only, that is, read/describe/select. An object (resource) and its permissions are considered as a whole. You can delete resources in a package. The permissions are revoked when resources are deleted.

Allow other projects to use a package

Run the following commands to allow other projects to use a package:

```
allow project <prjname> to install package <pkgname> [using label <number>]
```

Revoke the permission for other projects to use a package

Run the following commands to revoke another project's permission to use package:

```
disallow project <prjname> to install package <pkgname>
```

View the list of packages already created and installed

Run the following commands to view the list of packages already created and installed:

```
show packages
```

View details of a package

Run the following commands to view details of a package:

```
describe package <pkgname>
```

1.20.5.2.2. Operations for package users

The installed package is a type of independent object in MaxCompute. To access resources in a package (other projects' resources shared with you), you must have the permission to read the package. If you do not have read permissions, submit an application to the project owner or admin for the permissions. The project owner or admin can grant the permissions by using ACL authorization or policy authorization.

For example, the following ACL authorization rule allows user odps_test@aliyun.com to access resources in a package:

```
use prj2 security
install package prj1.testpkg
grant read on package prj1.testpackage to user aliyun$odps_test@aliyun.com
```

The following policy authorization rule allows any user in prj2 to access resources in a package:

```
use prj2
install package prj1.testpkg
put policy /tmp/policy.txt
```

The contents of /tmp/policy.txt are as follow:

```
{
"Version": "1", "Statement": [{
"Effect":"Allow",
"Principal":"*",
"Action":"odps:Read", "Resource":"acs:odps:*:projects/prj2/packages/prj1.testpkg"
}]
}
```

Install a package

Run the following commands to install a package:

```
install package <pkgname>;
```

> **Note** The pkgName of a package to be installed must be in the format of <projectName>.<packageName>.

Uninstall package

Run the following commands to uninstall a package:

```
uninstall package <pkgname>;
```

> **Note** The pkgName of a package to be uninstalled must be in the format of <projectName>.<packageName>.

View packages

Run the following commands to view packages:

```
show packages
-- View the list of packages already created and installed.
describe package <pkgname>
-- View details of a package.
```

1.20.6. Project protection

1.20.6.1. Overview

Some enterprises (such as financial institutions and military enterprises) have high data security requirements. For example, their employees can only perform their jobs in the workplace, and are not allowed to take work materials out of the office. All USB ports on office computers are disabled. These measures aim to prevent leakage of sensitive data.

For example, you are a MaxCompute project administrator in charge of a project with sensitive data. The data must not be shared to other projects. You are required to perform the following configurations to prohibit all operations that could result in data outflow.

1.20.6.2. Data protection

MaxCompute provides a project protection mechanism that prohibits operations that introduce data leakage risks. You can simply configure your project as follows to enable project protection:

```
set security.ProjectProtection=true
-- Enable project protection. This rule allows inbound data flows, but prohibits outbound data flows.
```

After project protection is enabled, the data flow of the project is controlled. Data can flow in, but cannot flow out.

Project protection is disabled by default (ProjectProtection = false). If you have access permissions on multiple projects, you can use any cross-project data access to migrate data between projects. If a project stores highly-sensitive data, the administrator must configure a project protection mechanism.

1.20.6.3. Data export methods when project protection is enabled

After you enable project protection, you may soon encounter this situation: A user (Alice) submits a request to export the data of a table from the project. It is verified that this table contains no sensitive data. MaxCompute provides two methods to export data after project protection is enabled.

Configure an exception policy

The project owner can run the following command to attach an exception policy when enabling project protection:

```
SET ProjectProtection=true WITH EXCEPTION <policyFile>
```

> **Note** This policy mechanism is different from the policy-based authorization mechanism (though the command syntax is the same). This policy describes exceptions of the project protection mechanism. All access requests matching the policy are not subject to the project protection rules.

Example:

The following policy allows the user Alice@aliyun.com to export data out of the alipay project when performing the SELECT operation on the alipay.table_test table in a SQL task:

```
{
"Version": "1", "Statement": [{
"Effect":"Allow", "Principal":"ALIYUN$Alice@aliyun.com",
"Action":["odps:Select"],
"Resource":"acs:odps:*:projects/alipay/tables/table_test",
"Condition":{
"StringEquals": { "odps:TaskType":["DT", "SQL"]
}
}
}]
}
```

Note

- The preceding exception policy does not grant any permissions. If Alice does not have the SELECT permission on alipay.table_test, the preceding exception policy does not allow Alice to export data. Project protection specifies data flow control, not access control. Data flow control is effective only when a user can access the target data.
- Data leakage due to TOC2TOU (also known as the race condition problem) arises in the following situation:
  i. [TOC stage] User A submits an application to the project owner to export table t1. The project owner verifies that t1 does not contain sensitive data. The project owner configures an exception policy, which allows user A to export t1.
  ii. A malicious user changes the content of t1 by writing sensitive data to it.
  iii. [TOU stage] User A exports t1. The t1 exported by the user is not the same t1 that was authorized by the project owner.

  Suggestions on TOC2TOU prevention: For a table that a user applies to export, the project owner must make sure that no other user (including admins) can update the table or create a table with the same name (using DROP TABLE and CREAT TABLE). In the preceding TOC2TOU scenario, we recommend that the project owner create a snapshot of t1 in step 1. Then, create an exception policy for the user to use this snapshot. Do not grant the admin role to any users.

Configure a trusted project

If the current project is protected, and the target project is a trusted project of the current project, data flows to the target project are not subject to the project protection rules. If each project in a group is mutually configured as trusted projects, the group is considered a trusted project group. Data can flow freely within the group, but cannot flow out.

Run the following command to manage trusted projects:

```
ist trustedprojects
-- Show all trusted projects of the current project.
add trustedproject <projectname>
-- Add a trusted project of the current project.
remove trustedproject <projectname>
-- Remove a trusted project of the current project.
```

1.20.6.4. Resource sharing and data protection

In MaxCompute, package-based resource sharing and project protection are mutually independent mechanisms that take effect at the same time, but their functions are mutually restrictive.

In MaxCompute, resource sharing takes precedence over project protection. If a data object is shared to users in other projects through resource sharing, the project protection rules will not apply to this data object.

To prevent data outflow from the project, after you enable project protection (ProjectProtection=true), you must verify the following points:

- Make sure that no trusted projects are added. If one is added, evaluate possible risks.
- Make sure that no exception policies are configured. If one is configured, evaluate possible risks, especially risks due to TOC2TOU.
- Check whether package data sharing is not in use. If package data sharing is in use, make sure that the package contains no sensitive data.

1.20.7. Project security configuration

MaxCompute is a multi-tenant data processing platform. Different tenants may have different data security requirements. MaxCompute provides project-level security configuration to satisfy data security requirements of different tenants. Project owners can customize their external accounts and authentication models as required.

MaxCompute supports multiple orthogonal authorization mechanisms, such as ACL-based authorization, policy-based authorization, and implicit authorization (for example, an object creator is automatically authorized to access the object). However, not all users require these security mechanisms. You can configure an authentication model that best suits your business demands and usage habits.

```
show SecurityConfiguration
-- View the security configuration of the project.
set security.CheckPermissionUsingACL=true/false
-- Enable or disable ACL-based authorization. Default value: true.
set security.CheckPermissionUsingPolicy=true/false
-- Enable or disable policy-based authorization. Default value: true.
set security.ObjectCreatorHasAccessPermission=true/false
-- Allow or disallow an object creator to be granted the object access permission by default. Default value: tr
ue.
set security.ObjectCreatorHasGrantPermission=true/false
-- Allow or disallow an object creator to be granted the authorization permission by default. Default value: tr
ue.
set security.LabelSecurity=true/false
-- Enable or disable the label security policy.
set security.ProjectProtection=true/false
-- Enable or disable project protection to allow or prohibit data transfer from the project.
```

1.20.8. Authorization policies

1.20.8.1. Policy overview

Policy authorization is a principal-based authorization. Permission data authorized by policy (that is, access policy) is considered as a type of sub-resource of the authorization subject. Policy authorization can be performed only if the subject exists. When a subject is deleted, their authorization data is deleted automatically. Policy authorization uses an access policy language customized for MaxCompute to allow or deny subjects access to project objects.

Policy authorization is a new authorization mechanism mainly used to handle complicated authorization scenarios that ACL authorization struggles to deal with, such as:

- Authorize a group of objects, such as all functions and all tables starting with taobao, at a time.
- For authorizations with restrictive conditions, such as one that takes effect only in a specified period, one that takes effect only if the requester initiates the request from a specified IP addresses, or one that allows the user to use SQL only (disallowing other tasks) to access a table.

The command format of policy authorization is as follows:

```
GET POLICY;
-- Read the project policy.
PUT POLICY <policyFile>;
-- Set (overwrite) the project policy.
GET POLICY ON ROLE <roleName>;
-- Read the policy of a role in the project.
PUT POLICY <policyFile> ON ROLE <roleName>;
-- Set (overwrite) the policy of a role in the project.
```

> **Note** MaxCompute currently supports project policies and role policies. A project policy applies to all users of the project, while a role policy applies only to users to whom the role is assigned. You must specify a principal (user) for project policies, but you cannot specify a principal for role policies, because the role will be assigned to users.

An example of project policy authorization is as follows:

Scenario: Authorized user alice@aliyun.com can only submit a request before 23:59:59 2017-11-11 from an IP address in the subnet 10.32.180.0-23, and can only perform the CreateInstance, CreateTable, and List operations in test_project. No tables in test_project can be dropped.

The policy is as follows:

```
{
"Version": "1", "Statement": [{
"Effect":"Allow", "Principal":"ALIYUN$alice@aliyun.com",
"Action":["odps:CreateTable","odps:CreateInstance","odps:List"],
"Resource":"acs:odps:*:projects/test_project",
"Condition":{ "DateLessThan": {
"acs:CurrentTime":"2017-11-11T23:59:59Z"
},
"IpAddress": { "acs:SourceIp":"10.32.180.0/23"
}
}
},
{
"Effect":"Deny", "Principal":"ALIYUN$alice@aliyun.com", "Action":"odps:Drop", "Resource":"acs:odps:*:p
rojects/test_project/tables/*"
}]
}
```json
```
```

```json
{
"Version": "1", "Statement": [{
"Effect":"Allow", "Principal":"ALIYUN$alice@aliyun.com",
"Action":["odps:CreateTable","odps:CreateInstance","odps:List"],
"Resource":"acs:odps:*:projects/test_project",
"Condition":{ "DateLessThan": {
"acs:CurrentTime":"2017-11-11T23:59:59Z"
},
"IpAddress": { "acs:SourceIp":"10.32.180.0/23"
}
}
},
{
"Effect":"Deny", "Principal":"ALIYUN$alice@aliyun.com",
"Action":"odps:Drop",
"Resource":"acs:odps:*:projects/test_project/tables/*"
}]
}
```

```
{
"Version": "1", "Statement": [{
"Effect":"Allow", "Principal":"ALIYUN$alice@aliyun.com",
"Action":["odps:CreateTable","odps:CreateInstance","odps:List"],
"Resource":"acs:odps:*:projects/test_project",
"Condition":{ "DateLessThan": {
"acs:CurrentTime":"2017-11-11T23:59:59Z"
},
"IpAddress": { "acs:SourceIp":"10.32.180.0/23"
}
}
},
{
"Effect":"Deny", "Principal":"ALIYUN$alice@aliyun.com",
"Action":"odps:Drop",
"Resource":"acs:odps:*:projects/test_project/tables/*"
}]
}
```

Note

- Currently, only role policies and project policies are supported, and user policies are not.
- Every policy only supports one policy file. Since put policies override existing policies, you must follow the sequence below to modify a policy:
  i. Get Policy.
  ii. Merge policy statements.
  iii. Put policies.

1.20.8.2. Policy-related terms

Permission is a basic concept of access control. When a requester wants to take an action on a resource, the action may be allowed or denied, based on the permission settings. A statement refers to the formal description of a single permission, and policy refers to a set of statements.

An access policy comprises the following access control elements: principal, action, resource, access restriction, and effect. These elements are briefly described below.

Principal

A principal of an object is a user or group to which permissions are assigned in an access policy. For example, the access policy allows Michael to perform the CreateObject action on the resource SampleBucket before December 31, 2017. Michael is the principal of the object.

Action

An action is an activity that the principal has permission to perform. For example, the access policy allows Michael to perform the CreateObject action on the resource SampleBucket before December 31, 2017. Therefore, CreateObject is an action of the access policy.

Resource

Resource is the object a principal requests access to. For example, the access policy allows Michael to perform the CreateObject action on the resource SampleBucket before December 31, 2017. SampleBucket is a resource of the access policy.

Access restriction

Access restriction is the prerequisite for the permission to take effect. For example, the access policy allows Michael to perform the CreateObject action on resource SampleBucket before December 31, 2017. The access restriction is before December 31, 2017.

Effect

Authorization effect has two options: Allow (action) or deny (action). In general, deny actions are generally more efficient and are checked first during permission checks.

Notice The deny action and revoking pemission are completely different concepts. The latter usually revokes permissions for both allow action and deny action. For example, a traditional database supports the revoke and revoke deny actions.

1.20.8.3. Access policy structure

1.20.8.3.1. Overview

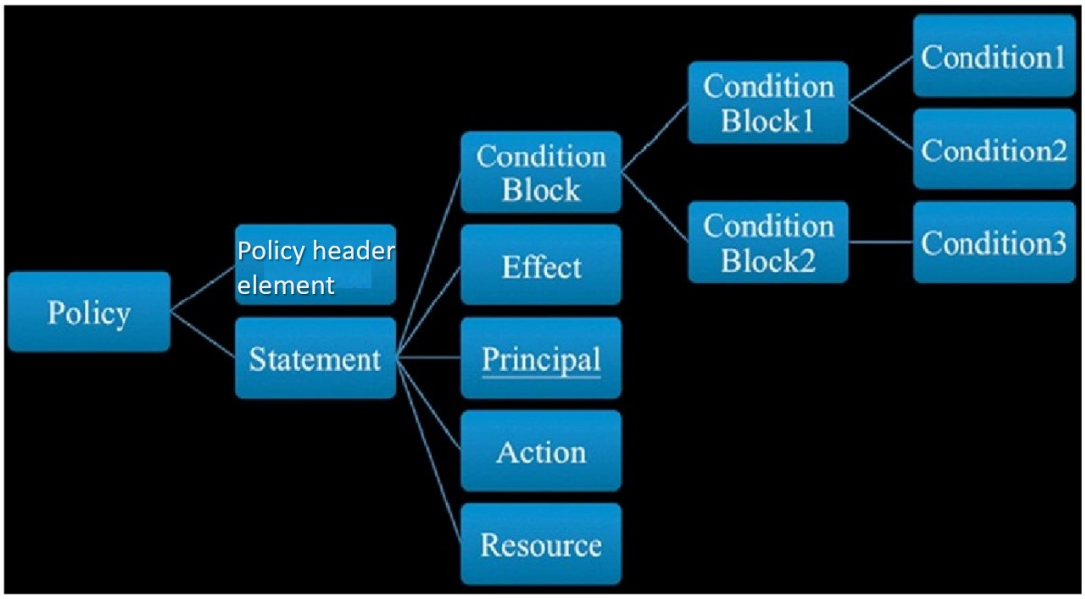
The following figure shows the structure of an access policy. A policy consists of the following parts:

- An optional policy header
- One or more statements

The policy header is optional and includes the policy version. The policy body is a set of statements.

The following figure shows the structure of a policy.

Policy structure



1.20.8.3.2. Authorization statement structure

An authorization statement includes the following entries:

- Effect: indicates the permission type of this statement. The value can be either Allow or Deny.
- Principal: If a policy is bound to a user or role in the authorization process, such as the role policy of MaxCompute, you cannot appoint a principal. If a policy is bound to a project or objects of the project in the authorization process, such as the project policy of MaxCompute, you must specify a principal.
- Action: indicates the authorization operation. It can be one or more operation names, and supports the asterisk (*) and question mark (?) wildcard characters. The asterisk (*) matches any number of characters, and the question mark (?) matches a single character. For example, Action = * indicates all operations.
- Resource: indicates the authorization object. It can be one or more object names, and supports the asterisk (*) and question mark (?) wildcard characters. The asterisk (*) matches any number of characters, and the question mark (?) matches a single character. For example, Resource = * indicates all objects.
- Condition block: indicates the conditions that must be met for the permission described by this authorization statement to take effect. See the next topic for the structure of the condition block.

1.20.8.3.3. Conditional block structure

A condition block consists of one or more condition clauses. A condition clause consists of an action type, keyword, and condition value. The action types and keywords will be described in detail in the subsequent sections.

Whether a condition block is satisfied is determined as follows:

- A conditional keyword can correspond to one or more values. If the conditional keyword value is equal to one of the corresponding values, the condition is satisfied.
- A condition clause of a conditional operation type is satisfied if all conditional keywords in the clause are satisfied.
- A condition block is satisfied only if all of its condition clauses are satisfied.

1.20.8.3.4. Conditional action type

The following action types are supported: string, number, date, Boolean, and IP address. The methods supported by each conditional operation type are as follows:

String:

```
StringEquals
StringNotEquals
StringEqualsIgnoreCase
StringNotEqualsIgnoreCase
StringLike
StringNotLike
```

Numeric:

```
NumericEquals
NumericEquals
NumericLessThan
NumericLessThanEquals
NumericGreaterThan
NumericGreaterThanEquals
```

Date and time:

```
DateEquals
DateNotEquals
DateLessThan
DateLessThanEquals
DateGreaterThan
DateGreaterThanEquals
```

Boolean:

```
Bool
```

IP address:

```
IpAddress NotIpAddress
```

1.20.8.3.5. Conditional keywords

MaxCompute supports the conditional keywords reserved by Alibaba Cloud Service (ACS). The following table describes these conditional keywords.

Conditional keywords

Conditional keywords reserved by ACS	Type	Description
acs:CurrentTime	Date and time	The time when the Web server receives a request. It is based on the ISO 8601 standard, for example, 2017-11-11T23:59:59Z.
acs:SecureTransport	Boolean	Whether the request is sent over a secure channel, such as an HTTPS channel.
acs:SourceIp	IP address	The IP address of the client that sent the request.
acs:UserAgent	String	The UserAgent of the client that sent the request.
acs:Referer	String	The HTTP referer that sent the request.

Note acs:SourceIp refers to the remote_ip of the HTTP connection, not the (leftmost) client IP address in the x-forwarded-for HTTP header field. For example, if 10.230.205.105 is a LAN IP address, acs:SourceIp is the egress gateway IP address of this LAN. If the network egress uses a proxy server, acs:SourceIp is the IP address of the proxy server. If the request traverses across multiple proxy servers, acs:SourceIp is the IP address of the final proxy server. The value of acs:SourceIp may vary depending on the rules configured on the proxy server.

1.20.8.4. Access policy norm

1.20.8.4.1. Principal naming convention

The principal is the request sender. Currently, only an Alibaba Cloud account, domain account, or Taobao account is accepted as a principal. A cloud account can be represented by ID or DisplayName.

Example:

```
"Principal": "43274"
"Principal": "ALIYUN$bob@aliyun.com"
"Principal": ["ALIYUN$bob@aliyun.com","ALIYUN$jack@aliyun.com", "TAOBAO$alice"]
```

1.20.8.4.2. Resource naming convention

The following naming conventions are used for MaxCompute resources.

```
acs:<service-name>:<namespace>:<relative-id>
```

The parameters are described as follows.

Parameters

Name	Description
acs	Retained resource header.
service-name	The name of an open cloud service, such as MaxCompute, OSS, and TableStore.
namespace	Naming space, used for resource isolation. If a cloud account ID is used for resource isolation, the value can be the cloud account ID. If this option is not supported, use the asterisk (*) wildcard character instead.
relative-id	Indicates the service-related resource. Its meaning depends on specific services. This part of the format description supports a tree structure similar to the file path. Using MaxCompute as an example, the format of relative-id is: `projects/<project_name>/<object_type>/<object_name>`

Some MaxCompute resource naming examples.

Naming examples

Item	Description
*	All objects in the project.
projects/prj1/tables/t1	Table t1 of Project prj1.
projects/prj1/instances/*	All instances of Project prj1.
projects/prj1/tables/*	All tables of Project prj1.
projects/prj1/tables/taobao*	All tables of Project prj1 whose names start with "taobao".

1.20.8.4.3. Action naming

Action naming conventions are as follows:

```
<service-name>:<action-name>
```

Description:

- service-name: name of an open cloud service, for example, maxcompute, oss, and table store.
- action-name: name of service-related action APIs.

The following table lists MaxCompute action naming examples.

MaxCompute action naming examples

Naming example	Description
*	All actions.
odps:*	All MaxCompute actions.
odps:CreateTable	The CreateTable action of MaxCompute.
odps:Create*	All MaxCompute actions whose names start with "Create".

1.20.8.4.4. Condition keys naming

The naming format for condition keys retained by the open cloud service is:

```
acs:<condition-key>
```

Description:

condition-key: ACS reservs 5 types of condition keys, which are accessible for all open services. They are: acs:CurrentTime, acs:SecureTransport, acs:SourceIp, acs:UserAgent, acs:Referer.

The naming format for condition keys related to the specific service is:

```
<service-name>:<condition-key>
```

Description:

Condition-key: service-defined condition key.

1.20.8.4.5. Access policy example

Policy example:

```
{
"Version": "1",
"Statement": [{
"Effect":"Allow",
"Principal":"ALIYUN$alice@aliyun.com",
"Action":["odps:CreateTable","odps:CreateInstance","odps:List"],
"Resource":"acs:odps:*:projects/prj1",
"Condition":{ "DateLessThan": {
"acs:CurrentTime":"2017-11-11T23:59:59Z"
},
"IpAddress": { "acs:SourceIp":"10.32.180.0/23"
}
}
},
{
"Effect":"Deny", "Principal":"ALIYUN$alice@aliyun.com",
"Action":"odps:Drop",
"Resource":"acs:odps:*:projects/prj1/tables/*"
}]
}
```

Note The authorized user (alice@aliyun.com) can only submit a request from subnet 10.32.180.0/23 before 2017-11-11T23:59:59Z. The user can only perform the CreateInstance, CreateTable, and List operations on the prj1 project. The user cannot delete tables from prj1.

1.20.8.5. Differences between policy authorization and ACL authorization

ACL authorization:

- Use ACL authorization to grant or revoke permissions when both the grantee (such as a user or role) and the object (such as a table) exist. Like the security feature of Oracle authorization, this avoids the security risk out of dropping and recreating an object with the same name.
- When dropping an object, all authorizations related to the object are automatically revoked.
- It only supports allow (whitelist) authorization, and does not support deny (blacklist) authorization.
- Use the classic Grant/Revoke commands for authorization. The command is simple and not prone to mistakes. Conditional authorization is not supported.
- This method is suitable for simple scenarios where condition or deny is not needed for authorization, and only the existing objects need to be authorized.

Policy authorization:

- Use policy authorization to grant or revoke permissions when the grantee or object is not available.

The Object parameter supports wildcard "". For example, *projects/tbproj/tables/taobao* matches all tables whose names start with taobao in project tbproj. Like the features of MySQL authorization, policy authorization allows a non-existent object to be authorized, so the authorizer must consider the security risks of dropping and recreating an object with the same name.

- When dropping an object, the policy authorization related to this object is not deleted.
- Both allow (whitelist) authorization and deny (blacklist) authorization are supported. If allow and deny conflict, the deny action takes priority.
- Conditional authorization is supported. The authorizer can enforce 20 conditions on allow or deny authorization. For example, these conditions can be used to limit access to IP addresses within a subnet, and allow access before 23:59:59 on November 11, 2017.
- This method is suitable for relatively complicated scenarios where conditional authorization and deny action are needed and non-existent objects need to be authorized.
- Using policy authorization is more complicated than ACL authorization, but provides more flexibility.

1.20.8.6. Application limits

Application limits

Item	Limit	Description
ACCESS_POLICY_SIZE_LIMIT	32 KB	The maximum size of AccessPolicy.
USER_NUMBER_LIMIT_IN_ON E_PROJECT	1,000	The maximum number of users in a project.
ROLE_NUMBER_LIMIT_IN_ON E_PROJECT	500	The maximum number of roles in a project.
ROLE_NAME_LENGTH_LIMIT	64	The maximum number of characters in a role name.
SECURITY_COMMENT_SIZE_L IMIT	1 KB	The maximum size of a security comment.
PACKAGE_NAME_LENGTH_LI MIT	128	The maximum number of characters in a package name.
ALLOW_PROJECT_NUMBER_LIMIT_IN_ONE _PACKAGE	1024	The maximum number of projects installed in a package.
RESOURCE_NUMBER_LIMIT_IN_ONE_PACK AGE	256	The maximum number of resources in a package.
PACKAGE_NUMBER_LIMIT_IN_ONE_PROJEC T	512	The maximum number of packages that can be created in a project.
INSTALLED_PACKAGE_NUMB ER_LIMIT_IN_ONE_PROJECT	64	The maximum number of packages that can be installed in a project.

1.20.9. Collection of security statements

1.20.9.1. Project security configuration

Authentication

Authorization configuration statements

Statement	Description
show SecurityConfiguration	Displays the project security configuration.
set CheckPermissionUsingACL=true/false	Enables or disables ACL-based authorization.
set CheckPermissionUsingPolicy=true/fal se	Enables or disables policy-based authorization.
set ObjectCreatorHasAccessPermission=true/false	Allows or disallows an object creator to be granted the object access permission by default.
set ObjectCreatorHasGrantPermission=true/false	Allows or disallows an object creator to be granted the ACL-based authorization permission by default.

Data protection

Data protection statements

Statement	Description
set ProjectProtection=false	Disables project protection.
set ProjectProtection=true [with exception <policy>]	Enables project protection.
list TrustedProjects	Displays the list of trusted projects.
add TrustedProject <projectName>	Adds a project to trusted projects.
remove trustedproject <projectname>;	Removes a project from trusted projects.

1.20.9.2. Project permission management

User management

User management statements

Statement	Description
list users	Lists all added users.
add user <username>	Adds a user.
remove user <username>	Removes a user.

Role management

Role management statements

Statement	Description
list roles	Lists all created roles.
create role <rolename>	Creates a role.
drop role <rolename>	Deletes a role.
grant <rolelist> to <username>	Revokes roles from a user.
revoke <rolelist> from <username>	Grants one or more roles to a user.

ACL-based authorization

ACL-based authorization statements

Statement	Description
grant <privList> on <objType> <objName> to user <username>	Authorizes a user.
grant <privList> on <objType> <objName> to role <rolename>	Authorizes a role.
revoke <privList> on <objType> <objName> from user <username>	Revokes permissions from a user.
revoke <privList> on <objType> <objName> from role <rolename>	Revokes permissions from a role.

Policy-based authorization

Policy-based authorization statements

Statement	Description
get policy	Displays policy settings at the project level.
put policy <policyFile>	Configures a policy at the project level.
get policy on role <roleName>	Displays the policy settings of a role.
put policy <policyFile> on role <roleName>	Configures a policy for a role.

Permission review

Permission review statements

Statement	Description
whoami	Displays information about the current user.
show grants [for <username>] [on type <objectType>]	Displays permissions and roles of a user.
show acl for <objectName> [on type <objectType>]	Displays the authorization information of an object.
describe role <roleName>	Displays the authorization and assignment information of a role.

1.20.9.3. Package-based resource sharing

Resource sharing

Resource sharing statements

Statement	Description
create package <pkgName>	Creates a package.
delete package <pkgName>	Deletes a package.
add <objType> <objName> to package<pkgName> [with privileges privs]	Adds resources that need to be shared to a package.
remove <objType> <objName> from package <pkgName>	Removes shared resources from a package.
allow project <prjName> to install package <pkgName> [using label <num>]	Allows a project to use a user package.
disallow project <prjName> to install package <pkgName>	Disables a project from using a user package.

Resource use

Resource use statements

Statement	Description
install package <pkgName>	Installs a package.
uninstall package <pkgName>	Uninstalls a package.

Package viewing

Package viewing statements

Statement	Description
show packages	Lists all created and installed packages.
describe package <pkgName>	Views details of a package.

1.21. Frequently-used tools

1.21.1. MaxCompute console

1.21.1.1. Usage notes

This topic provides usage notes for the MaxCompute client.

> **Notice**
>
> - Do not rely on the output data of the client in any development or planning processes, as the data format may change. The client output format may not be forward compatible. The command syntax and behavior vary according to versions.
> - The MaxCompute client is a Java program. It requires JRE to run. You need to download and install JRE 1.8 to use the MaxCompute client.

For more information about how to configure and use the client, see Quick start.

1.21.1.2. Install the client

This topic describes how to install the MaxCompute client.

1. Download the client package to your client computer.
2. Decompress the client package to a folder, where you can see the following folders:

```
bin/
conf/
lib/
plugins/
```

3. Edit the following parameters in the odps_config.ini file in the conf folder:

```
project_name=
access_id=**********
access_key=**********
end_point= <MaxCompute service address>
```

> Note
>
> - Set access_id and access_key to the AccessKey ID and AccessKey Secret of your cloud account.
> - If you frequently use a project, enter the project name after project_name=. Then, you do not need to run the `use project_name;` command each time you log on to the client.

4. After the modifications, run the odps file in the bin directory (*./bin/odpscmd* in a Linux system or *./bin/odpscmd.bat* in a Windows system). Then, you are ready to run SQL statements. An example is as follows:

```
create table tbl1(id bigint);
insert overwrite table tbl1 select count(*) from tbl1;
select 'welcome to MaxCompute!' from tbl1;
```

1.21.1.3. Configuration description

This topic describes some configurations and corresponding parameters of the MaxCompute client.

Help

Run the following command to view the help information about the client:

```
odps@ >./bin/odpscmd -h;
```

> Note You can also enter `h;` or `help;` (case insensitive) in the interaction mode.

Startup parameters

Run the following command to specify a number of startup parameters:

```
Usage: odpscmd [OPTION]...
where options include:
  --help (-h)for help
  --project= use project
  --endpoint= set endpoint
  -u  -p  user name and password
  -k  will skip beginning queries and start from specified position
  -r  set retry times
  -f <"file_path;"> execute command in file
  -e <"command;[command;]..."> execute command, include sql command
  -C will display job counters
```

Example: (-f is used as an example)

1. Prepare a local script file named script.txt. The file is stored in D:/. Its contents are as follows:

```
DROP TABLE IF EXISTS test_table_mj;
CREATE TABLE test_table_mj (id string, name string);
DROP TABLE test_table_mj;
```

2. Run the following command:

```
odpscmd\bin>odpscmd -f d:/script.txt;
```

3. The command output is as follows:

```
ID = 20170528122432906gux77io3
Log view:
http://webconsole.odps.aliyun-inc.com:8080/logview/?h=http://service-corp.odps.aliyun- inc.com/api&
podps_public_dev&i2017052 8122432906gux77io3&tokenRnlrSzJoL242YW43dFFIc1dmb1ZWZzFxQ1RFP
SxPRFBTX09CTzoxMDcwMDI1NjI3ODA1 NjI5LDE0MzM0MjA2NzMseyJTdGF0ZW1lbnQiOlt7IkFjdGlvbiI6Wy
JvZHBzOlJlYWQiXSwiRWZmZWN0IjoiQWxsb3ciLCJSZXNvdXJjZSI6WyJhY3M6b2RwczoqOnB yb2plY3RzL
29kcHNfcHVibGljX2Rld i9pbnN0YW5jZXMvMjAxNTA1MjgxMjI0MzI5MDZndXg3N2lvMyJdfV0sIlZlcnNpb24i
OiIxIn0=
OK
ID = 20170528122439318gcmkk6u1
Log view:
http://webconsole.odps.aliyun-inc.com:8080/logview/?h=http://service-corp.odps.aliyun- inc.com/api&
podps_public_dev&i2017052 8122439318gcmkk6u1&tokendSt0RXdlV0M5YjZET2I1MnJuUFkzWDN1aWp
zPSxPRFBTX09CTzoxMDcwMDI1NjI3ODA1NjI5LDE0MzM0MjA2ODAseyJTdGF0ZW1lbnQiOlt7IkFjdGlvbiI6
WyJvZHBzOlJlYWQiXSwiRWZmZWN0IjoiQWxsb3ciLCJSZXNvdXJjZSI6WyJhY3M6b2RwczoqOnB yb2plY3
RzL29kcHNfcHVibGljX2Rld i9pbnN0YW5jZXMvMjAxNTA1MjgxMjI0MzkzMThnY21razZ1MSJdfV0sIlZlcnNpb
24iOiIxIn0=
OK
ID = 20170528122440389g98cmlmf
Log view:
http://webconsole.odps.aliyun-inc.com:8080/logview/?h=http://service-corp.odps.aliyun- inc.com/api&
podps_public_dev&i2017052 8122440389g98cmlmf&tokenNWlwL0EvQThxUXhzcTRERDc5NFg0b2IxZ3Q
wPSxPRFBTX09CTzoxMDcwMDI1NjI3OD A1NjI5LDE0MzM0MjA2ODAseyJTdGF0ZW1lbnQiOlt7IkFjdGlvbiI6
WyJvZHBzOlJlYWQiXSwiRWZmZWN0IjoiQWxsb3ciLCJSZXNvdXJjZSI6WyJhY3M6b2RwczoqOnB yb2plY3
RzL29kcHNfcHVibGljX2Rld i9pbnN0YW5jZXMvMjAxNTA1MjgxMjI0NDAzODlnOThjbWxtZiJdfV0sIlZlcnNpb2
4iOiIxIn0=
OK
```

Interactive mode

Directly run the client, and you will enter the interaction mode. The following information is displayed:

```
[admin: ~]$odpscmd
Aliyun ODPS Command Line Tool
Version 1.0
@Copyright 2012 Alibaba Cloud Computing Co., Ltd. All rights reserved.
XXX@ XXX> INSERT OVERWRITE TABLE DUAL SELECT * FROM DUAL;
```

> **Note** The first XXX indicates the identifier of MaxCompute, and the second XXX indicates the project to which you belong. Enter a command at the cursor (terminated by a semicolon), and press Enter to run it.

Command output

The output of a SQL statement is in either HumanReadable (default) or MachineReadable format. If you use the -M parameter when running odpscmd, the output format is CSV.

> **Note** This function currently applies only to SELECT and READ statements, and takes effect when reading data.

Continue run

When you run odpscmd in -e or -f mode and want to start with an intermediate statement among a few statements, you can use the -k parameter. This parameter indicates that the execution starts from the specified statement while the preceding statements are skipped. If the parameter value is equal to or smaller than 0, execution starts from the first statement. A statement terminated by a semi-colon is considered a valid statement. At runtime, the process indicates the specific statement that is running successfully or fails.

For example, the */tmp/dual.sql* file includes the following three SQL statements:

```
drop table dual;
create table dual (dummy string);
insert overwrite table dual select count(*) from dual;
```

You can run the following command to ignore the first two statements:

```
odpscmd–k 3 –f dual.sql
```

Obtain information about the current logon user

Run the following command to obtain the cloud account of the current logon user and the endpoint that is used:

```
whoami
```

Example:

```
odps@ hiveut>whoami; Name: odpstest@aliyun.com ID: 1090142773636588 End_Point: <MaxCompute servi
ce address> Project: lijunsecuritytest
```

Exit

Command syntax:

```
odps@ > quit;
```

or

```
q;
```

Configure a job priority

Command syntax:

```
Admin@ > ./bin/odpscmd --instance-priority=<PRIORITY>;
```

Configuration file: odps_config.ini

```
instance_priority=<PRIORITY>
```

> **Notice**
>
> - The value range of <PRIORITY > is 0-9, where 0 indicates the highest priority and 9 the lowest priority.
> - The priority setting in the configuration file applies to all instances submitted in CLT.
> - The priority value is 9 by default.

DryRun mode

In the DryRun mode, MaxCompute parses a SQL statement to check if the syntax is correct and generates an execution plan. MaxCompute does not submit a distributed job. Command syntax:

```
./bin/odpscmd -y
```

SQL reliability

If an exception is returned during the execution of SQL statements such as INSERT or CREATE TABLE AS, the client tries to automatically recover data and metadata to the pre-execution state based on known information.

- Data that is overwritten by INSERT OVERWRITE during QUERY execution is recovered from the temporary backup directory to the original directory.
- Data that is generated by INSERT INTO during QUERY execution is removed.
- Tables created during QUERY execution and dynamically generated partition information are removed.

If MaxCompute fails to recover data, it returns a specific error code. The error code alerts you that further attempts can make some data unrecoverable. The error code is as follows:

```
ODPS-
0110999: Critical! Internal error happened in commit operation and rollback failed, possible breach of atomi
city
```

1.21.2. Eclipse development plugin

1.21.2.1. Install Eclipse

This topic describes how to install the Eclipse plug-in.

Context

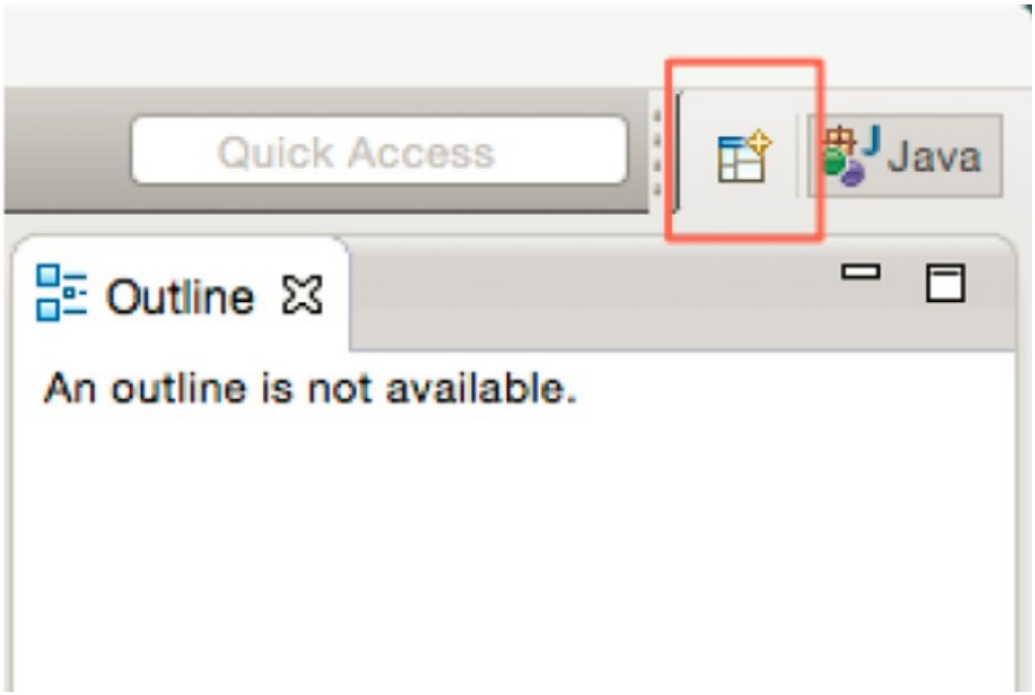
MaxCompute provides the Eclipse plug-in to help you easily use the Java SDKs for MapReduce and UDFs in your development work. This plug-in can simulate the running process of MapReduce or UDFs. It provides local debugging methods and simple template generation features. You can download the software package from Eclipse.

> **Note** Unlike the local running mode of MapReduce, the Eclipse plug-in cannot synchronize data with MaxCompute. You need to manually copy the required data to the warehouse directory of Eclipse.

Procedure

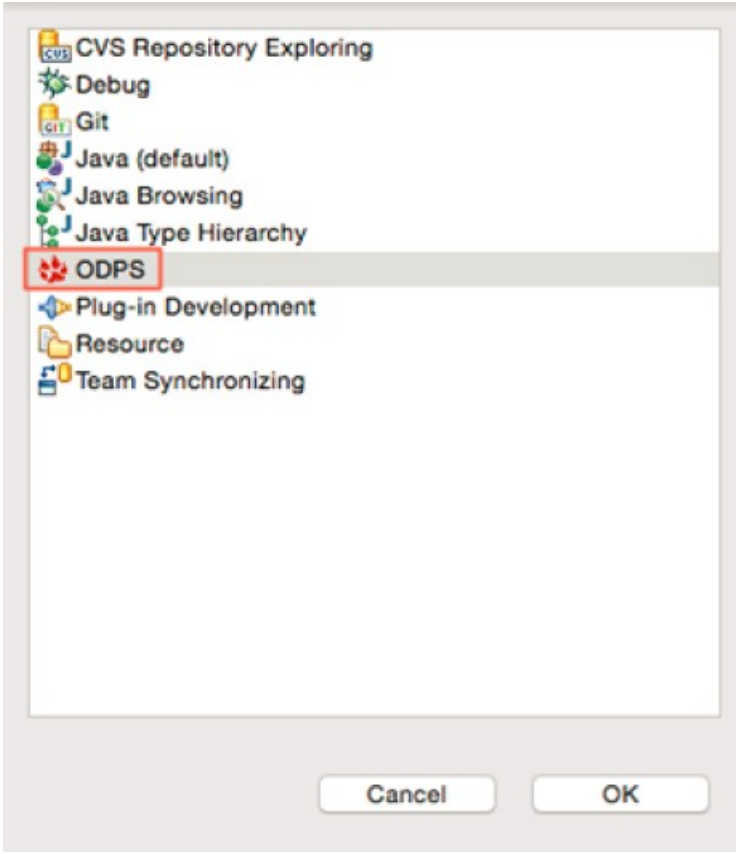
1. Decompress the Eclipse package to obtain the following JAR file: *odps-eclipse-plugin-bundle-0.15.0.jar*
2. Place the JAR file in the plugins folder under the Eclipse installation directory.
3. Start Eclipse and click the Open Perspective icon in the upper-right corner, as shown in the following figure.

   Eclipse installation 1



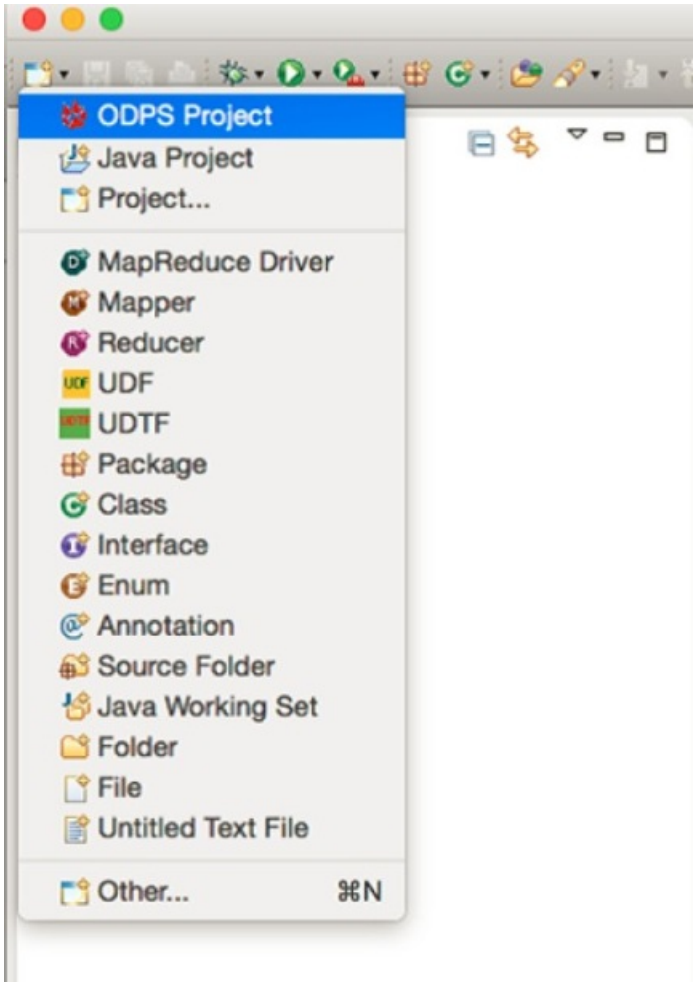
4. Click **ODPS** in the dialog box that appears, as shown in the following figure.

   Eclipse installation 2



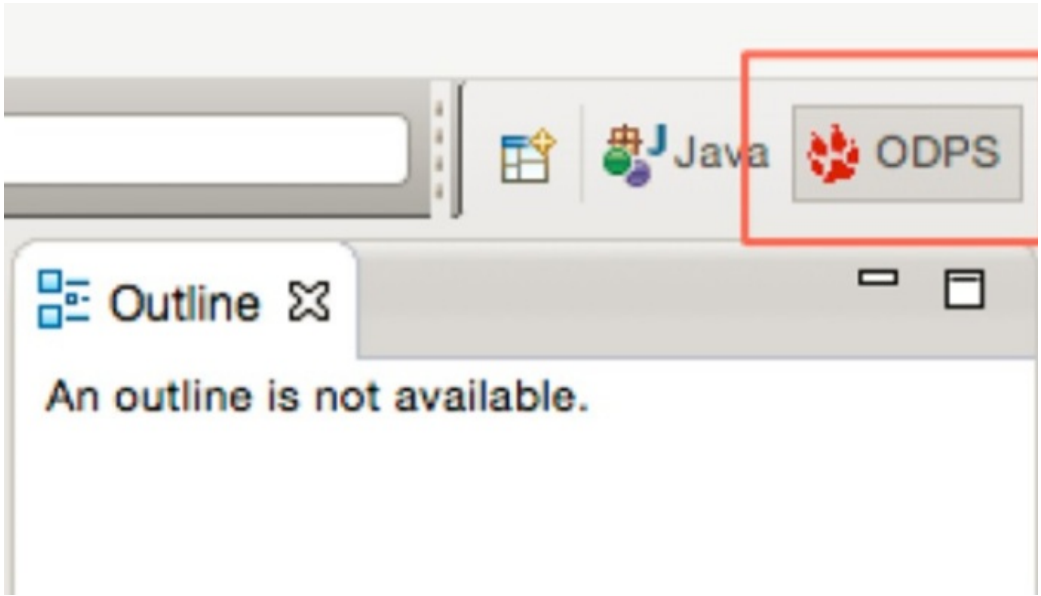
5. After you click **ODPS**, a navigation pane appears, as shown in the following figure.

   Eclipse installation 3



6. Click **ODPS Project** in the navigation pane and then click **OK**. The ODPS icon is displayed in the upper-right corner, as shown in the following figure. The icon indicates that the plug-in has taken effect.

Eclipse installation 4



1.21.2.2. Create a project

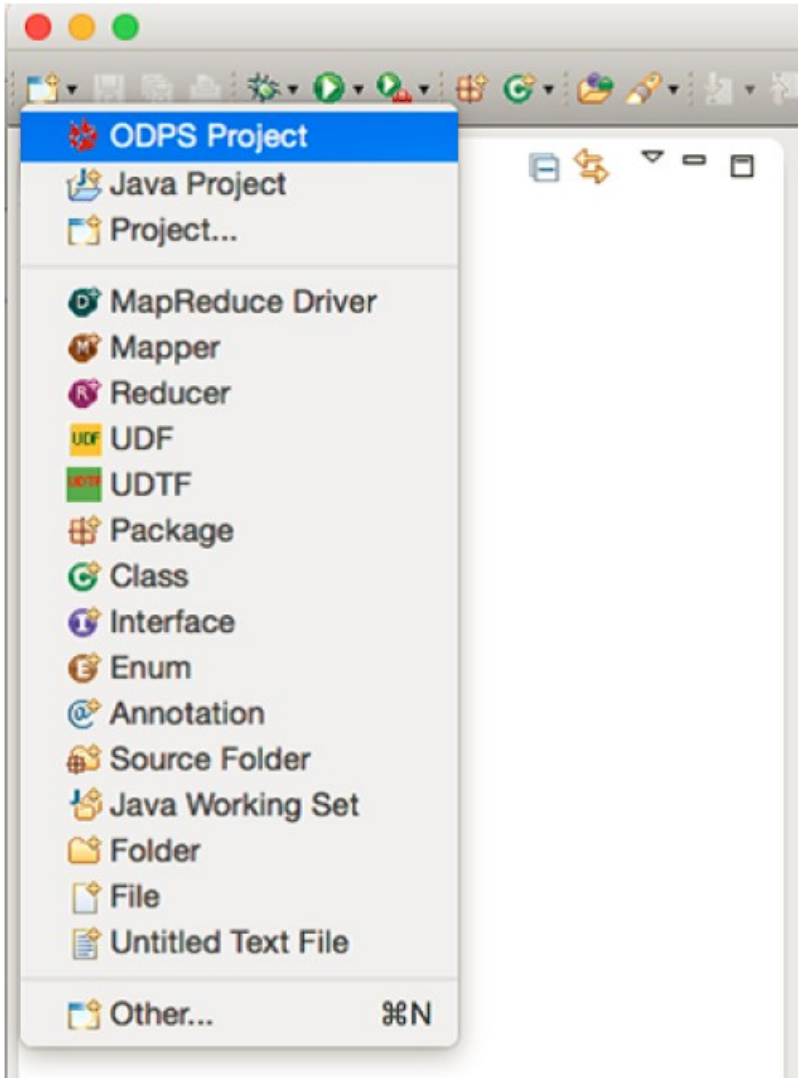
1.21.2.2.1. Method 1

This topic describes the first method to create a project in the Eclipse development plugin.

Procedure

1. Start Eclipse. Choose **File > New > Project > ODPS > ODPS Project** in the upper-left corner to create a project, as shown in the following figure.

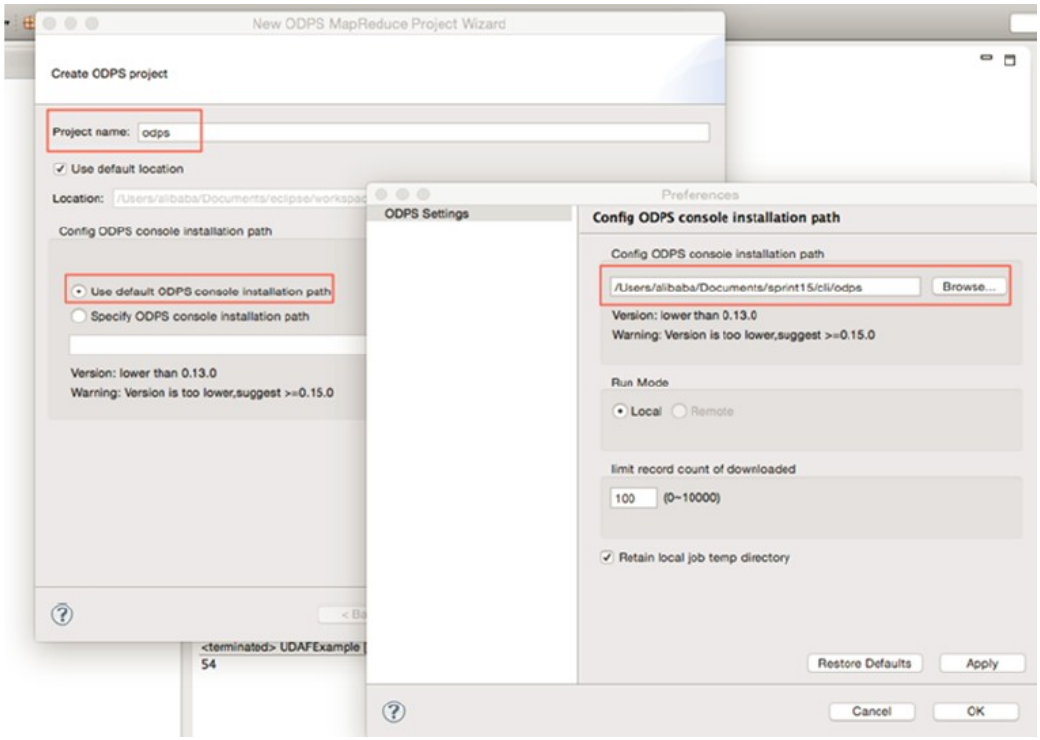
   Step 1

   > **Note** In this example, the project name is ODPS.

2. After the ODPS project is created, a dialog box is displayed, as shown in the following figure. Set Project name, select the path of the MaxCompute client, and then click **Finish**.

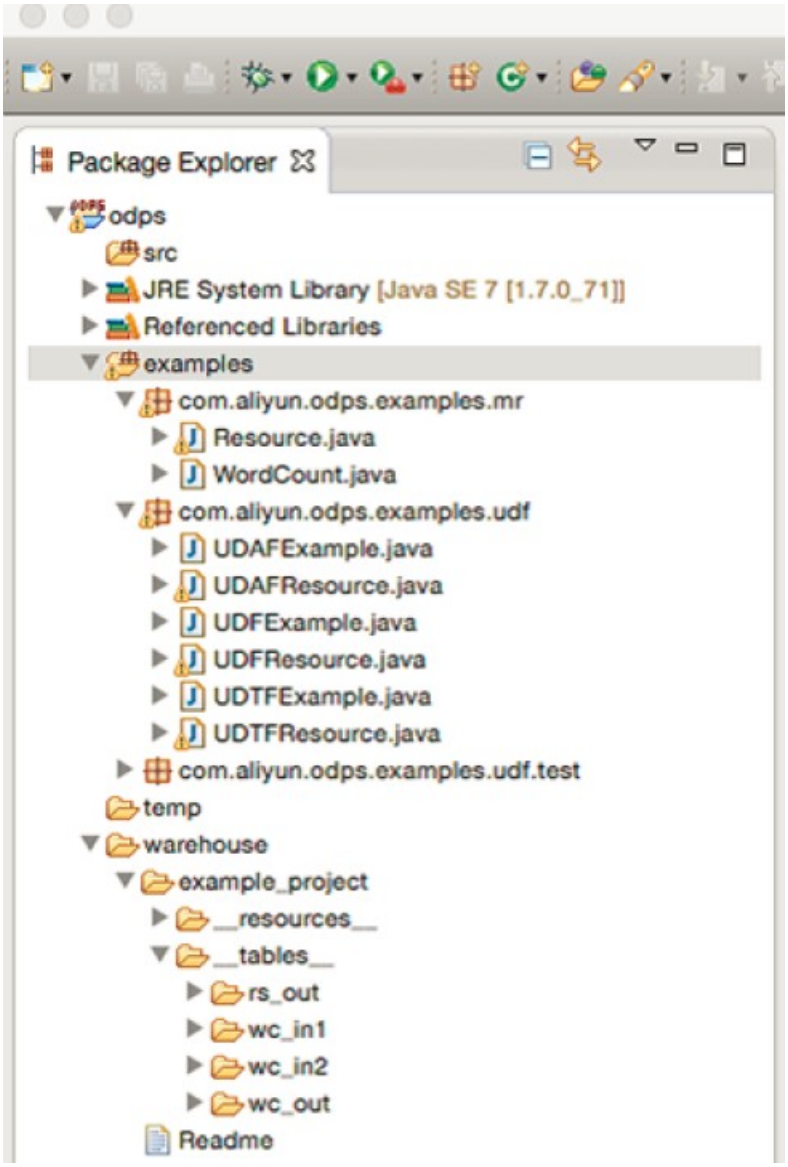
   Step 2



> **Note** The client must be installed in advance.

3. After creating a project, you can see the directory structure on the left-side Package Explorer pane, as shown in the following figure.

   Step 3



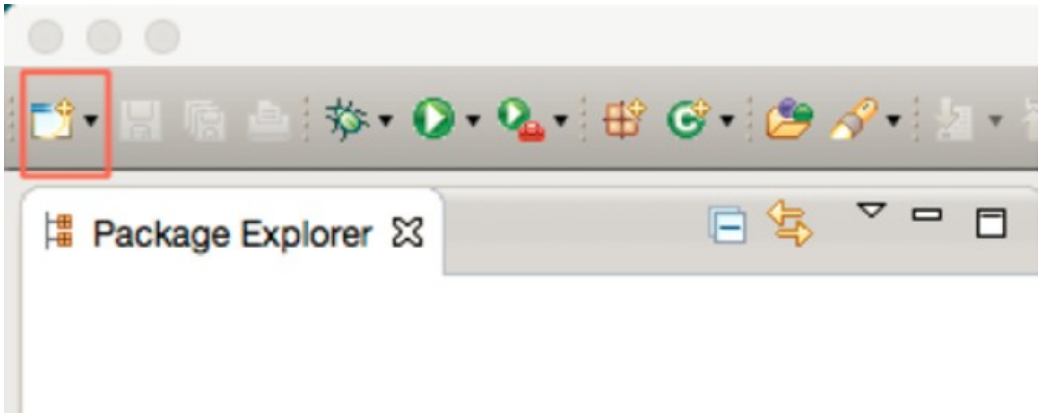
1.21.2.2.2. Method 2

This topic describes the second method to create a project in the Eclipse development plugin.

Procedure

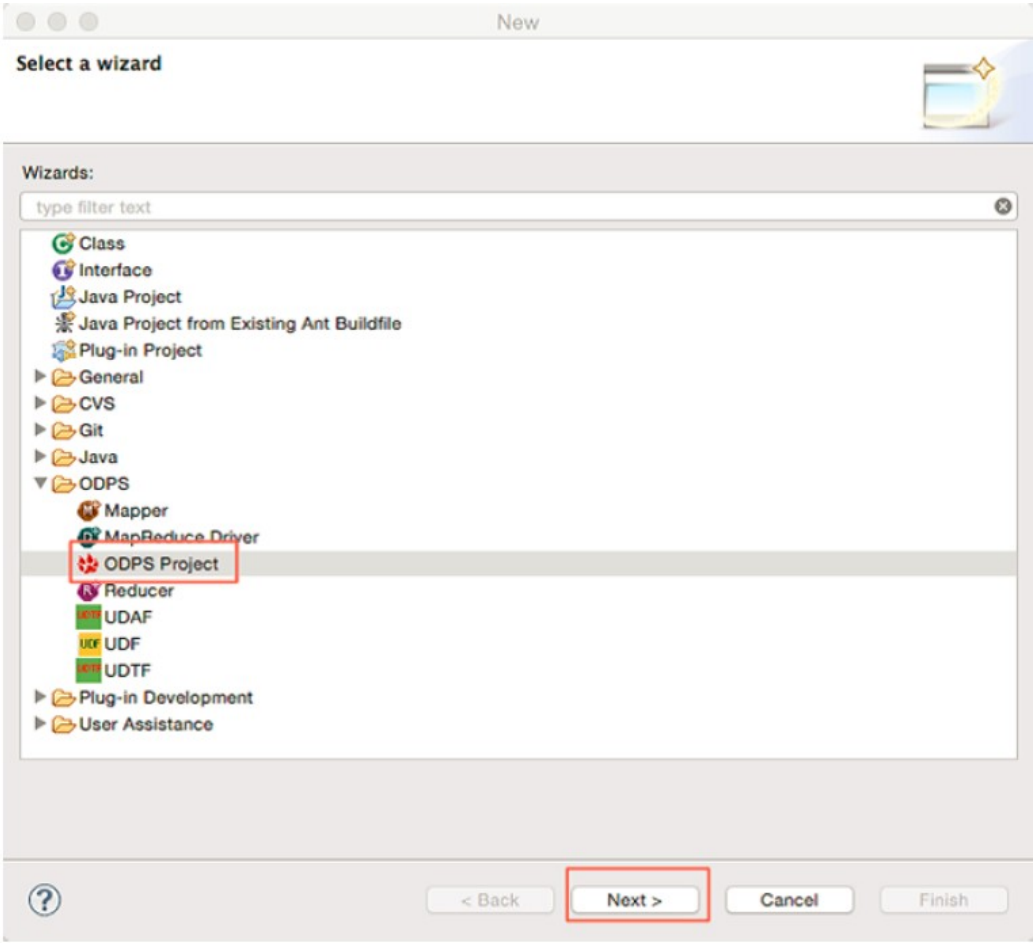
1. Start Eclipse. Click **New** in the upper-left corner, as shown in the following figure.

   Step 1



2. In the dialog box that appears, select **ODPS Project** and click **Next**, as shown in the following figure.

   Step 2



> **Note** In this example, the project name is ODPS.

3. The subsequent steps are the same as those in method 1. After installing the Eclipse plugin, you can use it to compile MapReduce or UDF programs.

> **Note** For a MapReduce running example, see MapReduce running example. For a UDF development and running example, see UDF development and running example.

1.21.2.3. MapReduce running example

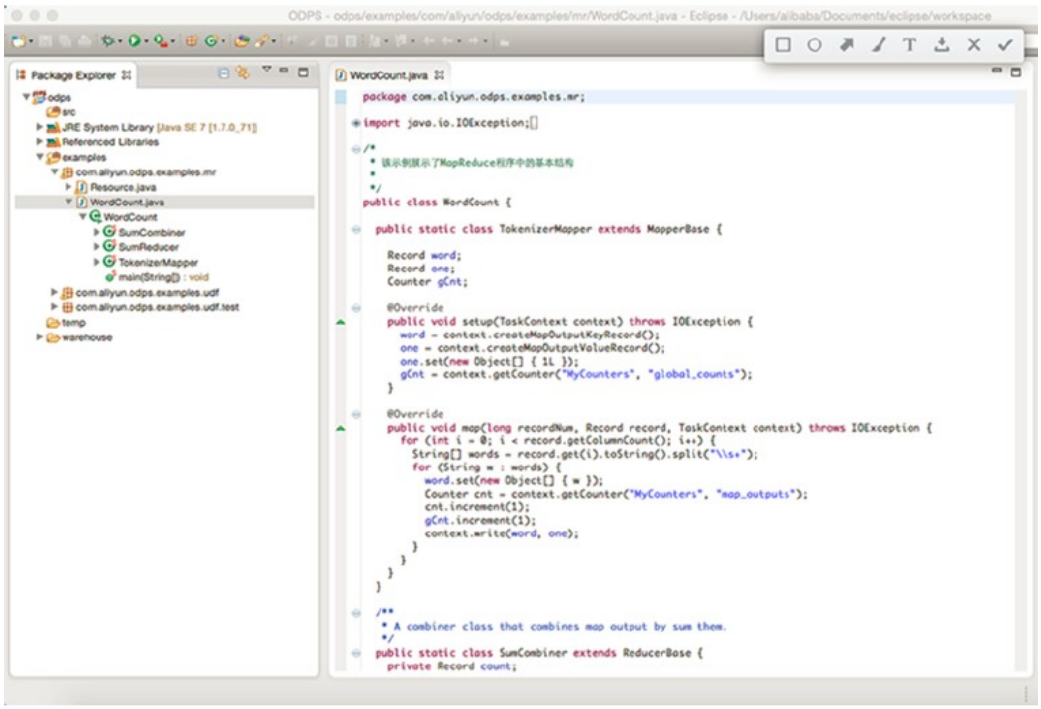
1.21.2.3.1. Quickly run a WordCount example

This topic describes how to use MapReduce to quickly run a WordCount example in the Eclipse plugin.

Procedure

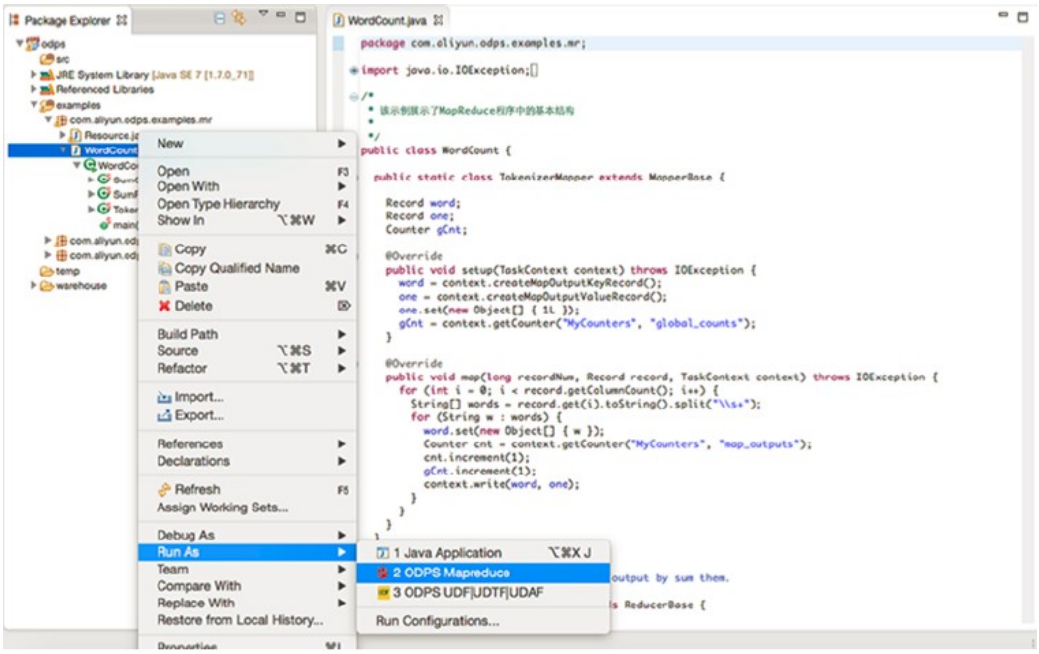
1. Select a WordCount example in MaxCompute, as shown in the following figure.

   WordCount example

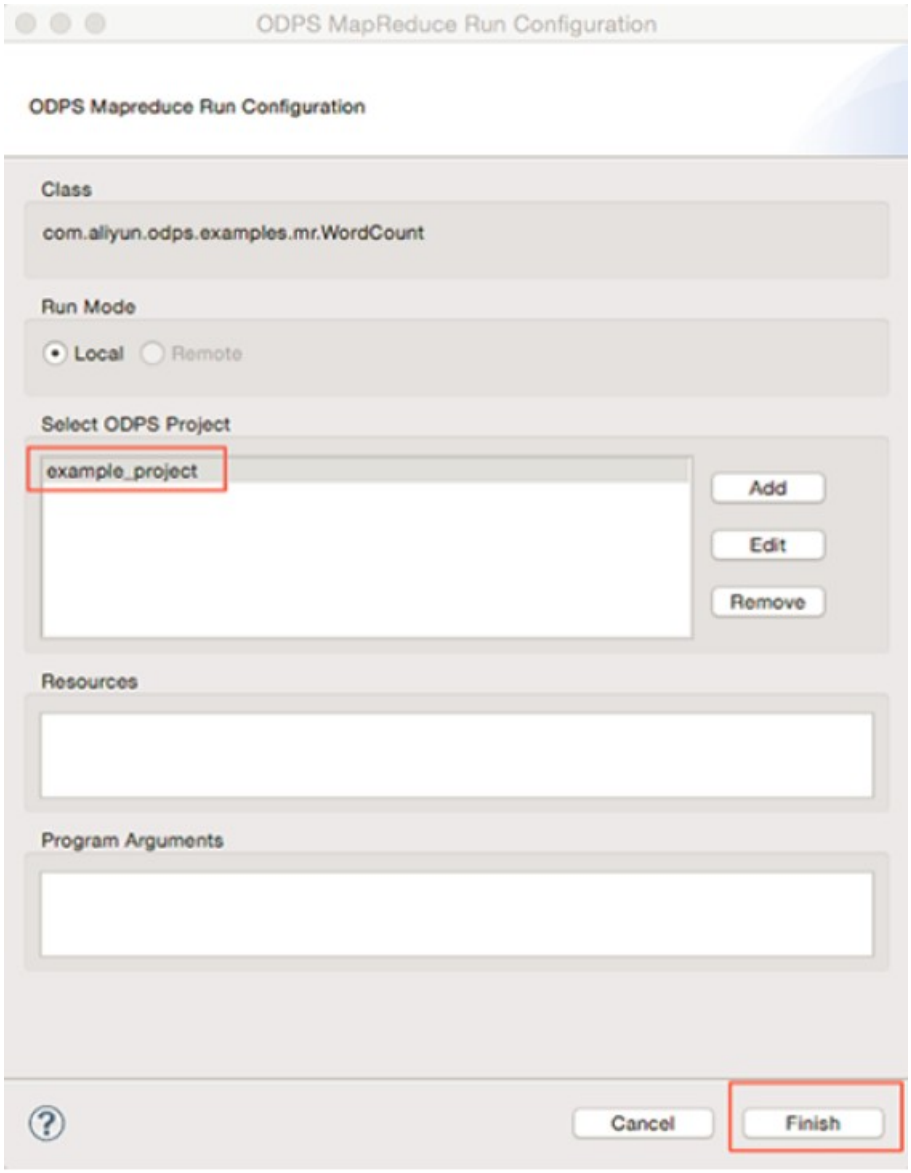
2. Right-click **WordCount.java** and choose **Run As**>**ODPS MapReduce** from the shortcut menu, as shown in the following figure.

   Run the WordCount example



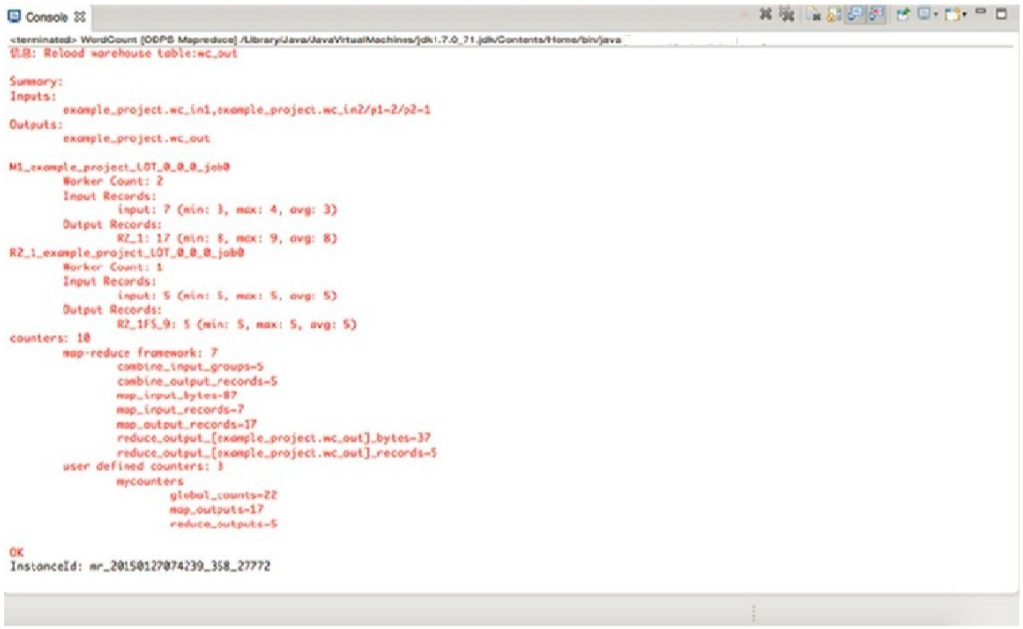
3. In the dialog box that appears, select **example_project** and click **OK**, as shown in the following figure.

   Run the WordCount example



4. The results of the operation are displayed after the operation is executed, as shown in the following figure.

   Execution result of the WordCount example



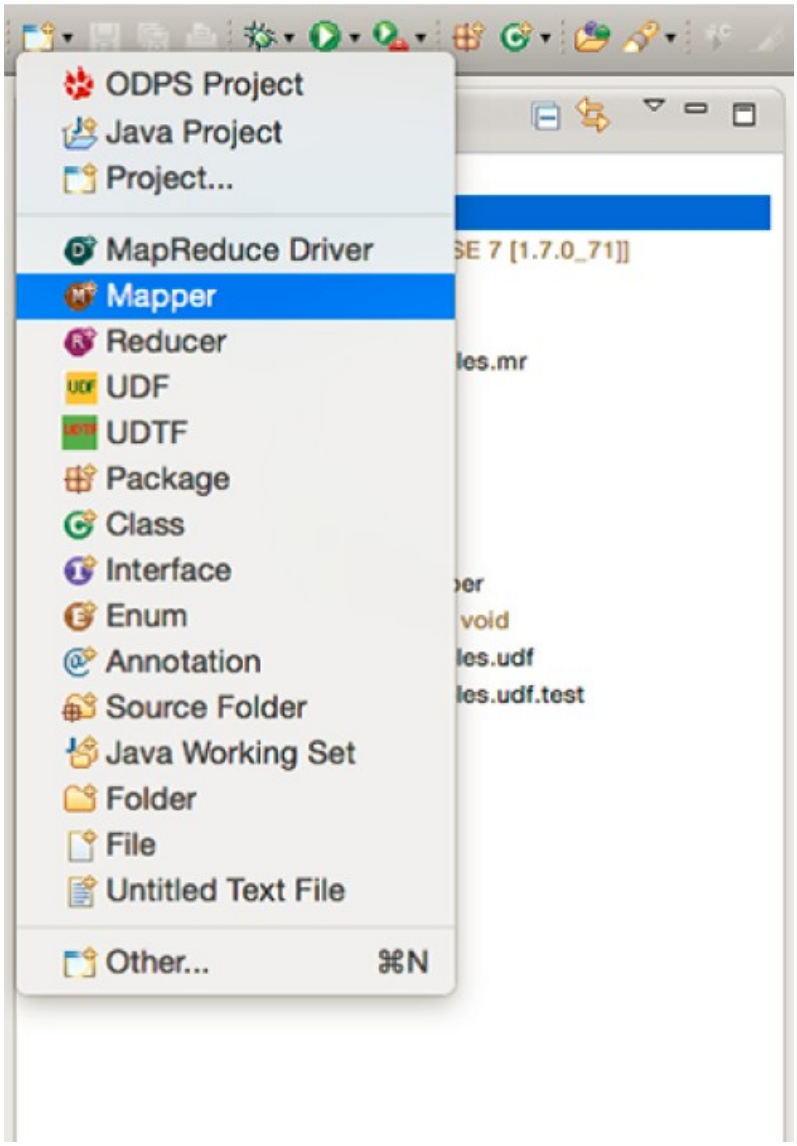
1.21.2.3.2. Run a custom MapReduce program

This topic provides an example on how to run a custom MapReduce program in the Eclipse plugin.

Procedure

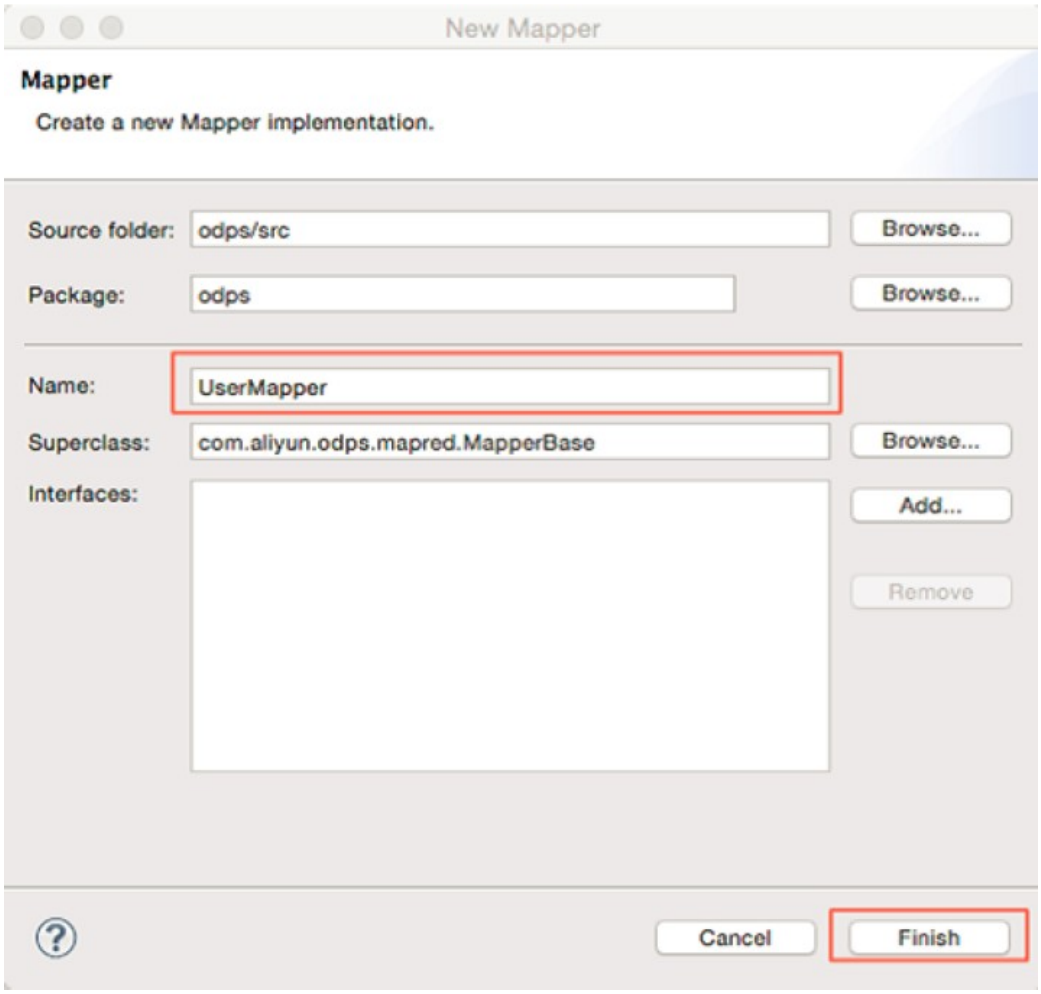
1. In Eclipse, right-click the **src** directory, and choose **New > Mapper** from the shortcut menu, as shown in the following figure.

   Step 1



2. Select Mapper. A dialog box is displayed, as shown in the following figure. Enter the name of the Mapper class, and click Finish.

   Step 2

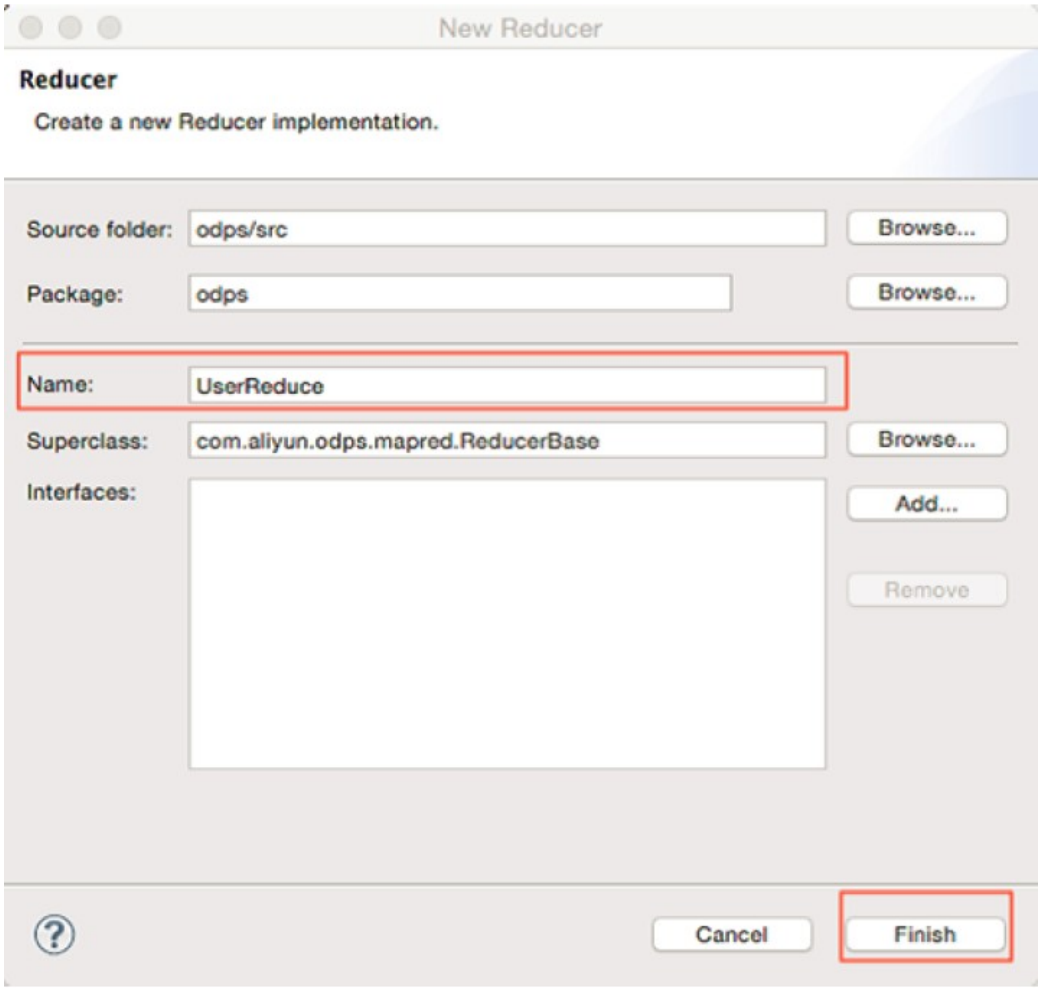


3. On the left-side Package Explorer, the UserReducer.java file is generated in the src directory. The file contains a Mapper class template. The package name is odps by default. The template content is as follows.

```
package odps;
import java.io.IOException;
import com.aliyun.odps.counter.Counter; import com.aliyun.odps.data.Record;
import com.aliyun.odps.mapred.MapperBase;
public class UserMapper extends MapperBase {
Record word; Record one; Counter gCnt;
@Override
public void setup(TaskContext context) throws IOException {
word = context.createMapOutputKeyRecord(); one = context.createMapOutputValueRecord(); one.set(
new Object[] { 1L });
gCnt = context.getCounter("MyCounters", "global_counts");
}
@Override
public void map(long recordNum, Record record, TaskContext context) throws IOException {
for (int i = 0; i < record.getColumnCount(); i++) { String[] words = record.get(i).toString().split("\\s+"); for
(String w : words) {
word.set(new Object[] { w });
Counter cnt = context.getCounter("MyCounters", "map_outputs"); cnt.increment(1);
gCnt.increment(1); context.write(word, one);
}
}
}
@Override
public void cleanup(TaskContext context) throws IOException {
}
}
```

4. In Eclipse, right-click the **src** directory, and choose **New > Reduce** from the shortcut menu, as shown in the following figure.

   Reducer



5. In the dialog box that appears, enter the name of the Reduce class and click Finish.

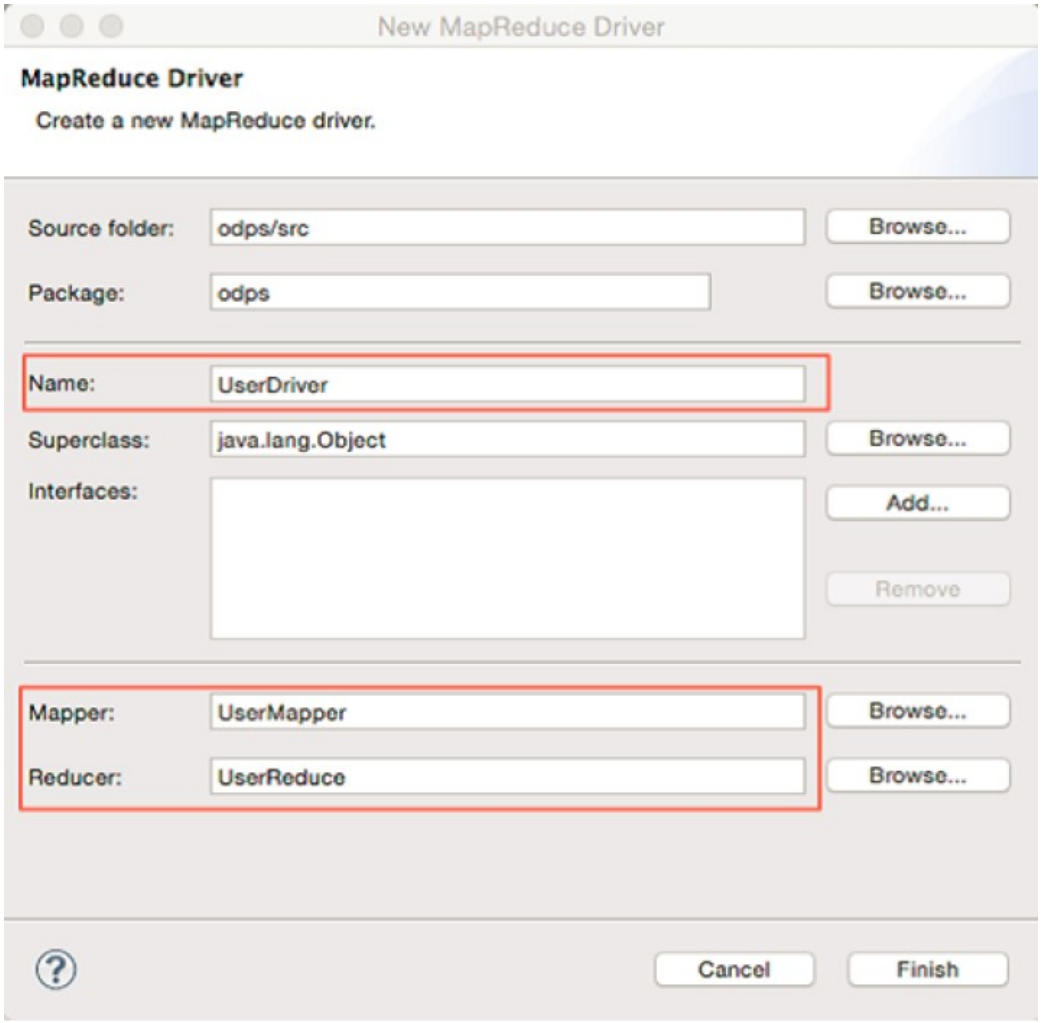
   > **Note** This example uses UserReducer.

6. On the left-side Package Explorer, the UserReducer.java file is generated in the src directory. The file contains a Reduce class template. The package name is odps by default. The template content is as follows:

```
package odps;
import java.io.IOException;
import java.util.Iterator;
import com.aliyun.odps.counter.Counter;
import com.aliyun.odps.data.Record;
import com.aliyun.odps.mapred.ReducerBase;
public class UserReducer extends ReducerBase {
private Record result; Counter gCnt;
@Override
public void setup(TaskContext context) throws IOException { result = context.createOutputRecord();
gCnt = context.getCounter("MyCounters", "global_counts");
}
@Override
public void reduce(Record key, Iterator<Record> values, TaskContext context) throws IOException {
long count = 0;
while (values.hasNext()) { Record val = values.next(); count += (Long) val.get(0);
}
result.set(0, key.get(0)); result.set(1, count);
Counter cnt = context.getCounter("MyCounters", "reduce_outputs"); cnt.increment(1);
gCnt.increment(1);
context.write(result);
}
@Override
public void cleanup(TaskContext context) throws IOException {
}
}
```

7. In Eclipse, right-click the **src** directory, and choose **New > MapReduce Driver** from the shortcut menu.
8. A dialog box is displayed, as shown in the following figure. Set Name, Mapper, and Reducer, and then click Finish.

   MapReduce Driver

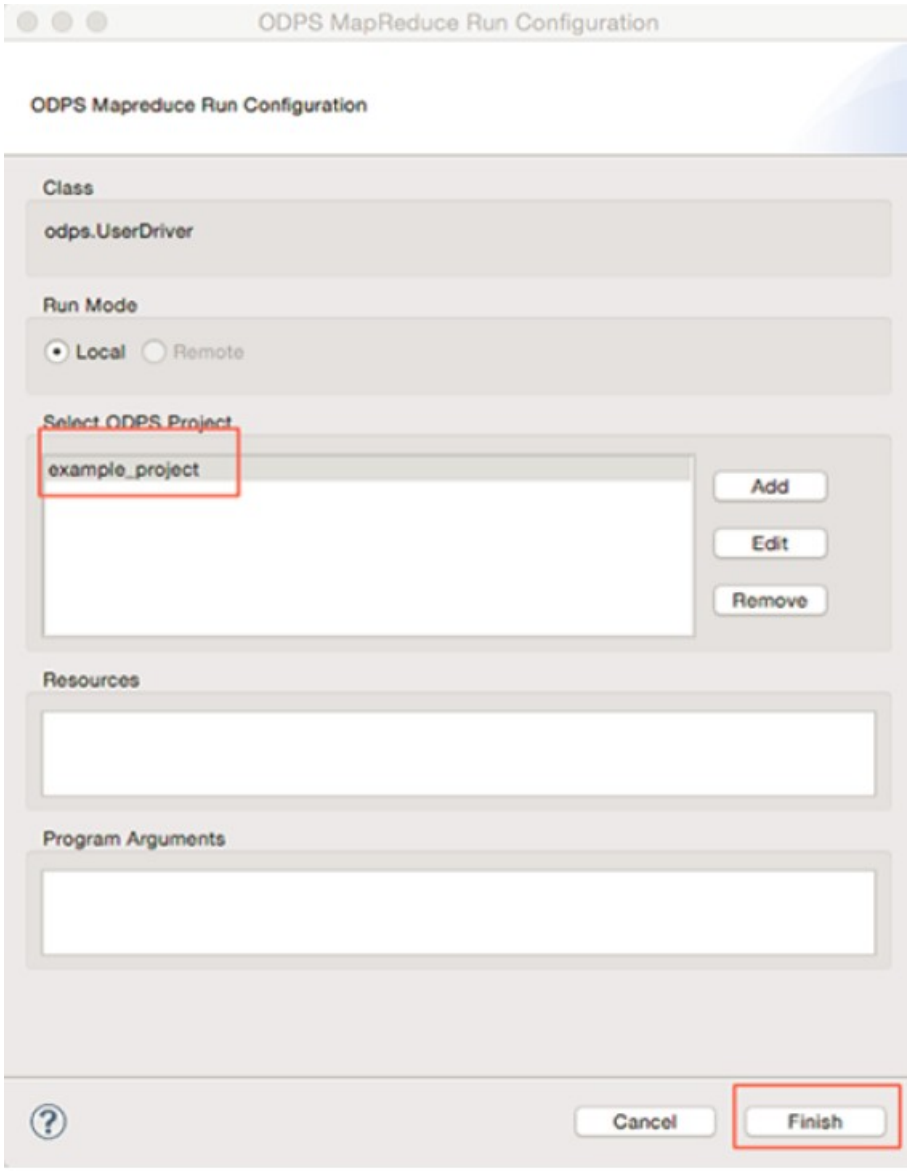


9. On the left-side Package Explorer, the MyDriver.java file is generated in the src directory. The file contains a MapReduce Driver template. The package name is odps by default. The template content is as follows:

```
package odps;
import com.aliyun.odps.OdpsException;
import com.aliyun.odps.data.TableInfo;
import com.aliyun.odps.examples.mr.WordCount.SumCombiner;
import com.aliyun.odps.examples.mr.WordCount.SumReducer;
import com.aliyun.odps.examples.mr.WordCount.TokenizerMapper;
import com.aliyun.odps.mapred.JobClient;
import com.aliyun.odps.mapred.RunningJob;
import com.aliyun.odps.mapred.conf.JobConf;
import com.aliyun.odps.mapred.utils.InputUtils;
import com.aliyun.odps.mapred.utils.OutputUtils;
import com.aliyun.odps.mapred.utils.SchemaUtils;
public class UserDriver {
public static void main(String[] args) throws OdpsException { JobConf job = new JobConf();
job.setMapperClass(TokenizerMapper.class);
job.setCombinerClass(SumCombiner.class);
job.setReducerClass(SumReducer.class);
job.setMapOutputKeySchema(SchemaUtils.fromString("word:string"));
job.setMapOutputValueSchema(SchemaUtils.fromString("count:bigint"));
InputUtils.addTable(
TableInfo.builder().tableName("wc_in1").cols(new String[] { "col2", "col3" }).build(), job);
InputUtils.addTable(TableInfo.builder().tableName("wc_in2").partSpec("p1=2/p2=1").build(), job);
OutputUtils.addTable(TableInfo.builder().tableName("wc_out").build(), job);
RunningJob rj = JobClient.runJob(job); rj.waitForCompletion();
}
}
```

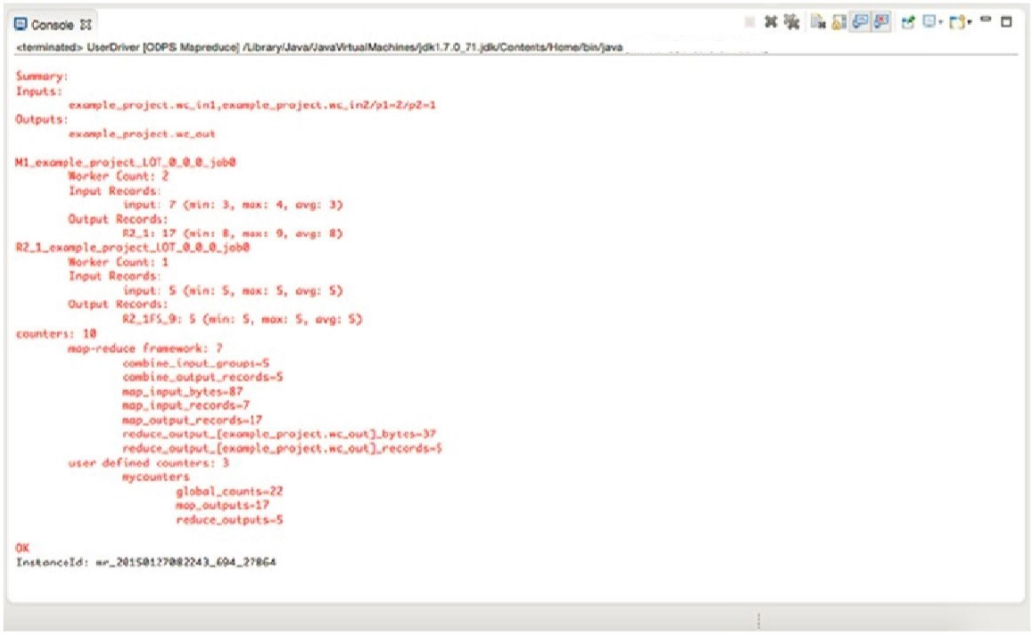
10. Run the MapReduce program. Right-click UserDriver.java and choose **Run As > ODPS MapReduce** from the shortcut menu. In the dialog box that appears, click **OK**. A dialog box is displayed, as shown in the following figure.

    ODPS MapReduce Run Configuration



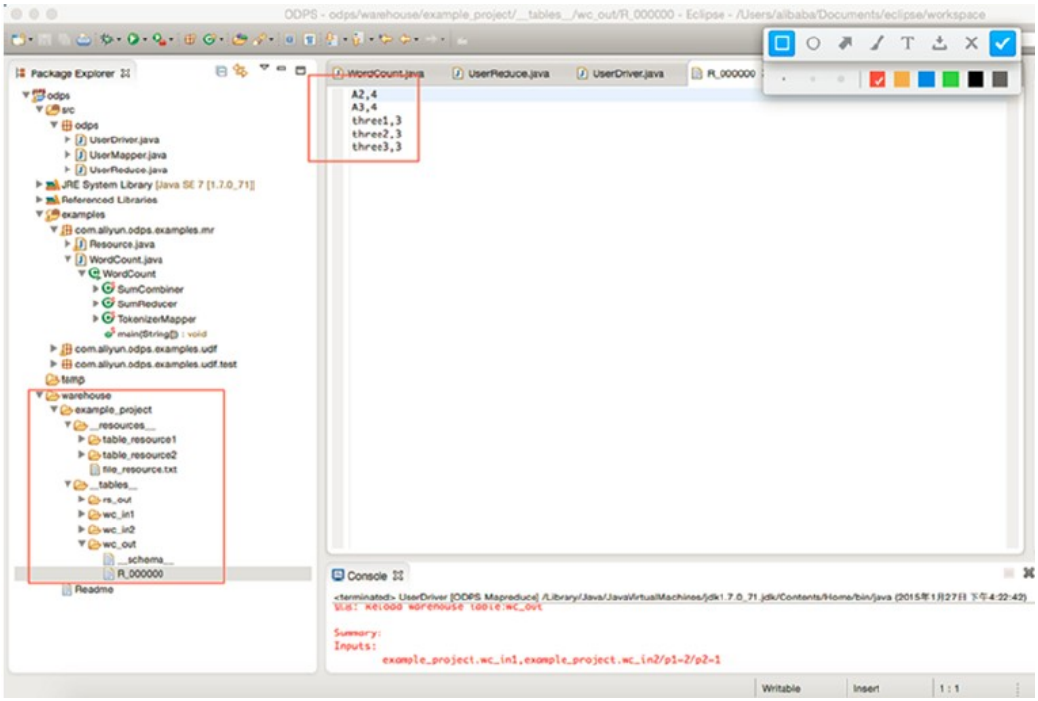
11. Select example_project as the MaxCompute project. Click **Finish** to start running the MapReduce program locally. If the output is as shown in the following figure, the local running is successful.

    Console



12. The execution result is stored in the warehouse directory. Refresh the ODPS project, as shown in the following figure.

    Output

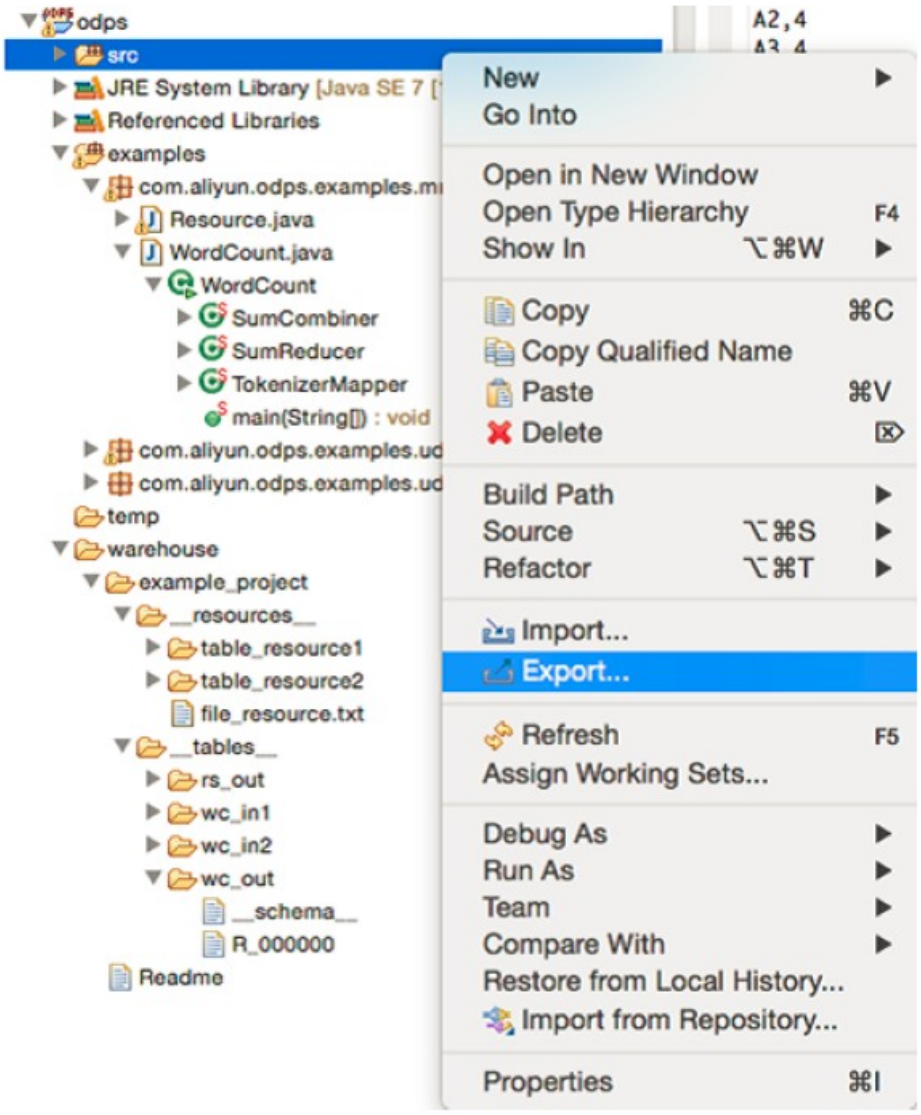


> **Note** wc_out is the output directory, and R_000000 is the result file. After confirming that the result is correct through local debugging, you can use the export function of Eclipse to package the MapReduce program for subsequent use in the distributed environment.

13. The export procedure is as follows:

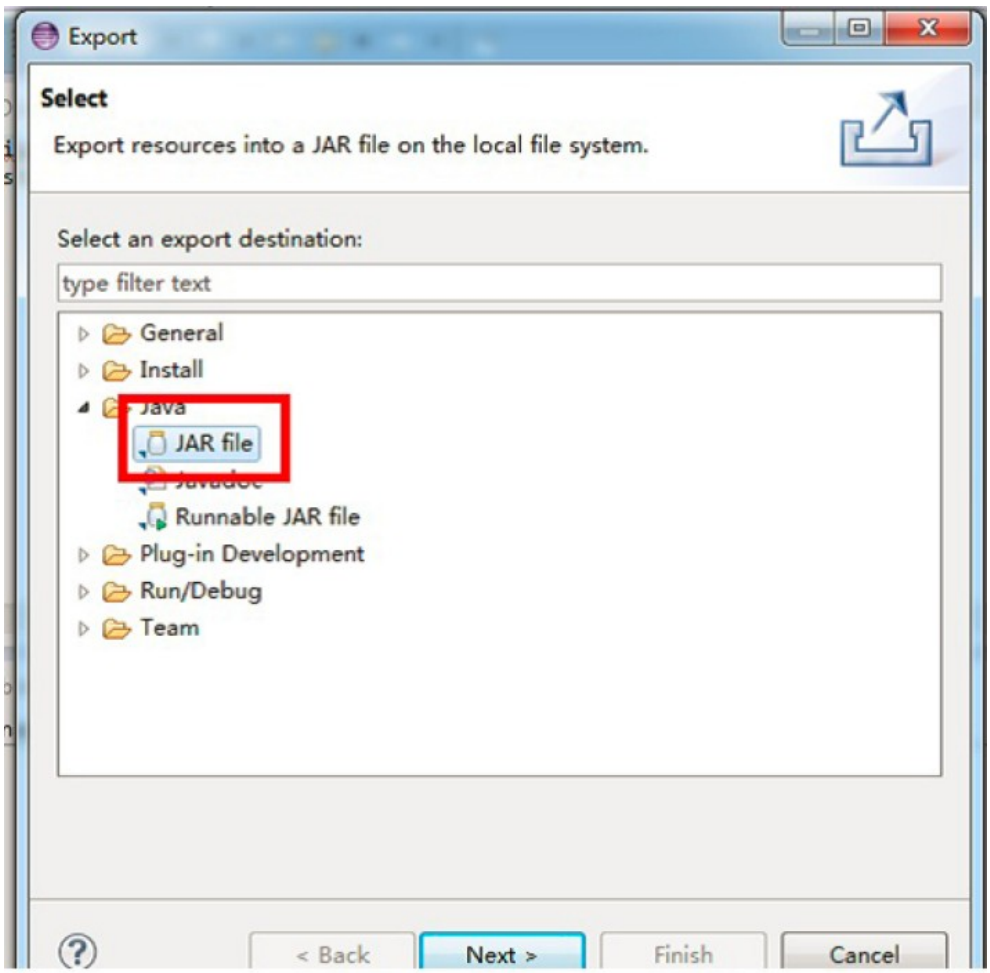
i. Right-click the **src** directory and select **Export** from the shortcut menu, as shown in the following figure.

Step 1



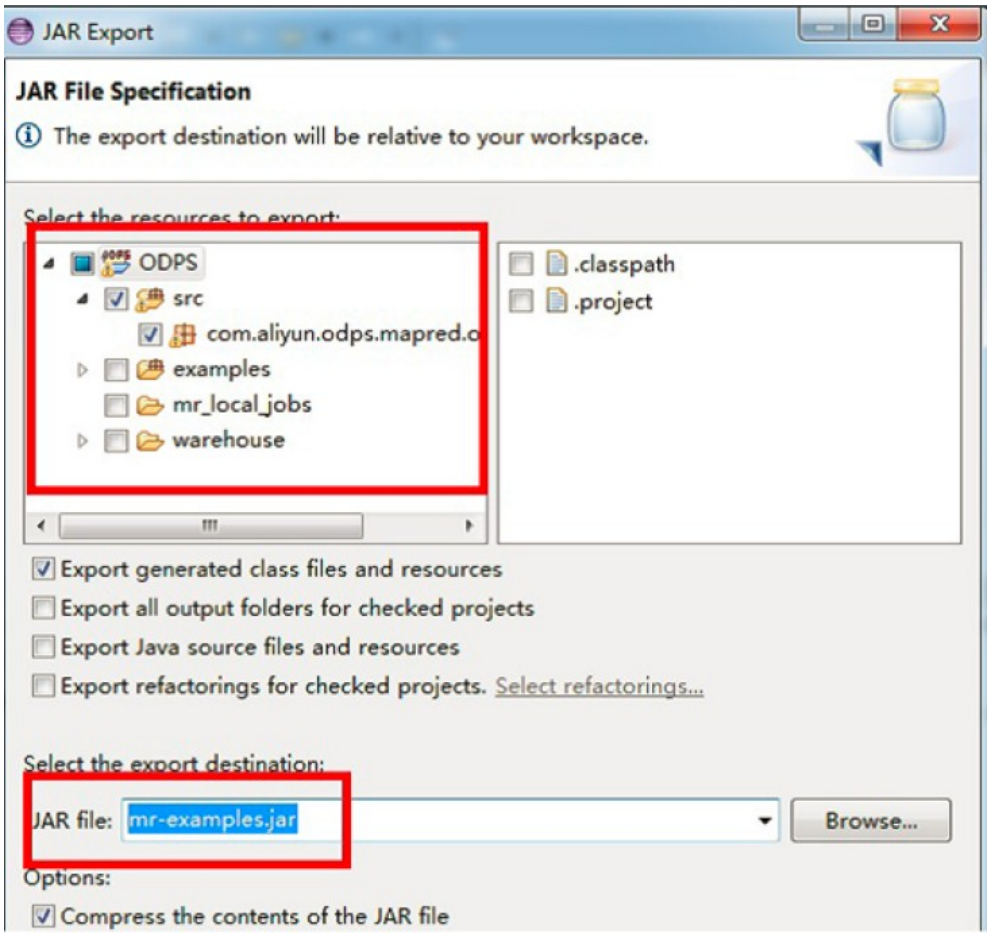
ii. Select JAR file as the export destination, as shown in the following figure.

Step 2



iii. You only need to export the package (com.aliyun.odps.mapred.open.example) in the **src** directory. Set JAR file to mr- examples.jar, as shown in the following figure.

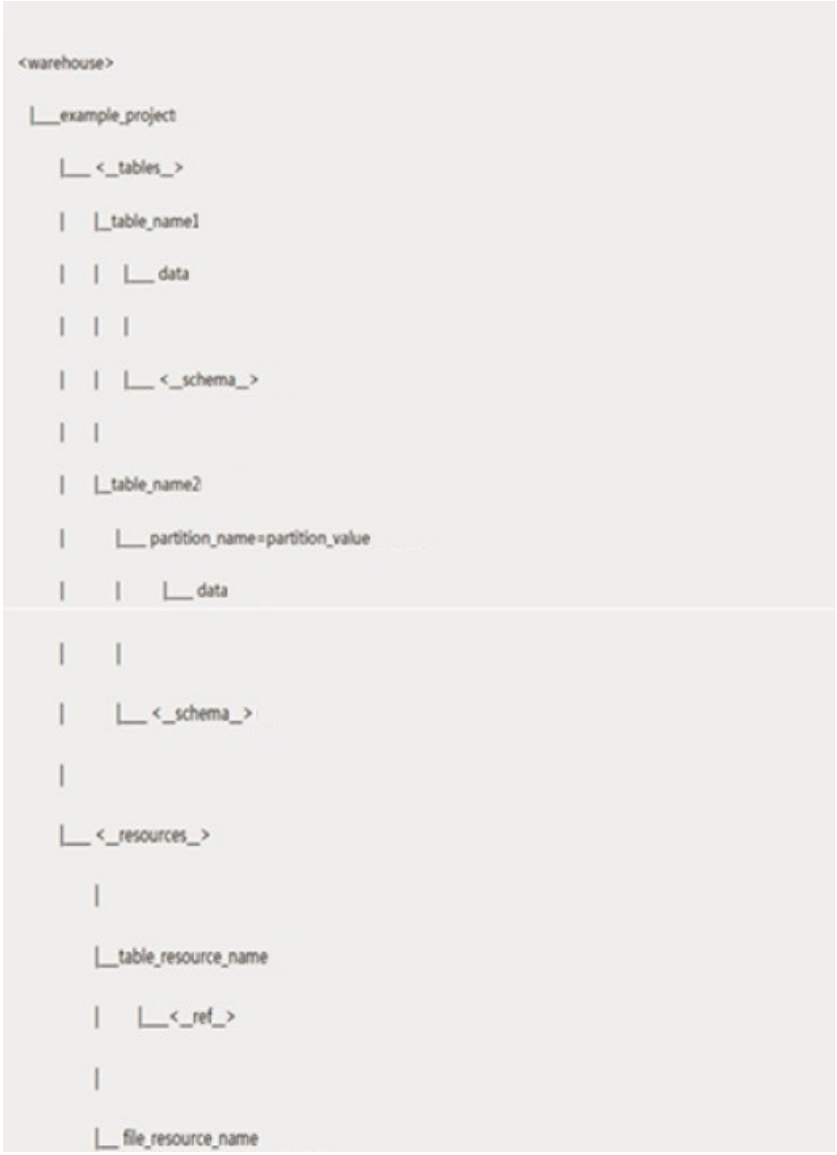
Step 3



> **Note** In this example, the program package is named mr-examples.jar. You can name the package based on your actual requirements.

iv. Click OK. The export process is complete.

14. If you want to create a new project locally, you can create a new subdirectory (at the same level as example_project) under warehouse. The following figure shows the directory structure.



An example of the schema file:

Non-partitioned table:

```
project=project_name table=table_name
columns=col1:BIGINT,col2:DOUBLE,col3:BOOLEAN,col4:DATETIME,col5:STRING
-- Partitioned table: project=project_name table=table_name
columns=col1:BIGINT,col2:DOUBLE,col3:BOOLEAN,col4:DATETIME,col5:STRING partitions=col1:BIGINT,c
ol2:DOUBLE,col3:BOOLEAN,col4:DATETIME,col5:STRING
-- Note that the following data formats are supported: bigint, double, boolean, datetime, and string. Th
ese formats correspond to the following Java data types: long, double, boolean, java.util.Date, and java
.lang.String.
```

An example of the data file:

```
1,1.1,true,2015-06-04 11:22:42 896,hello world
\N,\N,\N,\N,\N
-- Note that the time is in milliseconds. For all time formats, \N is used to represent NULL.
```

> **Note**
>
> - Run the MapReduce program locally. The warehouse directory is checked for data tables or resources by default. If the tables or resources do not exist, data of the server is downloaded to the warehouse directory. Then the program runs locally.
> - After running MapReduce, refresh the warehouse directory to view the generated result.

1.21.2.4. UDF development and running example

1.21.2.4.1. Local debug UDF programs

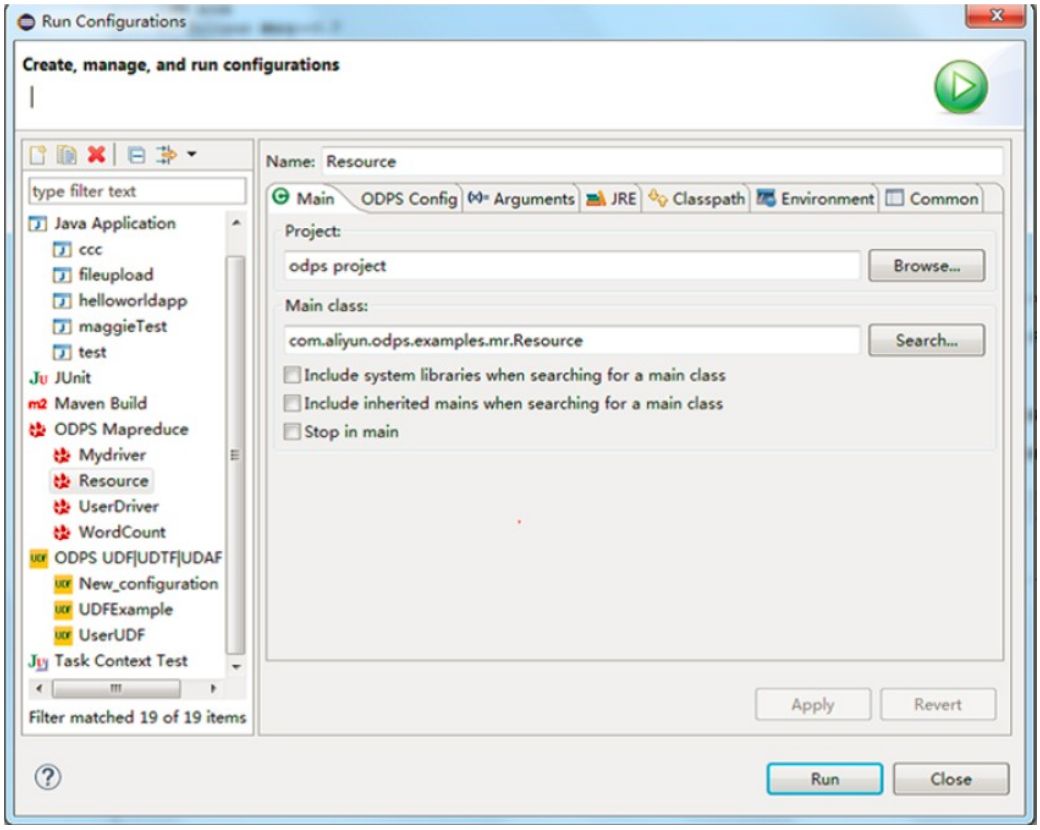
1.21.2.4.1.1. Run a UDF from the menu bar

This topic describes how to quickly run a UDF from the menu bar of the Eclipse plugin.

Procedure

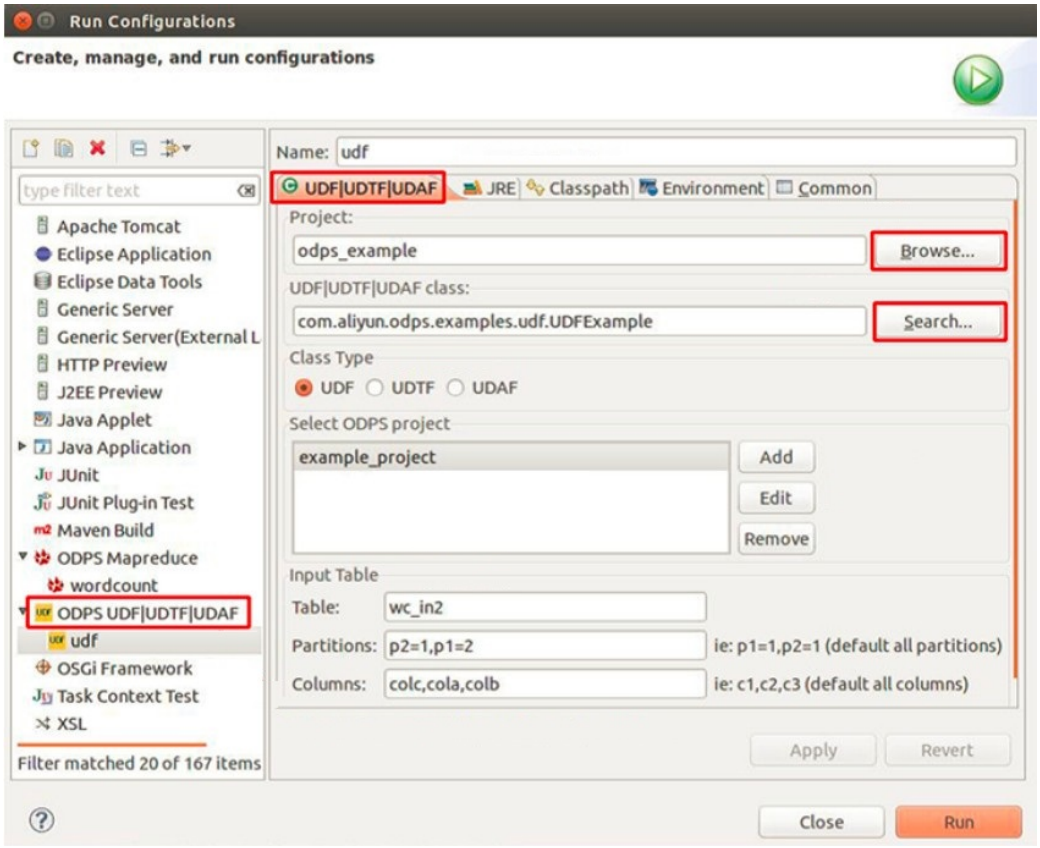
1. Choose **Run > Run Configurations** from the menu bar. A dialog box is displayed, as shown in the following figure.

   Run Configurations 1



2. To create a run configuration, select the UDF class and type to be run, select an ODPS project, and fill in the input table information, as shown in the following figure.

   Run Configurations 2



Note There are three parameters in the Input Table area: Enter the input table of the UDF in Table. Enter the partitions from which data is read in Partitions. Separate multiple partitions by commas (,). Enter the columns in which data is transmitted as UDF parameters in Columns. Separate multiple columns by commas (,).

3. Click **Run**. The running result is displayed in the console, as shown in the following figure.

   Console

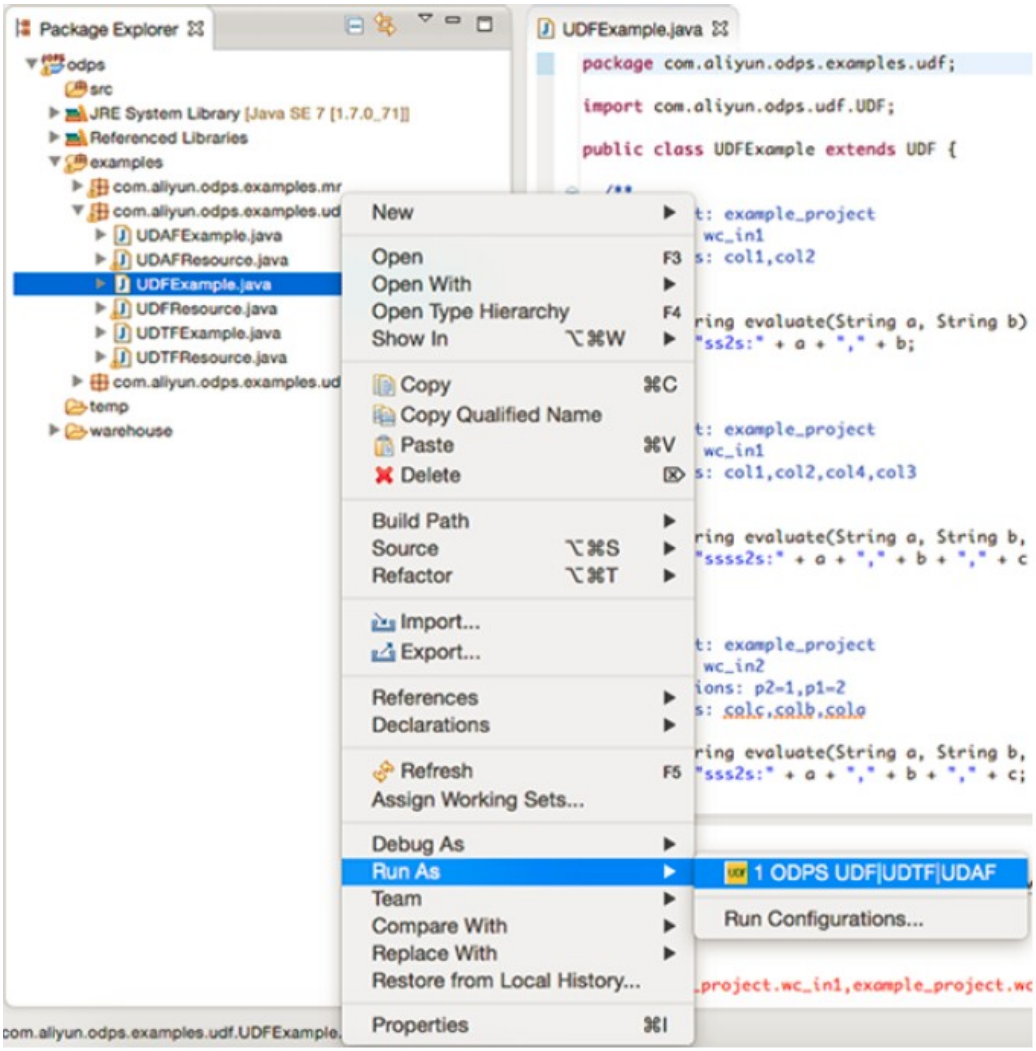
1.21.2.4.1.2. Use the right-click shortcut menu to quickly run a UDF

This topic describes how to use the right-click shortcut menu to quickly run a UDF in the Eclipse development plugin.

Procedure

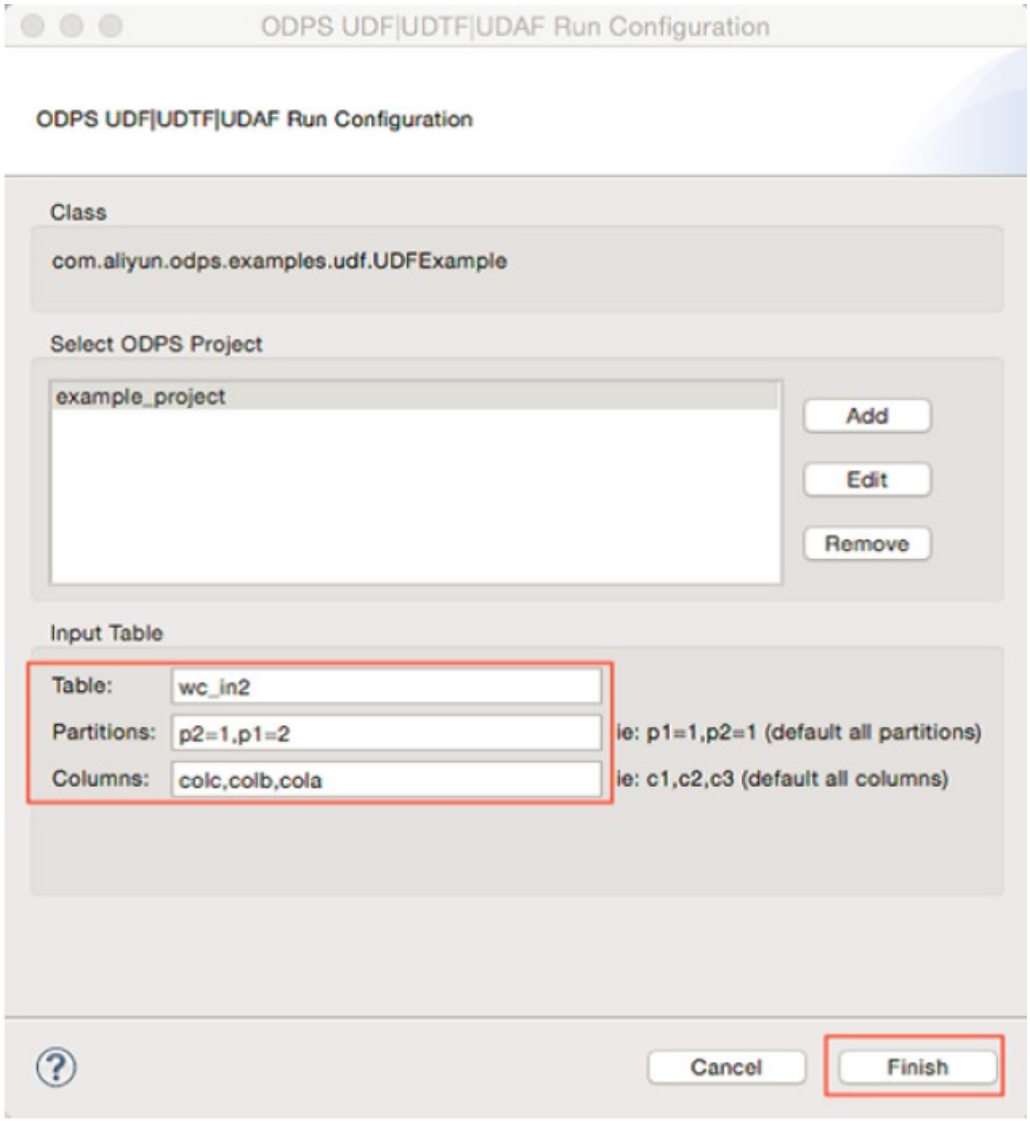
1. Right-click a udf.java file (such as UDFExample.java) and choose **Run As > Run UDF|UDAF|UDTF** from the shortcut menu, as shown in the following figure.

Step 1



2. In the dialog box that appears, configure the relevant parameters, as shown in the following figure.

Step 2



Note Table indicates the input table of the UDF. Partitions indicate the partitions from which data is read. Multiple partitions are separated by commas. Columns indicate the columns from which data is read. Multiple columns are separated by commas. These parameters are imported to the UDF as parameters.

3. Click **Finish** to run the UDF and obtain the result.

1.21.2.4.2. Run a UDF program

This topic describes how to run a UDF program in the Eclipse development plugin.

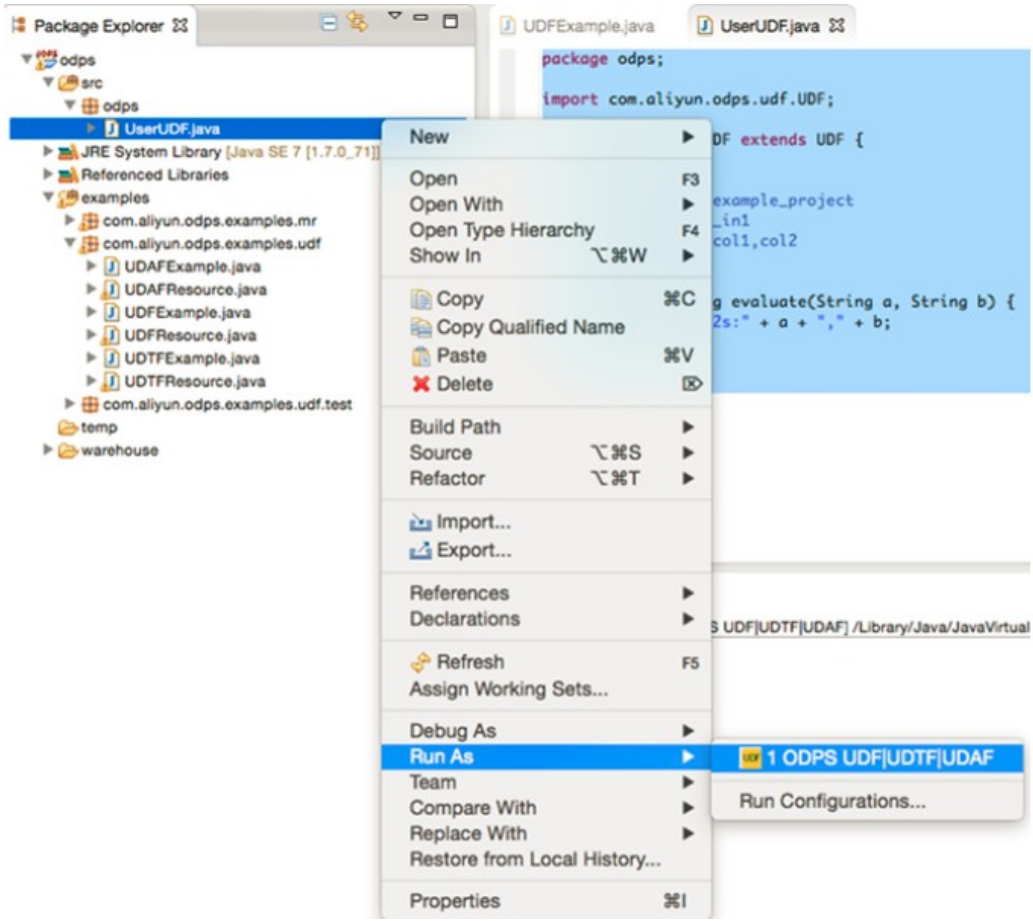
Procedure

1. Right-click a project and choose **New > UDF** (or choose **File > New > UDF** from the menu bar). Enter a UDF class name and click **Finish**. A Java file with the same name as the UDF class is generated in the **src** directory. Edit the content of the java file as follows:

```
package odps;
import com.aliyun.odps.udf.UDF;
public class UserUDF extends UDF {
/**
* project: example_project
* table: wc_in1
* columns: col1,col2
*
*/
public String evaluate(String a, String b) { return "ss2s:" + a + "," + b;
}
}
```

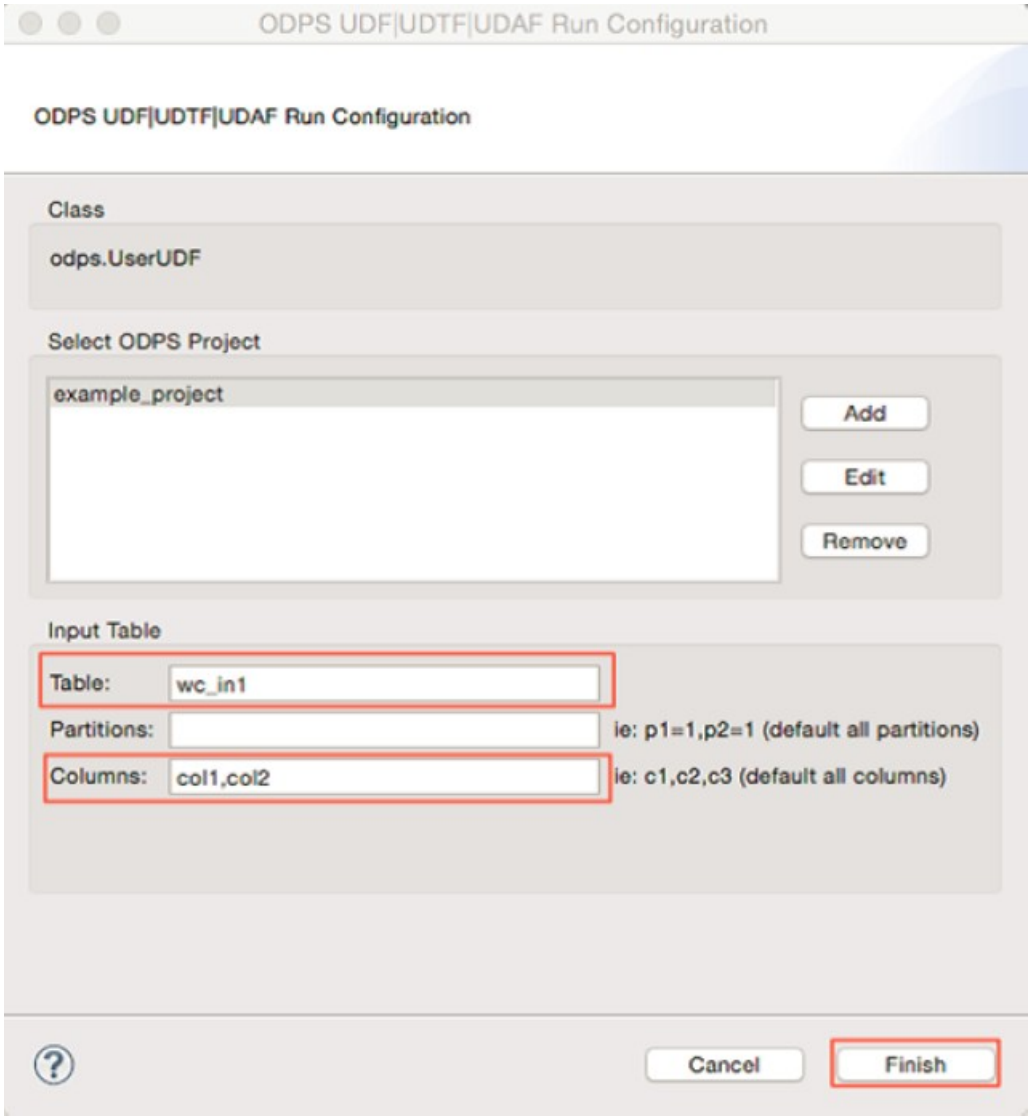
2. Right-click the Java file (such as UserUDF.java) and choose **Run As > ODPS UDF|UDTF|UDAF** from the shortcut menu, as shown in the following figure.

Step 1



3. In the dialog box that appears, configure the relevant parameters, as shown in the following figure.

Step 3-1



4. Click **Finish** to obtain the result.

```
ss2s:A1,A2
ss2s:A1,A2
ss2s:A1,A2
ss2s:A1,A2
```

> **Note** This example shows how to run a UDF program. You can use the same method to run a UDTF program.

1.21.2.5. Graph running example

After creating a MaxCompute project, you can write your own Graph program and debug it locally by performing the following steps.

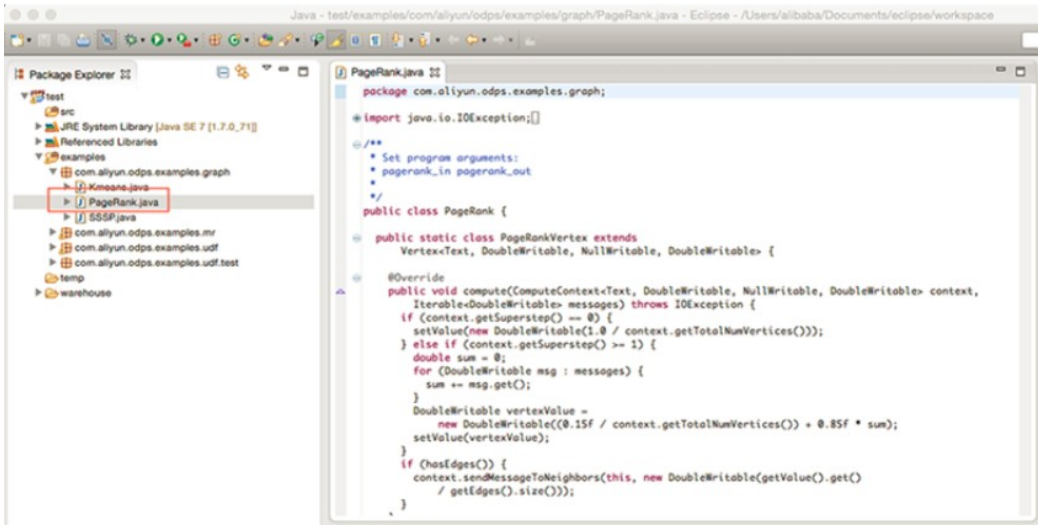
Context

In this example, you can use PageRank.java provided by the plugin to perform local debugging.

Procedure

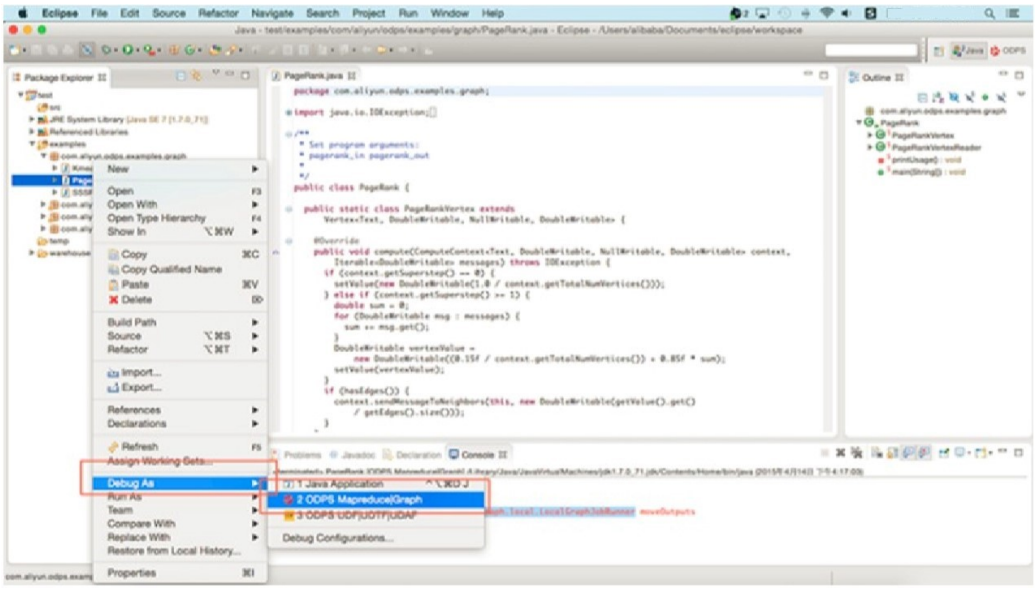
1. Choose **examples > PageRank.java**, as shown in the following figure.

   PageRank.java code 1

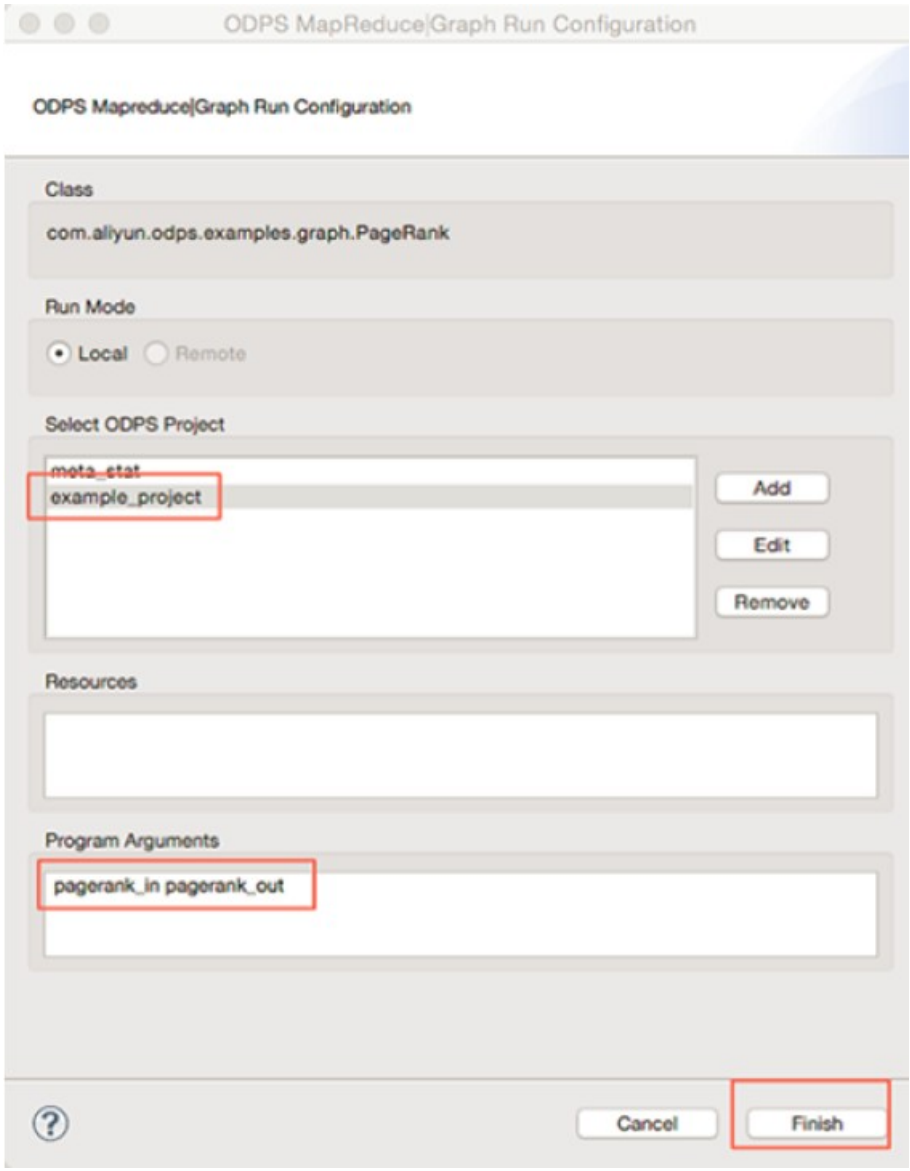
2. Right-click it and choose **Debug As > ODPS MapReduce|Graph**, as shown in the following figure.

   PageRank.java code 2

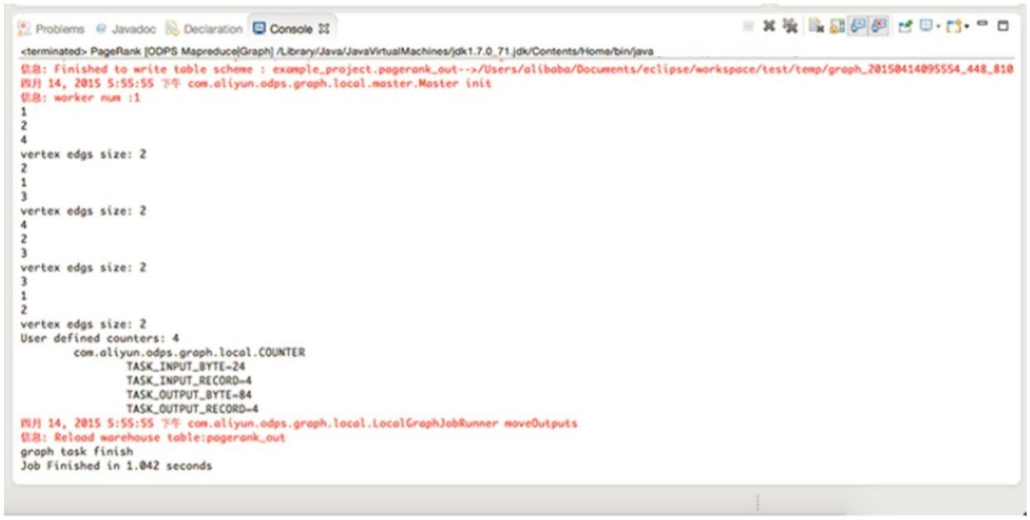
3. In the pop-up dialog box, enter the information as shown below.

   Configuration Drawings



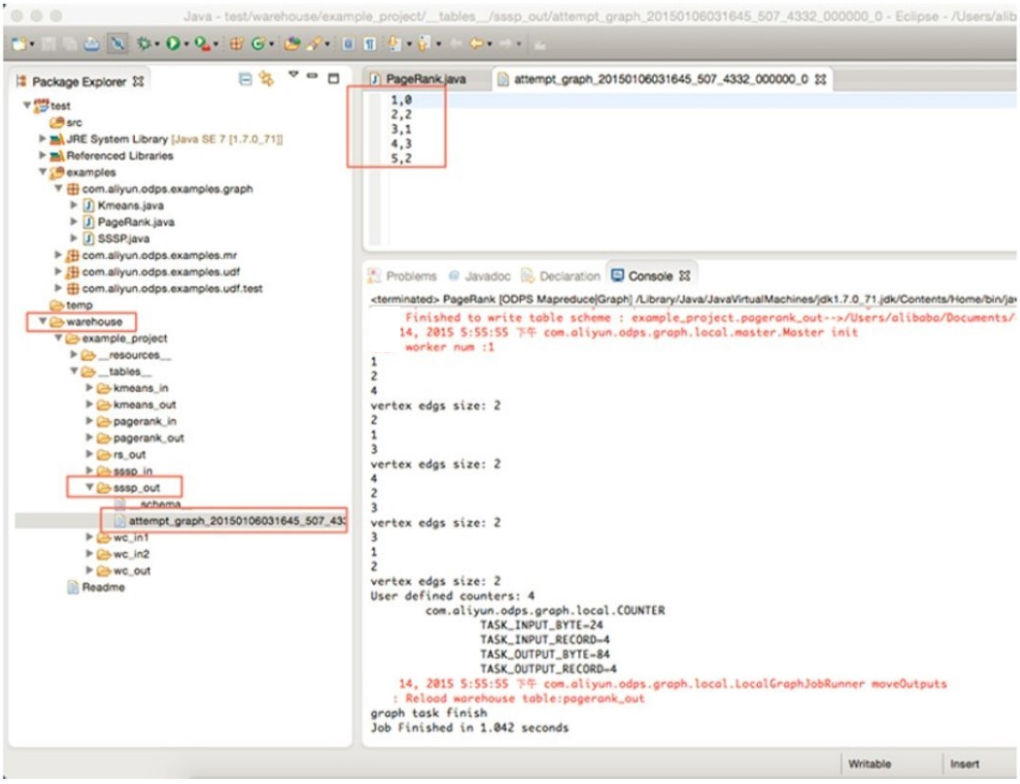
4. Click **Finish**. Check the running result, as shown in the following figure.

   Running Result



Check the local computing result as shown below:

Local computing result



After passing the debugging, you can package the program, upload it to MaxCompute in the form of JAR resource, and submit the Graph job.

> Note
>
> - For more information about the packaging process, see MapReduce running example.
> - For more information about the directory structure of local results, see MapReduce running example.
> - For more information about uploading JAR resources, see Compile and run a Graph job.

1.22. MaxCompute FAQ

This topic describes MaxCompute FAQ and solutions.

SQL statement execution is slow. How do I check MaxCompute resource usage?

Log on to the MaxCompute AG as the admin user and perform the following steps:

1. Run the following command to display the remaining resources on the hosts in the MaxCompute cluster in ascending order:

```
r tfrl|sed 's/,//g'|sort -t "|" -k2 -n
```

2. Run the following command to view resource details of the hosts and the total cluster resources in

MaxCompute:

```
r ttrl|sed 's/,//g'
```

3. Determine whether the remaining resources in MaxCompute are sufficient based on the ratio of remaining resources to total resources.

How do I handle the slow execution of jobs submitted by a project in a MaxCompute cluster with sufficient resources?

A possible cause is that the resources for the quota group where the project is located are exhausted. Perform the following steps to check whether the resources are exhausted and determine whether to add resources to the quota group:

1. Log on to the MaxCompute AG as the admin user and run the following command to check the resource usage of the quota group:

```
r quota
```

2. If you confirm that the resources for the quota group are exhausted, you can make modifications to the quota list on MaxCompute in Big Data Manager.

How do I modify quota group settings?

1. Run the following command in the MaxCompute AG to create or modify a quota:

```
sh/apsara/deploy/rpc_wrapper/rpc.sh setquota -i $QUOTAID -a $QUOTANAME -t fair -s$max_cpu_quota $max_mem_quota -m $min_cpu_quota $min_mem_quota
```

> **Note** If $QUOTAID already exists, that quota is modified. Otherwise, a quota with that ID is created.

2. Log on to MaxCompute in Big Data Manager and configure relevant settings.

How do I perform simple operations on the metadata warehouse?

1. Log on to the MaxCompute AG.
2. Run the following commands:

```
/apsara/odps_tools/clt/bin/odpscmd
```

```
use meta;
```

3. Run the following command to view all tables in the metadata warehouse:

```
show tables;
```

4. Run the following command to obtain the description of a specific table:

```
desc <table>;
```

How do I use the smart metadata warehouse (package+view)?

You need to install the metadata warehouse enhancement package **package+view** first. Before you install the package, ensure that you are the owner of a project that is granted the package installation permission. After you have installed the package, you can follow the instructions provided in Package usage to use the smart metadata warehouse.

The following is a brief description on how to use the smart metadata warehouse:

- **Installation**

  package+view is a metadata warehouse enhancement package that depends on the metadata warehouse. You can install it by running the `odpscmd --config=odps_config.ini -f init.sql` command in the *system metadata warehouse* directory.

  > **Note**
  > - If the system asks you to re-install the package, remove the create package comment in the first line of init.sql and then run the preceding command again.
  > - **odps_config.ini**: This configuration file contains the configuration of the account used to access the metadata warehouse, which is also the project owner of the metadata warehouse.

- **Authorization**

  Run the following command to allow a project, such as p1, to install the package+view package:

  ```
  odpscmd --config=odps_config.ini -e "allow project p1 to install package systables;"
  ```

  Run the following command to allow all projects to install the package+view package:

  ```
  odpscmd --config=odps_config.ini -e "allow project * to install package systables;"
  ```

- **User operations**

  You can run the following command to install the package. Ensure that you are the owner of the project that is granted the package installation permission.

  ```
  install package meta.systables;
  ```

  After the installation is complete, you can run the following command to see the description of views in the package:

  ```
  desc package meta.systables;
  ```

  > **Note** After you have completed the preceding operations, you can start to use the smart metadata warehouse.

- **Views**

> **Note** To learn the definition of table schema, refer to the relevant content in the view description, which is available after you run the following command:
>
> ```
> desc viewname
> ```

View name	Content
allowed_package_installers	Information about the project that is granted the package installation permission
column_label_grants	Column label authorization information
column_labels	Column label information of a table
columns	Table schema information
installed_packages	Information about the package installed for the project
object_privileges	Table, UDF, resource authorization information
package_resources	Object information contained in the package
partitions	Partition information of a partitioned table
policies	User, role, and permission information defined in policies
resources	Resource information
roles	Role information
table_label_grants	Label authorization information of a table
table_labels	Label information of a table
tables	Table and view information
tasks	Job execution records
tunnels	Data upload and download records
udf_resources	Information about resources used in UDFs
udfs	Information about UDFs
user_roles	User and role association information
users	User information

- **Notes**

- By default, the smart metadata warehouse allows you to query data from the past 180 days. If you do not run a job on a specific day, you cannot obtain query results of that day from the smart metadata warehouse.
- We recommend that you specify a query range so that the system does not scan all data from the past 180 days.
- The time the data of the previous day is available depends on the specific output time of the metadata warehouse in the early morning. The data is available immediately after it is generated.
- The metadata warehouse does not provide metadata on the day when the project is created. The purpose is to avoid obtaining data of the project with the same name.

How do I grant Java sandbox permissions?

1. Log on to the AdminConsole and choose **MaxCompute Configuration > Project Management**. Select the project to which you want to grant Java sandbox permissions and double-click it to open the property dialog box.
2. In the **ODPS Sandbox Setting** area, enter the method or class you want to use in Sandbox Java Permissions.

   > **Note** Make sure that your input is in the correct format. The following example is for demonstration only. Enter each item in a single line and end it with a semicolon (;).

   ```
   permission java.lang.RuntimePermission "readSystemProperty"; permission java.lang.RuntimePermission "modifyThreadGroup"; permission java.security.AllPermission;
   ```

3. Click **Finish Modification**.

How do I handle exhausted disk capacity?

In most cases, you can clear scripts to free disk capacity. The most possible cause is that the root directory of MaxCompute AG or the /apsara directory occupies too much disk space. Therefore, you need to clear scripts in these two directories.

How do I find an AccessKey pair and configure correct AccessKey information?

1. Access the framework cluster management page of the Apsara Stack data center, and choose **Operations > Cluster Operations**. Select the cluster for which you want to find and configure the AccessKey pair, and access the cluster configuration page.
2. Double-click the kv.conf file in the file list to find the AccessKey information. You can also modify the information in this file and then save your modifications.

How do I add a MaxCompute host to a blacklist?

1. Log on to the Apsara AG as the admin user. Run the following command to enable the Fuxi blacklist function:

   ```
   r sgf fuximaster"{\"fuxi_Enable_BadNodeManager\":false}"
   ```

2. Run the following command to view the Fuxi blacklist:

   ```
   /apsara/deploy/rpc_wrapper/rpc.shblacklist cluster get
   ```

3. Run the following command to add a MaxCompute host to the Fuxi blacklist:

```
/apsara/deploy/rpc_wrapper/rpc.shblacklist cluster add $hostname
```

4. Run the following command to view the Fuxi blacklist again and confirm that the host is added:

```
/apsara/deploy/rpc_wrapper/rpc.shblacklist cluster get
```

How do I export data from MaxCompute?

There are two methods to export data from MaxCompute: The first is to use the Tunnel command. The second is to configure synchronization tasks in DataWorks to export data from MaxCompute to other destinations.

How do I view the current MaxCompute version?

Run the following commands to view the MaxCompute version:

```
cat /apsara/odps_info/version|grep odps
```

```
cat /apsara/version
```

How do I restart MaxCompute services?

1. Run the following commands to save the configurations of resident MaxCompute services to a file. This configuration file is required when you restart MaxCompute services.

```
ssh odpsAG
cd /home/admin/
If you do not use a service, you can ignore the corresponding command.
You can use the r al command to view resident services.
r plan Odps/CGServiceControllerx > CGServiceControllerx
r plan sys/sqlonline-OTS >sqlonline-OTS
r plan Odps/MessagerServicex >MessagerServicex
r plan Odps/OdpsServicex >OdpsServicex
r plan Odps/HiveServerx >HiveServerx
r plan Odps/XStreamServicex >XStreamServicex
r plan Odps/QuotaServicex > QuotaServicex
r plan Odps/ReplicationServicex >ReplicationServicex
```

2. Run the following commands to stop MaxCompute services:

```
r sstop Odps/CGServiceControllerx
r sstop sys/sqlonline-OTS
r sstop Odps/MessagerServicex
r sstop Odps/OdpsServicex
r sstop Odps/HiveServerx
r sstop Odps/XStreamServicex
r sstop Odps/QuotaServicex
r sstop Odps/ReplicationServicex
```

3. Run the following commands to start MaxCompute services:

```
ssh odpsAG
cd /home/admin/
r start CGServiceControllerx
r start sqlonline-OTS
r start MessagerServicex.txt
r start OdpsServicex.txt
r start HiveServerx.txt
r start XStreamServicex.txt
r start QuotaServicex.txt
r start ReplicationServicex.txt
```

How do I power MaxCompute on and off?

1. Run the following commands to save the configurations of resident MaxCompute services to a file. This configuration file is required when you restart MaxCompute services.

```
ssh odpsAG
cd /home/admin/
If you do not use a service, you can ignore the corresponding command.
You can use the r al command to view resident services.
r plan Odps/CGServiceControllerx > CGServiceControllerx
r plan sys/sqlonline-OTS >sqlonline-OTS
r plan Odps/MessagerServicex >MessagerServicex
r plan Odps/OdpsServicex >OdpsServicex
r plan Odps/HiveServerx >HiveServerx
r plan Odps/XStreamServicex >XStreamServicex
r plan Odps/QuotaServicex > QuotaServicex
r plan Odps/ReplicationServicex >ReplicationServicex
```

2. Run the following commands to stop MaxCompute services:

```
r sstop Odps/CGServiceControllerx
r sstop sys/sqlonline-OTS
r sstop Odps/MessagerServicex
r sstop Odps/OdpsServicex
r sstop Odps/HiveServerx
r sstop Odps/XStreamServicex
r sstop Odps/QuotaServicex
r sstop Odps/ReplicationServicex
```

3. Run the following command to shut down the Apsara system:

```
/home/admin/dayu/bin/allapsara stop
```

4. Run the following command to shut down compute nodes gracefully:

```
Shutdown
```

5. Start compute nodes.
6. Run the following command to start the Apsara system:

```
/home/admin/dayu/bin/allapsara start
```

7. Run the following commands to start MaxCompute services:

```
ssh odpsAG
cd /home/admin/
r start CGServiceControllerx
r start sqlonline-OTS
r start MessagerServicex.txt
r start OdpsServicex.txt
r start HiveServerx.txt
r start XStreamServicex.txt
r start QuotaServicex.txt
r start ReplicationServicex.txt
```

How do I reduce the heavy load on a host?

1. Log on to the host with a heavy load and run the top command to check whether task processes occupy too many resources.
2. Generally, resources are occupied by user tasks. If task processes occupy too many resources, wait until these tasks are completed or ask users to stop these tasks.

1.23. Open source features of MaxCompute

This topic describes open source features related to MaxCompute.

SDKs

MaxCompute provides Java SDK and Python SDK interfaces to create, view, and delete MaxCompute tables. You can use the SDKs to manage MaxCompute by editing code.

How to obtain service support: Visit the official documentation or submit a ticket online.

MaxCompute RODPS

MaxCompute RODPS is an R plug-in for MaxCompute. For more information about the plug-in, see ODPS Plugin for R on GitHub.

How to obtain service support: Leave a message or create an issue in ODPS Plugin for R on GitHub.

MaxCompute JDBC

MaxCompute JDBC is an official JDBC driver provided by MaxCompute. It provides a set of interfaces to execute SQL tasks for Java programs. The project is hosted in ODPS JDBC on GitHub.

How to obtain service support: Leave a message or create an issue in ODPS JDBC on GitHub.

Mars

Mars is a tensor-based unified distributed computing framework. Mars makes it possible to execute large-scale scientific computing tasks by using only several lines of code, whereas MapReduce requires hundreds of lines of code. In addition, Mars improves computing performance.

The source code of Mars is now available on GitHub. You are welcome to contribute to Mars. You can visit Mars on GitHub to obtain its open source code.

For more information about Mars, see Mars Development Guide.

How to obtain service support: Leave a message or create an issue in Mars on GitHub.

Data Collector

Data Collector is a collection of the major open source data collection tools of MaxCompute, such as the Flume plug-in, OGG plug-in, Sqoop, Kettle plug-in, and Hive Data Transfer UDTF.

The Flume and OGG plug-ins are implemented based on the DataHub SDK, whereas Sqoop, the Kettle plug-in, and Hive Data Transfer UDTF are implemented based on the Tunnel SDK. DataHub is a real-time data transfer channel, and Tunnel is a batch data transfer channel. The Flume and OGG plug-ins are used to transfer data in real time. Sqoop, the Kettle plug-in, and Hive Data Transfer UDTF are used to transfer data in batches in offline mode.

For information about the source code, see Aliyun MaxCompute Data Collectors on GitHub. For more information about these tools, see wiki on GitHub.

How to obtain service support: Leave a message or create an issue in Aliyun MaxCompute Data Collectors on GitHub.

2.DataWorks

2.1. Log on to the DataWorks console

This topic describes how to log on to the DataWorks console.

Prerequisites

- The domain name of the ASCM console is obtained from the deployment personnel before you log on to the ASCM console.
- A browser is available. We recommend that you use the Google Chrome browser.

Procedure

1. In the address bar, enter the URL used to log on to the ASCM console. Press the Enter key.
2. Enter your username and password.

   Obtain the username and password used to log on to the console from the operations administrator.

   > **Note** When you log on to the ASCM console for the first time, you must change the password of your username. For security reasons, your password must meet the minimum complexity requirements. The password must be 8 to 20 characters in length and must contain at least two of the following character types:
   >
   > - Uppercase or lowercase letters.
   > - Digits.
   > - Special characters. Special characters include exclamation points (!), at signs (@), number signs (#), dollar signs ($), and percent signs (%).

3. Click **Login** to go to the ASCM console homepage.
4. In the top navigation bar, click the **Products** icon and click **DataWorks** in the **Big Data** section.
5. On the page that appears, set the **Organization** and **Region** parameters and click **DataWorks** to go to the **DataStudio** page.

   > **Note** You cannot navigate to the DataStudio page from the root organization.

2.2. Quick Start

2.2.1. Overview

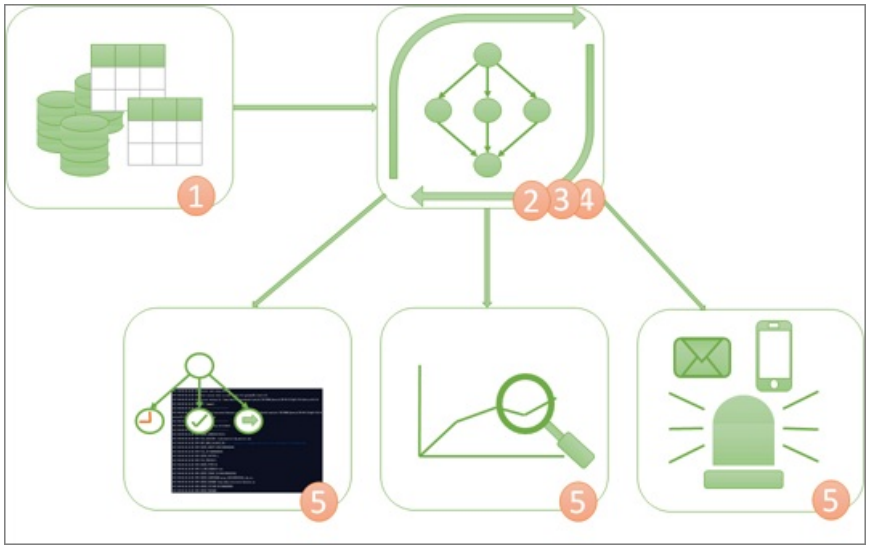
Quick Start guides you through a complete process of data analytics and O&M.

Generally, you can complete the following data analytics and O&M operations in a workspace of DataWorks:

1. Create tables and import data
2. Create a workflow

3. Create a sync node
4. Configure recurrence and dependencies for a node
5. Run a node and troubleshoot errors

The following figure shows the basic process of data analytics and O&M.



2.2.2. Create tables and import data

This topic takes the bank_data and result_table tables as an example to describe how to create tables and import data in the DataWorks console.

> **Note** The bank_data table stores business data, whereas the result_table table stores data analytics results.

Create the bank_data table

1. Log on to the DataWorks console.
2. On the **DataStudio** page that appears, move the pointer over the icon and click **Table**.
3. In the **Create Table** dialog box, set **Table Name** to bank_data.
4. Click **Commit**.
5. On the editing page of the created table, click **DDL Statement**.
6. In the **DDL Statement** dialog box, enter the table creation statement, and click **Generate Table Schema**. In the dialog box that appears, click **OK**.

   In this topic, the following statement is used as an example:

```
CREATE TABLE IF NOT EXISTS bank_data
(
 age         BIGINT COMMENT 'age',
 job         STRING COMMENT 'job type',
 marital     STRING COMMENT 'marital status',
 education   STRING COMMENT 'education level',
 default     STRING COMMENT 'credit card',
 housing     STRING COMMENT 'mortgage',
 loan        STRING COMMENT 'loan',
 contact     STRING COMMENT 'contact',
 month       STRING COMMENT 'month',
 day_of_week STRING COMMENT 'day in a week',
 duration    STRING COMMENT 'duration',
 campaign    BIGINT COMMENT 'number of contacts during the campaign',
 pdays       DOUBLE COMMENT 'interval from the last contact',
 previous    DOUBLE COMMENT 'number of contacts with the customer',
 poutcome    STRING COMMENT 'result of the previous marketing campaign',
 emp_var_rate   DOUBLE COMMENT 'employment change rate',
 cons_price_idx DOUBLE COMMENT 'consumer price index',
 cons_conf_idx  DOUBLE COMMENT 'consumer confidence index',
 euribor3m   DOUBLE COMMENT 'Euro deposit rate',
 nr_employed DOUBLE COMMENT 'number of employees',
 y           BIGINT COMMENT 'whether time deposit is available'
);
```

7. After the table schema is generated, enter the display name of the table and click **Commit to Development Environment** or **Commit to Production Environment**.

   > **Note** If you are using a workspace of the basic mode, click **Commit to Production Environment**.

8. In the left-side navigation pane, click **Workspace Tables**. On the page that appears, enter the table name to search for the created table. After you find the table, double-click the table name to view the table information.

Create the result_table table

1. On the **DataStudio** page that appears, move the pointer over the icon and click **Table**.
2. In the **Create Table** dialog box, set **Table Name** to result_table.
3. On the editing page of the created table, click **DDL Statement**.
4. In the **DDL Statement** dialog box, enter the table creation statement, and click **Generate Table Schema**. In the dialog box that appears, click **OK**.

In this topic, the following statement is used as an example:

```
CREATE TABLE IF NOT EXISTS result_table
(
 education     STRING COMMENT 'education level',
 num       BIGINT COMMENT 'number of people'
);
```

5. After the table schema is generated, enter the display name of the table and click **Commit to Development Environment** or **Commit to Production Environment**.
6. In the left-side navigation pane, click **Workspace Tables**. On the page that appears, enter the table name to search for the created table. After you find the table, double-click the table name to view the table information.

Upload a local file to import its data to the bank_data table

You can perform the following operations in the DataWorks console:

- Upload a local text file to import its data to a table in a workspace.
- Use Data Integration to import business data from different data stores to a workspace.

> **Note** In this topic, a local file is used as the source of data. Comply with the following rules when uploading a local file:
>
> - File format: The file must be in the .txt, .csv, or .log format.
> - File size: The size of the file cannot exceed 10 MB.
> - Destination object: The destination object can be a partitioned table or a non-partitioned table. The partition key value cannot be in Chinese.

To upload the local file banking.txt to DataWorks, follow these steps:

1. On the **Data Analytics** tab, click the **Import** icon.
2. In the **Data Import Wizard** dialog box, select the table to which you want to import data and click **Next**.
3. Set **Select Data Import Method** to **Upload Local File** and click **Browse**. In the dialog box that appears, select the target local file and configure import information.

Parameter	Description
Select Data Import Method	The method of importing data. Valid values: **Upload Local File**, **DataService Studio**, and **Workbooks from Data Analysis**. In this example, select **Upload Local File**.
Select File	Click **Browse** and select the local file to upload.
Select Delimiter	The delimiter of fields in the file. Valid values: **Comma**, **Tab**, **Semicolon**, **Space**, **|**, **#**, and **&**. In this example, select **Comma**.
Original Character Set	The character set of the file. Valid values: **GBK**, **UTF-8**, **CP936**, and **ISO-8859**. In this example, select **GBK**.

Parameter	Description
Import First Row	The line from which data is to be imported. In this example, select **1**.
First Row as Field Names	Specifies whether to use the first line as the header line.
Data Preview	The preview of the data to import. **Note** If the data volume is large, only the data in the first 100 lines and 50 columns appears.

4. After the configuration is completed, click **Next**.
5. Select a matching mode for the fields in the source file and destination table. In this example, select **By Location**.
6. Click **Import Data**.

Data import methods

- Create a sync node

  This method is used to import data from various data stores, such as Relational Database Service (RDS), MySQL, SQL Server, PostgreSQL, MaxCompute, ApsaraDB for Memcache, Distribute Relational Database Service (DRDS), Object Storage Service (OSS), Oracle, FTP, DM, Hadoop Distributed File System (HDFS), and MongoDB.

- Upload a local file

  This method is used to upload .txt and .csv files not exceeding 10 MB. The destination object can be a partitioned table or a non-partitioned table. The partition key value cannot be in Chinese.

- Run Tunnel commands to upload a file

  This method is used to upload local files and other resource files of any size.

What to do next

Now you have learned how to create tables and import data. You can proceed with the next tutorial. In the next tutorial, you will learn how to create a workflow and how to compute and analyze data in a workspace. For more information, see Create a workflow.

2.2.3. Create a workflow

This topic describes how to create a workflow, create nodes in the workflow, and configure the dependencies among the nodes. After the configuration is completed, you can use the Data Analytics feature to further compute and analyze data in the workspace.

Prerequisites

The bank_data table for storing business data and the result_table table for storing data analytics results are created in the workspace. Data is imported to the bank_data table. For more information, see Create tables and import data.

Context

The Data Analytics feature of DataWorks allows you to drag and drop nodes in a workflow and configure the dependencies among the nodes. You can process data and configure dependencies in the data based on the workflow.

Create a workflow

1. Log on to the DataWorks console.
2. On the **DataStudio** page that appears, move the pointer over the **Create** icon and click **Workflow**.
3. In the **Create Workflow** dialog box, set the **Business Name** and **Description** parameters.
4. Click **Create**.

Create nodes and configure dependencies among the nodes

This section describes how to create a zero load node named start and an ODPS SQL node named insert_data in the workflow, and configure the insert_data node to depend on the start node.

> **Note** Pay attention to the following points when you use a zero load node:
>
> - A zero load node is a control node used to maintain and control its descendant nodes. When the zero load node runs in a workflow, it does not generate any data.
> - If other nodes are dependent on the zero load node and it is manually set to Failed by an administration expert, the pending descendant nodes cannot be triggered. During the O&M process, an administration expert can disable the zero load node to prevent errors of ancestor nodes from being further expanded.
> - Typically, the ancestor node of the zero load node in a workflow is set to the root node of the workspace. The root node of the workspace is named in the `Workspace name_root` format.

We recommend that you create a zero load node as the root node of a workflow to control the entire workflow.

1. Double-click the name of the workflow to go to the dashboard of the workflow. Move the pointer over **Zero-Load Node** and drag it to the development panel on the right.
2. In the **Create Node** dialog box, set **Node Name** to start and click **Commit**.
3. Repeat steps 1 and 2 to create an **ODPS SQL** node and name it insert_data.
4. Draw a line to connect the nodes and set the start node as the ancestor node of the insert_data node.

Configure the ancestor node of the zero load node

The zero load node in a workflow is the controller of the entire workflow, and also the ancestor of all nodes in the workflow. Generally, the zero load node in a workflow depends on the root node of the workspace.

1. Double-click the name of the zero load node. On the page that appears, click the **Properties** tab in the right-side navigation pane.
2. In the **Properties** section, click **Use Root Node** and set the ancestor node of the zero load node as the root node of the workspace.

3. After the configuration is completed, click in the upper-left corner.

Edit code in the ODPS SQL node

This section provides a sample SQL statement used to query and save the number of singles with different education levels who loan to buy houses in the ODPS SQL node insert_data. The queried data can be analyzed by and presented in descendant nodes of insert_data.

The SQL statement is as follows:

```
INSERT OVERWRITE TABLE result_table  --Insert data to the result_table table.
SELECT education
  , COUNT(marital) AS num
FROM bank_data
WHERE housing = 'yes'
  AND marital = 'single'
GROUP BY education
```

Run and debug the ODPS SQL node

1. After the SQL statement is entered in the insert_data node, click **Save**.
2. Click **Run** to view the runtime logs and result.

Commit the workflow

1. After running and debugging the ODPS SQL node insert_data, return to the workflow editing page and click **Commit**.
2. In the **Commit** dialog box, select the nodes to be committed, set **Description**, and then select **Ignore I/O Inconsistency Alerts**.
3. Click **Commit**.

What to do next

Now you have learned how to create and commit a workflow. You can proceed with the next tutorial. In the next tutorial, you will learn how to create a sync node to export data to different types of data stores. For more information, see Create a sync node.

2.2.4. Create a sync node

This topic describes how to create a sync node to export data from MaxCompute to a MySQL database.

Background

In DataWorks, Data Integration can be used to periodically transfer the business data generated in a business system to a workspace. After the data is computed in SQL nodes, Data Integration periodically exports the computing results to your specified data store for further display or use.

Add a connection

> **Note** Only the workspace administrator can create connections, and members of other roles can only view the connections.

1. Log on to the DataWorks console. On the DataSudio page that appears, click the DataWorks icon in the upper-left corner and choose **All Products > Data Integration**.
2. In the left-side navigation pane, choose **Sync Resources > Connections**. On the **Connections** page, click **Create Connection**.
3. In the **Create Connection** dialog box, set Data Source Type to **MySQL**.
4. Set parameters in the **Add MySQL Connection** dialog box. The following table lists the parameters that need to be set when the connection type is set to **User-Created Data Store**.

Parameter	Description
Data Source Type	The type of the connection. In this example, set the type to **MySQL > User-Created Data Store**.
Data Source Name	The name of the connection. The name can contain letters, digits, and underscores (_) and must start with a letter.
Description	The description of the connection. The description cannot exceed 80 characters in length.
Applicable Environment	The environment where the connection is configured. Valid values: **Development** and **Production**. **Note** This field is available only for workspaces in standard mode.
JDBC URL	The JDBC connectivity URL of the database, in the format of `jdbc:mysql://ServerIP:Port/Database`.
Username	The username for logging on to the database. **Note** You must enter the information of your MySQL database.
Password	The password for logging on to the database.

5. Click **Test Connection**.
6. If the connectivity test is successful, click **Complete**.

Verify that a table exists in the destination MySQL database

Use the following table creation statement to create the odps_result table in the MySQL database:

```
CREATE TABLE `ODPS_RESULT` (
`education` varchar(255) NULL ,
`num` int(10) NULL
);
```

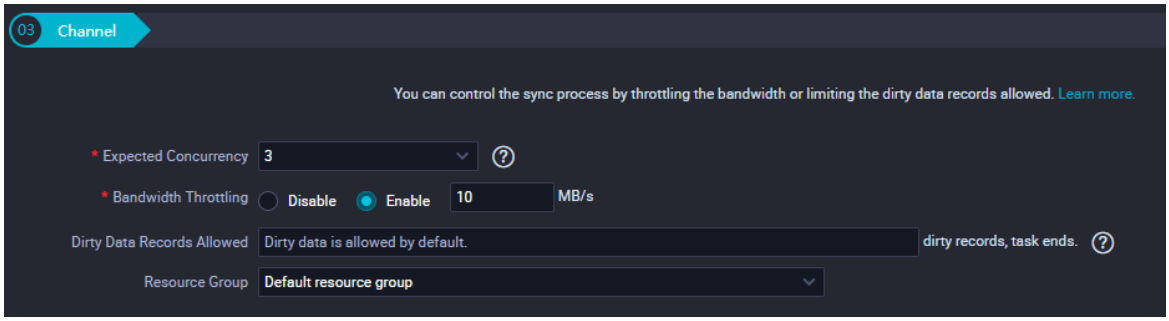
After the table is created, run the `desc odps_result;` statement to view the table details.

Create and configure a sync node

This section describes how to create and configure the sync node write_result to export data in the result_table table to your MySQL database. The procedure is as follows:

1. Go to the **Data Analytics** tab and create the sync node write_result.
2. Configure the insert_data node as the ancestor node of the write_result node.
3. Set **Data Source** to **MaxCompute > odps_first** and **Table** to result_table.
4. Select the odps_result table in your MySQL database as the destination table.
5. Configure the mapping between the fields in the source and destination tables.

   Fields in the source table on the left have a one-to-one mapping with fields in the destination table on the right. You can click **Add Line** to add a field or move the pointer over a field and click the **Delete** icon to delete the field.
6. In the Channel section, configure the synchronization rate limit and dirty data check rules.



Parameter	Description
Expected Maximum Concurrency	The maximum number of concurrent threads to read data from and write data to data storage within the sync node. You can configure the concurrency for a node on the codeless UI.
Bandwidth Throttling	Specifies whether to enable bandwidth throttling. You can enable bandwidth throttling and set a maximum transmission rate to avoid heavy read workload of the source. We recommend that you enable bandwidth throttling and set the maximum transmission rate to a proper value.
Dirty Data Records Allowed	The maximum number of dirty data records allowed.

Parameter	Description
Resource Group	The servers on which nodes are run. If an excessively large number of nodes are run in the default resource group, some nodes may be delayed due to insufficient resources. In this case, we recommend that you add a custom resource group.

7. Preview and save the configuration.

   After the configuration is completed, scroll up and down to view the node configuration. Verify that the configuration is correct and click **Save**.

Commit the sync node

Return to the workflow after saving the sync node. In the top navigation bar, click **Commit** to commit the sync node to scheduling system. The scheduling system automatically and periodically runs the node starting from the next day based on the configured properties of the node.

What to do next

Now you have learned how to create a sync node to export data to a specific data store. You can proceed with the next tutorial. In the next tutorial, you will learn how to configure recurrence and dependencies for a sync node. For more information, see Configure recurrence and dependencies for a node.

2.2.5. Configure recurrence and dependencies for a node

This topic describes how to configure recurrence and dependencies for a node in the DataWorks console.

> **Note** In this topic, the sync node write_result is used as an example and the recurrence is set to weekly.

DataWorks has a powerful scheduling engine to trigger nodes based on the recurrence and dependencies of nodes. DataWorks guarantees that tens of millions of nodes run accurately and punctually per day based on directed acyclic graphs (DAGs). In the DataWorks console, you can set the recurrence to minutely, hourly, daily, weekly, or monthly.

Configure recurrence for the sync node

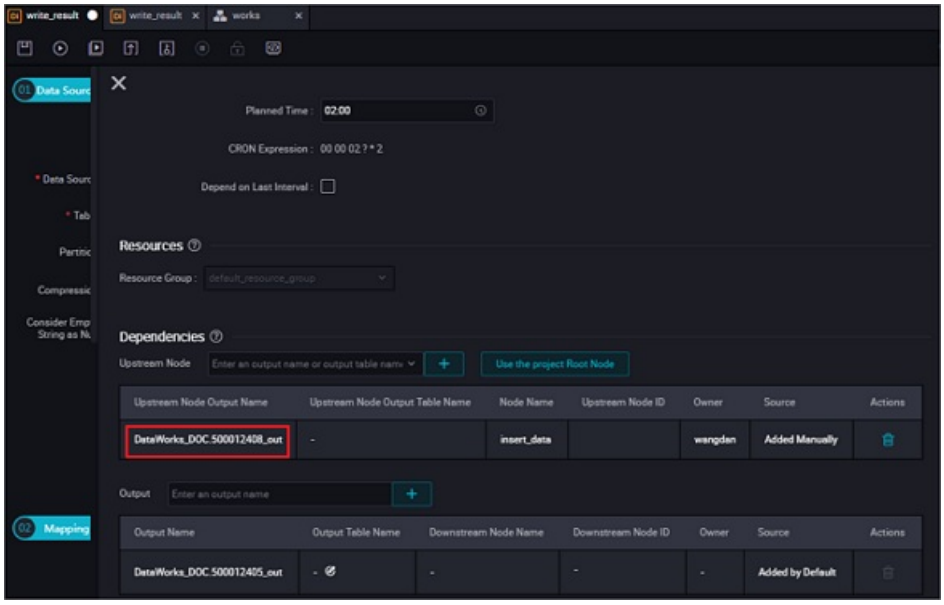
1. After the sync node write_result is created, double-click the sync node to configure it.
2. Click the **Properties** tab in the right-side navigation pane to configure recurrence for the sync node.

Parameter	Description
Execution Mode	The mode in which the node is run. Valid values: **Normal** and **Dry-Run**. You can select one based on your own needs.
Retry Upon Error	Specifies whether to rerun the node upon an error.

Parameter	Description
Valid From	The date from which the node is effective.
Skip Execution	Specifies whether to skip execution of the node.
Cycle	The recurrence of the node, which can be monthly, weekly, daily, hourly, or minutely. In this example, the recurrence is set to weekly.
Customize Runtime	Specifies whether to run the node periodically. This field is selected by default.
Run Every or **Run At**	The specific day or time when the node is run. For example, you can configure a node to run at 02:00 every Tuesday.
CRON Expression	The value is `00 00 02 ? * 2` by default. It cannot be modified.
Cross-Cycle Dependencies	Specifies whether the node depends on the result of the last cycle.

Configure dependencies for the sync node

After configuring recurrence for the sync node write_result, you can continue to configure dependencies for the sync node.



You can configure the ancestor node on which the sync node depends. After that, the scheduling system can trigger the sync node when the specified time arrives, only after the instance of the ancestor node is run.

The configuration shown in the preceding figure indicates that the instance of the sync node is not triggered until the instance of the ancestor node insert_data is run.

The scheduling system creates the Workspace name_root node for each workspace as the root node by default. If no ancestor node is configured for the sync node, the sync node depends on the root node.

Commit the sync node

Save the configuration of the sync node write_result and click **Commit** to commit the node to the scheduling system.

Only after a node is committed, the scheduling system can automatically generate and run instances at the specified time starting from the next day according to the recurrence property.

> **Note** If a node is committed after 23:30, the scheduling system automatically generates and runs instances of the node starting from the third day.

What to do next

Now you have learned how to configure recurrence and dependencies for a sync node. You can proceed with the next tutorial. In the next tutorial, you will learn how to perform O&M on the committed node and troubleshoot errors based on the runtime logs. For more information, see Run a node and troubleshoot errors.

2.2.6. Run a node and troubleshoot errors

This topic describes how to run and maintain a node, and troubleshoot errors based on logs.

When you configure recurrence and dependencies for the sync node write_result, you have configured the sync node to run at 02:00 every Tuesday. After you commit this node, you have to wait until the next day to view the automatic execution result of this node. DataWorks allows you to run nodes in the following modes: test run, retroactive run, and periodic run. This helps you confirm the run time of each node instance, dependencies among node instances, and whether generated data meets your expectation.

- Test run: Nodes are triggered manually. This method is recommended if you only want to confirm the run time and running of a single node.
- Retroactive run: Nodes are triggered manually. This method is recommended if you want to confirm the run time of multiple nodes and dependencies among them, or if you want to re-perform data analysis and computing from the specific root node.
- Periodic run: Nodes are triggered automatically. The scheduling system automatically triggers the instances of committed nodes at the specified time points starting from 00:00 the next day after the nodes are committed. In addition, the scheduling system checks whether the ancestor instances of each instance have been run when the scheduled time arrives. If all the ancestor instances have been run when the scheduled time arrives, the current instance is automatically triggered without manual intervention.

> **Note** The scheduling system generates instances for manually triggered nodes and auto triggered nodes based on the same rules.
>
> - The scheduling system generates an instance for each recurrence, which can occur by day, hour, minute, month, or week.
> - The scheduling system runs an instance only on the specified date and generates runtime logs for the instance.
> - The scheduling system does not run an instance on other dates except the specified date. Instead, it directly change the status of the instance to successful when the running conditions are met. In this case, the scheduling system does not generate runtime logs.

Test run

1. Log on to the DataWorks console.
2. On the DataStudio page that appears, click the DataWorks icon in the upper-left corner and choose **All Products > Operation Center** to go to the **Operation Center** page.
3. In the left-side navigation pane, click **Recurring**. On the page that appears, find the target node to run. Click **Test** next to the target node.
4. In the **Smoke Test** dialog box, set the **Smoke Test Instance Name** and **Data Timestamp** parameters and click **OK**.
5. On the **Smoke Test** page that appears, click an instance. The directed acyclic graph (DAG) of the instance appears on the right.

   Right-click the instance to view its dependencies and details, and stop or re-run this instance.

> Note
>
> - In test run mode, a node is triggered manually. The corresponding instance runs immediately when the scheduled time arrives, regardless of whether its ancestor instances have been run.
> - The sync node write_result is configured to run at 02:00 every Tuesday. According to the instance generation rules described earlier in this topic, if the data timestamp, which is one day before the run date, is set to Monday for a test run, the scheduling system runs the instance for the sync node write_result at 02:00 on Tuesday. If the data timestamp is not set to Monday for the test run, the scheduling system changes the status of the instance to successful at 02:00 on Tuesday with no runtime logs generated.

Retroactive run

A retroactive run is recommended if you want to confirm the run time of multiple nodes and dependencies among them, or if you want to re-perform data analysis and computing from the specific root node.

1. On the **Operation Center** page, choose **Task List > Recurring** in the left-side navigation pane.
2. Find the target node to run and choose **Patch Data > Current Node Retroactively** for the target node.
3. In the **Patch Data** dialog box, set parameters and click **OK**.

Parameter	Description
Retroactive Instance Name	Enter the name of the retroactive instance.
Data Timestamp	Select the data timestamp of the retroactive instance. The retroactive instance is run on the next day of the specified timestamp.
Node	The default value is the current node, which cannot be changed.
Parallelism	Select **Disable** or specify several nodes to run concurrently.

4. On the **Retroactive** page that appears, click the retroactive instance to view the DAG of the

instance.

Right-click the instance to view its dependencies and details, and stop or re-run this instance.

> Note
>
> - In retroactive run mode, instance running requires the result of instance running on the previous day. For example, retroactive instances are configured to run between September 15, 2017 and September 18, 2017. If the instance on September 15 fails to run, the instance on September 16 cannot run.
> - The sync node write_result is configured to run at 02:00 every Tuesday. According to the instance generation rules described earlier in this topic, if the data timestamp, which is one day before the run date, is set to Monday for a retroactive instance, the scheduling system runs the instance for the sync node write_result at 02:00 on Tuesday. If the data timestamp is not set to Monday for the retroactive instance, the scheduling system changes the status of the instance to successful at 02:00 on Tuesday with no runtime logs generated.

Periodic run

In periodic run mode, the scheduling system automatically triggers instances for all nodes based on the scheduling configuration. No menu item is provided for you to control the periodic run on the DataStudio page. You can view the instance information and runtime logs in either of the following ways:

- On the **Operation Center** page, choose **Operation Center > Node O&M > Recurring** in the left-side navigation pane. On the page that appears, set parameters such as the data timestamp or run date, find an instance of the sync node write_result, and then right-click the instance to view the instance information and runtime logs.
- On the **Recurring** page, click the instance of the target node to view the DAG of the instance.

  Right-click the instance to view its dependencies and details, and stop or re-run this instance.

> Note
>
> - If an ancestor node is not run, a descendant node does not run either.
> - If the initial status of an instance is pending, the scheduling system checks whether all its ancestor instances have been run when the scheduled time arrives.
> - The instance can be triggered and run only after all its ancestor instances have been run and the scheduled time arrives.
> - If an instance is pending, check whether all its ancestor instances have been run and whether the scheduled time arrives.

2.3. Data Integration

2.3.1. Data Integration

2.3.1.1. Overview

Data Integration is a stable and efficient data synchronization service provided by Alibaba Group. You can add data stores to and remove them from DataWorks by using this service. Data Integration is designed to implement fast and stable data transmission and synchronization between various heterogeneous data stores in complex networks.

Batch data synchronization

The Data Integration service facilitates data transmission between diverse structured and semi-structured data stores. It provides readers and writers for the supported data stores and defines a channel based on the data stores and datasets of a reader and a writer. This service applies a simplified data type system.

Supported data store types

Data Integration provides extensive options for data stores listed as follows:

- Text storage, such as File Transfer Protocol (FTP) and SSH File Transfer Protocol (SFTP) servers, Object Storage Service (OSS), and multimedia files
- Relational databases, such as Relational Database Service (RDS) , MySQL, and PostgreSQL
- NoSQL databases, such as Memcache, Redis, MongoDB, and HBase
- Big data products, such as MaxCompute, and Hadoop Distributed File System (HDFS)
- Massively parallel processor (MPP) databases

For more information, see Supported data sources.

> **Note** The parameter settings vary with data stores. Ensure that settings of data stores and data synchronization nodes are consistent with the site conditions.

Synchronization node configuration modes

You can configure data synchronization nodes by using the codeless UI or code editor.

- **Codeless UI**: enables you to configure data synchronization nodes by using the codeless UI. This mode provides step-by-step instructions to help you quickly complete the configuration of a data synchronization node. This mode is easy to use but provides only limited features.
- **Code editor**: allows you to write a JSON script for each data synchronization node. The code editor provides advanced features to facilitate flexible configuration. This mode is suitable for experienced users and increases the cost of learning.

> **Note**
>
> - The code generated for a data configuration node on the codeless UI can be converted to a script. This conversion is irreversible. After the conversion is complete, the configuration node cannot be switched back.
> - You must configure data stores and create a destination table before editing the code of a data synchronization node.

Network types

A data store can be located in the classic network, a VPC, or a user-created data center network.

Network type	Description
Classic network	A network deployed by Alibaba Cloud, which is shared with other tenants. Networks of this type are easy to use.
VPC	A Virtual Private Cloud (VPC) network created on Apsara Stack, which is isolated to only one Apsara Stack tenant account. You have full control over your VPC, including customizing the IP address range, dividing your VPC into multiple subnets, and configuring routing tables and gateways.
User-created data center network	A data center network deployed by yourself, which can be connected to DataWorks.

Note

- Specify the network type as classic network for public network connections. Note the public network bandwidth and other relevant billing. We recommend that you do not use public network connections.
- If you need to configure a data synchronization node on an on-premises data center network, use the code editor and run the node on a local resource group. You can also configure the node by specifying the reader and writer in a shell node.
- VPC is an isolated network environment, which allows you to customize the IP address range, subnets, and gateways. With its continuous security enhancement, VPC has become more widely used. In this context, Data Integration provides RDS-MySQL, and RDS-PostgreSQL. You do not need to create an ECS instance in a VPC. Instead, DataWorks automatically detects an ECS instance through a reverse proxy to provide network connectivity.

  Data Integration also supports other Apsara Stack and Alibaba Cloud databases, such as PPAS, OceanBase, Redis, MongoDB, Memcache, Table Store, and HBase. To establish a connection to a non-RDS data store in a VPC for configuring data synchronization nodes, you need to create an ECS instance in the VPC.

Constraints and limits

- Data Integration supports only the synchronization of structured, semi-structured, and unstructured data. Structured databases include RDS. Unstructured data, such as OSS objects and text files, must be capable of being converted to structured data. Data Integration allows you to synchronize logical two-dimensional tables that are converted from source data. However, it cannot synchronize other unstructured data, such as MP3 files stored in OSS, to MaxCompute.
- Data Integration supports data synchronization and exchange in one region or between multiple regions.

  In some regions, data can be transmitted over the classic network, but this cannot be guaranteed. We recommend that you use a public network connection if the classic network is required but cannot be connected.
- Data Integration supports only data synchronization but not data stream consumption.

2.3.1.2. Terms

Concurrency

Concurrency indicates the maximum number of concurrent threads to read data from or write data to data storage within a single sync node.

Bandwidth throttling

If bandwidth throttling is enabled for a sync node, you must specify a maximum transmission rate.

Dirty data

Dirty data indicates meaningless data and data that does not match the specified data type. For example, you want to write data of the Varchar type in the source table to an Int-type field in the destination table. A data conversion error occurs and the data cannot be written to the destination table. In this case, the data is dirty.

Connection

A connection in DataWorks indicates a data source, which can be a database or a data warehouse. DataWorks supports various connection types, and supports data synchronization between connections of different types.

2.3.2. Data sources

2.3.2.1. Supported connections

Data Integration is a stable, efficient, and scalable data synchronization service provided by Alibaba Cloud. It can be used to transmit large amounts of data for Alibaba Cloud services, such as MaxCompute, AnalyticDB, and Object Storage Service (OSS).

The following table lists the connection types supported by Data Integration.

Connection category	Connection type	Reader	Writer	Configuration method	Hosted on
Relational database	MySQL	Supported	Supported	Codeless UI or code editor	Apsara Stack or on-premises database
Relational database	PostgreSQL	Supported	Supported	Codeless UI or code editor	Apsara Stack or on-premises database
Relational database	Oracle	Supported	Supported	Codeless UI or code editor	On-premises database
Relational database	Db2	Supported	Supported	Code editor	On-premises database
Relational database	Dameng (DM)	Supported	Supported	Code editor	On-premises database
Relational database	RDS for PPAS	Supported	Supported	Code editor	Apsara Stack

Connection category	Connection type	Reader	Writer	Configuration method	Hosted on
Massively parallel processing (MPP)	HybridDB for PostgreSQL	Supported	Supported	Codeless UI or code editor	Apsara Stack
Big data storage	MaxCompute	Supported	Supported	Codeless UI or code editor	Apsara Stack
Big data storage	DataHub	Not supported	Supported	Code editor	Apsara Stack
Big data storage	Elasticsearch	Not supported	Supported	Code editor	Apsara Stack
Unstructured data storage	OSS	Supported	Supported	Codeless UI or code editor	Apsara Stack
Unstructured data storage	Hadoop Distributed File System (HDFS)	Supported	Supported	Code editor	On-premises database
Unstructured data storage	FTP	Supported	Supported	Codeless UI or code editor	On-premises database
Message queue	LogHub	Supported	Not supported	Codeless UI or code editor	Apsara Stack
NoSQL	HBase	Supported	Supported	Code editor	Apsara Stack or on-premises database
NoSQL	MongoDB	Supported	Supported	Code editor	Apsara Stack or on-premises database
NoSQL	Memcache	Not supported	Supported	Code editor	Apsara Stack or on-premises database
NoSQL	Table Store	Supported	Supported	Code editor	Apsara Stack
NoSQL	OpenSearch	Not supported	Supported	Code editor	Apsara Stack
NoSQL	Redis	Not supported	Supported	Code editor	Apsara Stack or on-premises database

Connection category	Connection type	Reader	Writer	Configuration method	Hosted on
Performance testing	Stream	Supported	Supported	Code editor	N/A

2.3.2.2. Connection isolation

DataWorks provides the connection isolation feature to isolate data of the development environment from that of the production environment for workspaces in standard mode.

If a connection is configured in both the development and production environments, you can use the connection isolation feature to isolate the connection in the development environment from that in the production environment.

> **Note** Currently, only workspaces in standard mode support the connection isolation feature.

When you configure a sync node, the connection in the development environment is used. After you commit and deploy the sync node to the production environment for running, the connection in the production environment is used. To commit and deploy a node to the production environment for scheduling, you must configure a connection in both the development and production environments. The connection must have the same name in the development and production environments.

The connection isolation feature has the following impacts on workspaces:

- Workspaces in basic mode: The features and configuration dialog boxes of connections are the same as those before the connection isolation feature is added. For more information, see Connection configuration.
- Workspaces in standard mode: The Applicable Environment parameter is added to the configuration dialog boxes of connections.
- Workspaces upgraded from the basic mode to the standard mode: During the upgrade, you are prompted to upgrade connections. After the upgrade, the connections in the development environment are isolated from those in the production environment.

2.3.2.3. Sync data monitoring

The Sync Data Monitoring page displays the total number of sync node instances for different connections and the instance details based on the selected workspace and time range.

The cut-off time of data to be displayed is 0 minutes 0 seconds of the current hour. For example, if the current time is 2019-04-04 10:10:00, the page displays the data generated before 2019-04-04 10:00:00.

1. Log on to the DataWorks console and select a workspace.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > Data Integration** to go to the **Data Integration** page.
3. In the left-side navigation pane, click **Sync Data Monitoring**. On the page that appears, view the total number of sync node instances for different connections and the instance details.
   - View summary data by connection type

The Source and Target sections display the summary data of source connections and that of destination connections, respectively. Take source connections as an example. If the Source section displays MaxCompute with the value 1, a sync node instance whose source connection is MaxCompute is run in the selected time range.

- View instance details

  The Sync Instances section displays the details of all sync node instances that are run in the selected time range. You can also perform the following operations:

  - Click a node in the **Node Name** column to go to the node configuration page.
  - Search for instances by condition, such as the ID, committer, node name, source connection type, and destination connection type. Sort search results based on the number of synchronized data entries or the size of synchronized data.

2.3.2.4. Connectivity testing

This topic describes the FAQ about connectivity testing on connections.

When configuring a security group for a connection hosted on an Elastic Compute Service (ECS) instance, add the IP address of the scheduling cluster to the inbound and outbound rules of the security group. If the security group is not properly configured, data synchronization fails due to a connection failure.

To set a wide port range for a security group rule, call relevant API operations, instead of using the console.

Common scenarios of connectivity test failures

When a connection fails the connectivity test, check whether the region, network type, whitelist, database name, and username are properly configured for the connection. The following errors may occur during connectivity testing:

- The database password is incorrect.
- The network connection fails.
- A network error occurs during data synchronization.

  Check the log and determine which resource group is used. Check whether the resource group is a custom one.

  For a Relational Database Service (RDS) connection or a MongoDB connection, if a custom resource group is used, check whether its IP addresses are added to the whitelist of the connection.

  Check whether both the source and destination connections pass the connectivity test. For an RDS connection or a MongoDB connection, check whether all relevant IP addresses are added to the whitelist of the connection. If the IP address of a server is not added to the whitelist, the sync node fails when it runs on this server. However, the sync node succeeds when it runs on another server whose IP address is added to the whitelist.

- The result shows that a sync node is run but the log contains a disconnection error in port 8000.

  This issue occurs because a custom resource group is used and no inbound rule is configured for the corresponding IP address and port 8000 in the security group. To resolve the issue, add the IP address and port to the inbound rule of the security group and run the node again.

Examples of connectivity test failures

Example 1

- Symptom

  A connection failed the connectivity test. The database connection failed. The following information is involved: Database URL: jdbc:mysql://xx.xx.xx.x:xxxx/t_uoer_bradef. Username: xxxx_test. Error message: Access denied for user 'xxxx_test'@'%' to database 'yyyy_demo'.

- Troubleshooting

  i. Check whether the configuration of the connection is correct.

  ii. Check whether the database password is correct, the whitelist is properly configured, and your account has the permission to access the database. You can grant the required permissions in the RDS console.

- Example 2

  - Symptom

    A connection failed the connectivity test. The following error message is returned:

    ```
    error message: Timed out after 5000 ms while waiting for a server that matches ReadPreferenceServer Selector{readPreference=primary}. Client view of cluster state is {type=UNKNOWN, servers=[(xxxxxxxxx x), type=UNKNOWN, state=CONNECTING, exception={com.mongodb.MongoSocketReadException: Prem aturely reached end of stream}}]
    ```

  - Troubleshooting

    Before testing the connectivity to a MongoDB connection that is not deployed in a Virtual Private Cloud (VPC), add relevant IP addresses to the whitelist of the connection.

2.3.2.5. Add a MySQL connection

DataWorks provides MySQL Reader and Writer for you to read data from and write data to MySQL connections. You can use the codeless user interface (UI) or code editor to configure sync nodes for MySQL connections.

Procedure

1. Log on to the DataWorks console as a workspace administrator.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > Data Integration** to go to the **Data Integration** page.
3. In the left-side navigation pane, choose **Sync Resources > Connections**. On the page that appears, click **Add Connection** in the upper-right corner.
4. In the **Add Connection** dialog box that appears, select **MySQL**.
5. Set parameters for the MySQL connection.

   The MySQL connection type can be set to **ApsaraDB for RDS** or **User-Created Data Store**.

   - The following figure shows the parameters that appear after you set **Connect To** to **ApsaraDB for RDS**.

Parameter	Description

Parameter	Description
Connect To	The type of the connection. In this example, set the value to **ApsaraDB for RDS**.
Connection Name	The name of the connection. The name can contain letters, digits, and underscores (_). It must start with a letter.
Description	The description of the connection. The description can be up to 80 characters in length.
Applicable Environment	The environment in which the connection is used. Valid values: **Development** and **Production**. **Note** This parameter is available only when the workspace is in standard mode.
RDS Instance ID	The ID of the ApsaraDB RDS for MySQL instance. You can view the ID in the ApsaraDB RDS for MySQL console.
RDS Instance Account ID	The ID of the Apsara Stack tenant account used to purchase the ApsaraDB RDS for MySQL instance.
Username and Password	The username and password used to connect to the database.

- The following figure shows the parameters that appear after you set **Connect To** to **User-Created Data Store**.

Parameter	Description
Connect To	The type of the connection. In this example, set the value to **User-Created Data Store**.
Connection Name	The name of the connection. The name can contain letters, digits, and underscores (_). It must start with a letter.
Description	The description of the connection. The description can be up to 80 characters in length.
Applicable Environment	The environment in which the connection is used. Valid values: **Development** and **Production**. **Note** This parameter is available only when the workspace is in standard mode.
JDBC URL	The Java Database Connectivity (JDBC) URL of the MySQL database, in the format of `jdbc:mysql://Server IP:Port/Database`.
Username and Password	The username and password used to connect to the database.

6. Click **Test Connection**.
7. After the connection passes the connectivity test, click **Complete**.

What to do next

Now you have learned how to configure the MySQL connection. You can proceed with the next tutorial, such as configuring MySQL Reader or Writer. For more information, see Configure the MySQL reader and Configure MySQL Writer.

2.3.2.6. Add an SQL Server connection

DataWorks provides SQL Server Reader and Writer for you to read data from and write data to SQL Server connections. You can use the codeless user interface (UI) or code editor to configure sync nodes for SQL Server connections.

Procedure

1. Log on to the DataWorks console as a workspace administrator.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > Data Integration** to go to the **Data Integration** page.
3. In the left-side navigation pane, choose **Sync Resources > Connections**. On the page that appears, click **Add Connection** in the upper-right corner.
4. In the **Add Connection** dialog box that appears, select **SQL Server**.
5. Set parameters for the SQL Server connection.

   The SQL Server connection type can be set to **ApsaraDB for RDS** or **User-Created Data Store**. You can select a type as required.

   The following figure shows the parameters that appear after you set **Connect To** to **ApsaraDB for RDS**.

Parameter	Description
Connect To	The type of the connection. In this example, set the value to **ApsaraDB for RDS**.
Connection Name	The name of the connection. The name can contain letters, digits, and underscores (_). It must start with a letter.
Description	The description of the connection. The description can be up to 80 characters in length.
Applicable Environment	The environment in which the connection is used. Valid values: **Development** and **Production**. **Note** This parameter is available only when the workspace is in standard mode.

Parameter	Description
RDS Instance ID	The ID of the ApsaraDB RDS for SQL Server instance. You can view the ID in the ApsaraDB RDS for SQL Server console. To view the ID of an ApsaraDB RDS for SQL Server instance, go to the **Dashboard** page, choose **Database > Relational Database Service** in the left-side navigation pane, and then click the target instance.
RDS Instance Account ID	The ID of the Apsara Stack tenant account used to purchase the ApsaraDB RDS for SQL Server instance.
Database Name	The name of the ApsaraDB RDS for SQL Server database.
Username and Password	The username and password used to connect to the database.

Note The connection becomes active only after you add relevant IP addresses to the whitelist of the ApsaraDB RDS for SQL Server instance.

The following figure shows the parameters that appear after you set **Connect To** to **User-Created Data Store**.

Parameter	Description
Connect To	The type of the connection. In this example, set the value to **User-Created Data Store**.
Connection Name	The name of the connection. The name can contain letters, digits, and underscores (_). It must start with a letter.
Description	The description of the connection. The description can be up to 80 characters in length.
Applicable Environment	The environment in which the connection is used. Valid values: **Development** and **Production**. **Note** This parameter is available only when the workspace is in standard mode.
JDBC URL	The Java Database Connectivity (JDBC) URL of the SQL Server database, in the format of `jdbc:sqlserver://Server IP:Port;DatabaseName=Database`.
Username and Password	The username and password used to connect to the database.

Parameter	Description
Enable reverse VPC access	Specifies whether to enable reverse Virtual Private Cloud (VPC) access. If you select **Enable reverse VPC access**, you must set **Datasource VPC ID** and **Datasource VPC Region**. You can set **Datasource instanceId(like ECS condition)** and **Datasource IP (IDC condition)** as required.

6. Click **Test Connection**.
7. After the connection passes the connectivity test, click **Complete**.

What to do next

Now you have learned how to configure the SQL Server connection. You can proceed with the next tutorial, such as configuring SQL Server Reader or Writer. For more information, see Configure SQL Server Reader and Configure SQL Server Writer.

2.3.2.7. Add a PostgreSQL connection

DataWorks provides PostgreSQL Reader and Writer for you to read data from and write data to PostgreSQL connections. You can use the codeless user interface (UI) or code editor to configure sync nodes for PostgreSQL connections.

Procedure

1. Log on to the DataWorks console as a workspace administrator.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > Data Integration** to go to the **Data Integration** page.
3. In the left-side navigation pane, choose **Sync Resources > Connections**. On the page that appears, click **Add Connection** in the upper-right corner.
4. In the **Add Connection** dialog box that appears, select **PostgreSQL**.
5. Set parameters for the PostgreSQL connection.

   The PostgreSQL connection type can be set to **ApsaraDB for RDS** or **User-Created Data Store**. You can select a type as required.

   The following figure shows the parameters that appear after you set **Connect To** to **ApsaraDB for RDS**.

Parameter	Description
Connect To	The type of the connection. In this example, set the value to **ApsaraDB for RDS**.
Connection Name	The name of the connection. The name can contain letters, digits, and underscores (_). It must start with a letter.
Description	The description of the connection. The description can be up to 80 characters in length.

Parameter	Description
Applicable Environment	The environment in which the connection is used. Valid values: **Development** and **Production**. **Note** This parameter is available only when the workspace is in standard mode.
RDS Instance ID	The ID of the ApsaraDB RDS for PostgreSQL instance. You can view the ID in the ApsaraDB RDS for PostgreSQL console.
RDS Instance Account ID	The ID of the Apsara Stack tenant account used to purchase the ApsaraDB RDS for PostgreSQL instance.
Database Name	The name of the ApsaraDB RDS for PostgreSQL database.
Username and Password	The username and password used to connect to the database.

The following figure shows the parameters that appear after you set **Connect To** to **User-Created Data Store**.

Parameter	Description
Connect To	The type of the connection. In this example, set the value to **User-Created Data Store**.
Connection Name	The name of the connection. The name can contain letters, digits, and underscores (_). It must start with a letter.
Description	The description of the connection. The description can be up to 80 characters in length.
Applicable Environment	The environment in which the connection is used. Valid values: **Development** and **Production**. **Note** This parameter is available only when the workspace is in standard mode.
JDBC URL	The Java Database Connectivity (JDBC) URL of the PostgreSQL database, in the format of `jdbc:postgresql://Server IP:Port/Database`.
Username and Password	The username and password used to connect to the database.
Enable reverse VPC access	Specifies whether to enable reverse Virtual Private Cloud (VPC) access. If you select **Enable reverse VPC access**, you must set **Datasource VPC ID** and **Datasource VPC Region**. You can set **Datasource instanceId(like ECS condition)** and **Datasource IP (IDC condition)** as required.

6. Click **Test Connection**.
7. After the connection passes the connectivity test, click **Complete**.

What to do next

Now you have learned how to configure the PostgreSQL connection. You can proceed with the next tutorial, such as configuring PostgreSQL Reader or Writer. For more information, see Configure PostgreSQL Reader and Configure the PostgreSQL writer.

2.3.2.8. Add an Oracle connection

DataWorks provides Oracle Reader and Writer for you to read data from and write data to Oracle connections. You can use the codeless user interface (UI) or code editor to configure sync nodes for Oracle connections.

Procedure

1. Log on to the DataWorks console as a workspace administrator.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > Data Integration** to go to the **Data Integration** page.
3. In the left-side navigation pane, choose **Sync Resources > Connections**. On the page that appears, click **Add Connection** in the upper-right corner.
4. In the **Add Connection** dialog box that appears, select **Oracle**.
5. Set parameters for the Oracle connection.

Parameter	Description
Connection Name	The name of the connection. The name can contain letters, digits, and underscores (_). It must start with a letter.
Description	The description of the connection. The description can be up to 80 characters in length.
Applicable Environment	The environment in which the connection is used. Valid values: **Development** and **Production**. **Note** This parameter is available only when the workspace is in standard mode.
JDBC URL	The Java Database Connectivity (JDBC) URL of the Oracle database, in the format of `jdbc:oracle:thin:@Server IP:Port:Database`.
Username and Password	The username and password used to connect to the database.
Enable reverse VPC access	Specifies whether to enable reverse Virtual Private Cloud (VPC) access. If you select **Enable reverse VPC access**, you must set **Datasource VPC ID** and **Datasource VPC Region**. You can set **Datasource instanceId(like ECS condition)** and **Datasource IP (IDC condition)** as required.

6. Click **Test Connection**.
7. After the connection passes the connectivity test, click **Complete**.

What to do next

Now you have learned how to configure the Oracle connection. You can proceed with the next tutorial, such as configuring Oracle Reader or Writer. For more information, see Configure Oracle Reader and Configure Oracle Writer.

2.3.2.9. Add a DM connection

DataWorks allows you to read data from and write data to Dameng (DM) connections. You can use the codeless user interface (UI) or code editor to configure sync nodes for DM connections.

Procedure

1. Log on to the DataWorks console as a workspace administrator.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > Data Integration** to go to the **Data Integration** page.
3. In the left-side navigation pane, choose **Sync Resources > Connections**. On the page that appears, click **Add Connection** in the upper-right corner.
4. In the **Add Connection** dialog box that appears, select **DM**.
5. Set parameters for the DM connection.

Parameter	Description
Connection Name	The name of the connection. The name can contain letters, digits, and underscores (_). It must start with a letter.
Description	The description of the connection. The description can be up to 80 characters in length.
Applicable Environment	The environment in which the connection is used. Valid values: **Development** and **Production**. **Note** This parameter is available only when the workspace is in standard mode.
JDBC URL	The Java Database Connectivity (JDBC) URL of the DM database, in the format of jdbc:mysql://Server IP:Port/Database.
Username and Password	The username and password used to connect to the database.
Enable reverse VPC access	Specifies whether to enable reverse Virtual Private Cloud (VPC) access. If you select **Enable reverse VPC access**, you must set **Datasource VPC ID** and **Datasource VPC Region**. You can set **Datasource instanceId(like ECS condition)** and **Datasource IP (IDC condition)** as required.

6. Click **Test Connection**.

7. After the connection passes the connectivity test, click **Complete**.

2.3.2.10. Add a DRDS connection

DataWorks provides Distributed Relational Database Service (DRDS) Reader and Writer for you to read data from and write data to DRDS connections. You can use the codeless user interface (UI) or code editor to configure sync nodes for DRDS connections.

Procedure

1. Log on to the DataWorks console as a workspace administrator.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > Data Integration** to go to the **Data Integration** page.
3. In the left-side navigation pane, choose **Sync Resources > Connections**. On the page that appears, click **Add Connection** in the upper-right corner.
4. In the **Add Connection** dialog box that appears, select **DRDS**.
5. Set parameters for the DRDS connection.

   The DRDS connection type can be set to **ApsaraDB for DRDS** or **User-Created Data Store**. You can select a type as required.

   - The following figure shows the parameters that appear after you set **Connect To** to **ApsaraDB for DRDS**.

Parameter	Description
Connect To	The type of the connection. In this example, set the value to **ApsaraDB for DRDS**.
Connection Name	The name of the connection. The name can contain letters, digits, and underscores (_). It must start with a letter.
Description	The description of the connection. The description can be up to 80 characters in length.
Applicable Environment	The environment in which the connection is used. Valid values: **Development** and **Production**. **Note** This parameter is available only when the workspace is in standard mode.
Instance ID	The ID of the DRDS instance. You can view the ID in the DRDS console.
Tenant Account ID	The ID of the Apsara Stack tenant account used to purchase the DRDS instance.
Database Name	The name of the DRDS database.
Username and Password	The username and password used to connect to the database.

   - The following figure shows the parameters that appear after you set **Connect To** to **User-**

Created Data Store.

Parameter	Description
Connect To	The type of the connection. In this example, set the value to **User-Created Data Store**.
Connection Name	The name of the connection. The name can contain letters, digits, and underscores (_). It must start with a letter.
Description	The description of the connection. The description can be up to 80 characters in length.
Applicable Environment	The environment in which the connection is used. Valid values: **Development** and **Production**. **Note** This parameter is available only when the workspace is in standard mode.
JDBC URL	The Java Database Connectivity (JDBC) URL of the DRDS database, in the format of `jdbc:mysql://Server IP:Port/Database`.
Username and Password	The username and password used to connect to the database.

6. Click **Test Connection**.
7. After the connection passes the connectivity test, click **Complete**.

What to do next

Now you have learned how to configure the DRDS connection. You can proceed with the next tutorial, such as configuring DRDS Reader or Writer. For more information, see Configure the DRDS reader.

2.3.2.11. Add a POLARDB connection

DataWorks allows you to read data from and write data to POLARDB connections. You can use the codeless user interface (UI) or code editor to configure sync nodes for POLARDB connections.

Procedure

1. Log on to the DataWorks console as a workspace administrator.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > Data Integration** to go to the **Data Integration** page.
3. In the left-side navigation pane, choose **Sync Resources > Connections**. On the page that appears, click **Add Connection** in the upper-right corner.
4. In the **Add Connection** dialog box that appears, select **POLARDB**.
5. Set parameters for the POLARDB connection.

Parameter	Description

Parameter	Description
Connect To	The type of the connection. Set the value to **ApsaraDB for POLARDB**.
Connection Name	The name of the connection. The name can contain letters, digits, and underscores (_). It must start with a letter.
Description	The description of the connection. The description can be up to 80 characters in length.
Applicable Environment	The environment in which the connection is used. Valid values: **Development** and **Production**. **Note** This parameter is available only when the workspace is in standard mode.
Cluster ID	The ID of the ApsaraDB for POLARDB cluster. You can view the ID in the ApsaraDB for POLARDB console.
POLARDB Instance Tenant Account ID	The ID of the Apsara Stack tenant account used to purchase the ApsaraDB for POLARDB instance.
Database Name	The name of the ApsaraDB for POLARDB database.
Username and Password	The username and password used to connect to the database.

6. Click **Test Connection**.
7. After the connection passes the connectivity test, click **Complete**.

2.3.2.12. Add a HybridDB for MySQL connection

DataWorks allows you to read data from and write data to HybridDB for MySQL connections. You can use the codeless user interface (UI) or code editor to configure sync nodes for HybridDB for MySQL connections.

Procedure

1. Log on to the DataWorks console as a workspace administrator.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > Data Integration** to go to the **Data Integration** page.
3. In the left-side navigation pane, choose **Sync Resources > Connections**. On the page that appears, click **Add Connection** in the upper-right corner.
4. In the **Add Connection** dialog box that appears, select **HybridDB for MySQL**.
5. Set parameters for the HybridDB for MySQL connection.

Parameter	Description
Connect To	The type of the connection. Set the value to ApsaraDB for AnalyticDB.

Parameter	Description
Connection Name	The name of the connection. The name can contain letters, digits, and underscores (_). It must start with a letter.
Description	The description of the connection.
Applicable Environment	The environment in which the connection is used. Valid values: **Development** and **Production**. **Note** This parameter is available only when the workspace is in standard mode.
Instance ID	The ID of the HybridDB for MySQL instance. You can view the ID in the HybridDB for MySQL console.
Tenant Account ID	The ID of the Apsara Stack tenant account used to purchase the HybridDB for MySQL instance.
Database Name	The name of the HybridDB for MySQL database.
Username and Password	The username and password used to connect to the database.

6. Click **Test Connection**.
7. After the connection passes the connectivity test, click **Complete**.

2.3.2.13. Add an AnalyticDB for PostgreSQL connection

DataWorks allows you to read data from and write data to AnalyticDB for PostgreSQL connections. You can use the codeless user interface (UI) or code editor to configure sync nodes for AnalyticDB for PostgreSQL connections.

Procedure

1. Log on to the DataWorks console as a workspace administrator.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > Data Integration** to go to the **Data Integration** page.
3. In the left-side navigation pane, choose **Sync Resources > Connections**. On the page that appears, click **Add Connection** in the upper-right corner.
4. In the **Add Connection** dialog box that appears, select **AnalyticDB for PostgreSQL**.
5. Set parameters for the AnalyticDB for PostgreSQL connection.

Parameter	Description
Connect To	The type of the connection. Set the value to **ApsaraDB for AnalyticDB**.
Connection Name	The name of the connection. The name can contain letters, digits, and underscores (_). It must start with a letter.

Parameter	Description
Description	The description of the connection. The description can be up to 80 characters in length.
Applicable Environment	The environment in which the connection is used. Valid values: **Development** and **Production**. **Note** This parameter is available only when the workspace is in standard mode.
Instance ID	The ID of the AnalyticDB for PostgreSQL instance. You can view the ID in the AnalyticDB for PostgreSQL console.
Tenant Account ID	The ID of the Apsara Stack tenant account used to purchase the AnalyticDB for PostgreSQL instance.
Database Name	The name of the AnalyticDB for PostgreSQL database.
Username and **Password**	The username and password used to connect to the database.

6. Click **Test Connection**.
7. After the connection passes the connectivity test, click **Complete**.

2.3.2.14. Add a MaxCompute connection

MaxCompute offers a comprehensive data import scheme to support fast computing for large amounts of data.

DataWorks provides MaxCompute Reader and Writer for you to read data from and write data to MaxCompute connections.

Note DataWorks automatically creates a connection named odps_first for each workspace based on the MaxCompute project that serves as the compute engine.

Procedure

1. Log on to the DataWorks console as a workspace administrator.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > Data Integration** to go to the **Data Integration** page.
3. In the left-side navigation pane, choose **Sync Resources > Connections**. On the page that appears, click **Add Connection** in the upper-right corner.
4. In the **Add Connection** dialog box that appears, select **MaxCompute (ODPS)**.
5. Set parameters for the MaxCompute connection.

Parameter	Description
Connection Name	The name of the connection. The name can contain letters, digits, and underscores (_). It must start with a letter.

Parameter	Description
Description	The description of the connection. The description can be up to 80 characters in length.
Applicable Environment	The environment in which the connection is used. Valid values: **Development** and **Production**. **Note** This parameter is available only when the workspace is in standard mode.
ODPS Endpoint	The endpoint of MaxCompute. This parameter is read-only, the value of which is automatically obtained from system configurations.
Tunnel Endpoint	The tunnel endpoint of MaxCompute.
MaxCompute Project Name	The name of the MaxCompute project.
AccessKey ID and AccessKey Secret	The AccessKey ID and AccessKey secret used as logon credentials.

6. Click **Test Connection**.
7. After the connection passes the connectivity test, click **Complete**.

What to do next

Now you have learned how to configure the MaxCompute connection. You can proceed with the next tutorial, such as configuring MaxCompute Reader or Writer. For more information, see Configure MaxCompute Reader and Configure the MaxCompute writer.

2.3.2.15. Add a DataHub connection

DataWorks provides DataHub Writer for you to write data from other connections to DataHub connections.

DataHub offers a comprehensive data import scheme to support fast computing for large amounts of data.

Procedure

1. Log on to the DataWorks console as a workspace administrator.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > Data Integration** to go to the **Data Integration** page.
3. In the left-side navigation pane, choose **Sync Resources > Connections**. On the page that appears, click **Add Connection** in the upper-right corner.
4. In the **Add Connection** dialog box that appears, select **DataHub**.
5. Set parameters for the DataHub connection.

Parameter	Description
Connection Name	The name of the connection. The name can contain letters, digits, and underscores (_). It must start with a letter.
Description	The description of the connection. The description can be up to 80 characters in length.
Applicable Environment	The environment in which the connection is used. Valid values: **Development** and **Production**. **Note** This parameter is available only when the workspace is in standard mode.
DataHub Endpoint	The endpoint of DataHub. This parameter is read-only, the value of which is automatically obtained from system configurations.
DataHub Project	The ID of the DataHub project.
AccessKey ID and AccessKey Secret	The AccessKey ID and AccessKey secret used as logon credentials.

6. Click **Test Connection**.
7. After the connection passes the connectivity test, click **Complete**.

   The connectivity test checks whether the entered information is correct.

What to do next

Now you have learned how to configure the DataHub connection. You can proceed with the next tutorial, such as configuring DataHub Writer. For more information, see Configure the DataHub writer.

2.3.2.16. Add an AnalyticDB connection

DataWorks supports writing data from other connections to AnalyticDB connections but does not support reading data from AnalyticDB connections. You can use the codeless user interface (UI) or code editor to configure sync nodes for AnalyticDB connections.

Procedure

1. Log on to the DataWorks console as a workspace administrator.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > Data Integration** to go to the **Data Integration** page.
3. In the left-side navigation pane, choose **Sync Resources > Connections**. On the page that appears, click **Add Connection** in the upper-right corner.
4. In the **Add Connection** dialog box that appears, select **AnalyticDB (ADS)**.
5. Set parameters for the AnalyticDB connection.

Parameter	Description
Connection Name	The name of the connection. The name can contain letters, digits, and underscores (_). It must start with a letter.
Description	The description of the connection. The description can be up to 80 characters in length.
Applicable Environment	The environment in which the connection is used. Valid values: **Development** and **Production**. **Note** This parameter is available only when the workspace is in standard mode.
Connection URL	The connection URL of AnalyticDB, in the format of `Address:Port`.
Database	The name of the AnalyticDB database.
AccessKey ID and AccessKey Secret	The AccessKey ID and AccessKey secret used as logon credentials.

6. Click **Test Connection**.
7. After the connection passes the connectivity test, click **Complete**.

   The connectivity test checks whether the entered information is correct.

What to do next

Now you have learned how to configure the AnalyticDB connection. You can proceed with the next tutorial, such as configuring AnalyticDB Writer.

2.3.2.17. Add a Vertica connection

DataWorks provides Vertica Reader and Writer for you to read data from and write data to Vertica connections. You can use the codeless user interface (UI) or code editor to configure sync nodes for Vertica connections.

Procedure

1. Log on to the DataWorks console as a workspace administrator.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > Data Integration** to go to the **Data Integration** page.
3. In the left-side navigation pane, choose **Sync Resources > Connections**. On the page that appears, click **Add Connection** in the upper-right corner.
4. In the **Add Connection** dialog box that appears, select **Vertica**.
5. Set parameters for the Vertica connection.

Parameter	Description

Parameter	Description
Connection Name	The name of the connection. The name can contain letters, digits, and underscores (_). It must start with a letter.
Description	The description of the connection. The description can be up to 80 characters in length.
Applicable Environment	The environment in which the connection is used. Valid values: **Development** and **Production**. **Note** This parameter is available only when the workspace is in standard mode.
JDBC URL	The Java Database Connectivity (JDBC) URL of the Vertica database, in the format of `jdbc:vertica://Server IP:Port/Database`.
Username and Password	The username and password used to connect to the database.
Enable reverse VPC access	Specifies whether to enable reverse Virtual Private Cloud (VPC) access. If you select **Enable reverse VPC access**, you must set **Datasource VPC ID** and **Datasource VPC Region**. You can set **Datasource instanceId(like ECS condition)** and **Datasource IP (IDC condition)** as required.

6. Click **Test Connection**.
7. After the connection passes the connectivity test, click **Complete**.

What to do next

Now you have learned how to configure the Vertica connection. You can proceed with the next tutorial, such as configuring Vertica Reader or Writer. For more information, see Configure Vertica Reader.

2.3.2.18. Add a GBase connection

DataWorks provides GBase Reader and Writer for you to read data from and write data to GBase connections. You can use the code editor to configure sync nodes for GBase connections.

> **Note**
>
> - Workspaces in standard mode support the connection isolation feature. You can add connections separately in the development and production environments to isolate connections in the development environment from those in the production environment. This protects data security.
> - When you add GBase connections deployed in Virtual Private Clouds (VPCs), note the following information:
>   - You can configure sync nodes that involve such connections. However, connectivity testing is not supported. You can click **Complete** without testing the connectivity.
>   - You must run such sync nodes on custom resource groups. Make sure that each connection can connect to the corresponding resource group.

Procedure

1. Log on to the DataWorks console as a workspace administrator.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > Data Integration** to go to the **Data Integration** page.
3. In the left-side navigation pane, choose **Sync Resources > Connections**. On the page that appears, click **Add Connection** in the upper-right corner.
4. In the **Add Connection** dialog box that appears, select **GBase**.
5. Set parameters for the GBase connection.

Parameter	Description
Connection Name	The name of the connection. The name can contain letters, digits, and underscores (_). It must start with a letter.
Description	The description of the connection. The description can be up to 80 characters in length.
Applicable Environment	The environment in which the connection is used. Valid values: **Development** and **Production**. **Note** This parameter is available only when the workspace is in standard mode.
JDBC URL	The Java Database Connectivity (JDBC) URL of the GBase database, in the format of `jdbc:mysql://Server IP:Port/Database`.
Username and Password	The username and password used to connect to the database.

6. Click **Test Connection**.
7. After the connection passes the connectivity test, click **Complete**.

What to do next

Now you have learned how to configure the GBase connection. You can proceed with the next tutorial, such as configuring GBase Reader or Writer. For more information, see Configure GBase 8a Reader and Configure GBase 8a Writer.

2.3.2.19. Add a Lightning connection

MaxCompute Lightning is an interactive query service that MaxCompute provides. Complying with the PostgreSQL standards and syntax, MaxCompute Lightning allows you to use common tools and standard SQL to quickly query and analyze data in MaxCompute projects.

Procedure

1. Log on to the DataWorks console as a workspace administrator.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > Data Integration** to go to the **Data Integration** page.
3. In the left-side navigation pane, choose **Sync Resources > Connections**. On the page that appears, click **Add Connection** in the upper-right corner.
4. In the **Add Connection** dialog box that appears, select **Lightning**.
5. Set parameters for the Lightning connection.

Parameter	Description
Connection Name	The name of the connection. The name can contain letters, digits, and underscores (_). It must start with a letter.
Description	The description of the connection. The description can be up to 80 characters in length.
Applicable Environment	The environment in which the connection is used. Valid values: **Development** and **Production**. **Note** This parameter is available only when the workspace is in standard mode.
Host	The endpoint of the MaxCompute Lightning server. Default value: `seahawks.aliyun-inc.com`.
Port	The port number of the MaxCompute Lightning server. Default value: 8099.
Database Name	The name of the MaxCompute database.
Username and **Password**	The username and password used to connect to the database.
ODPS Endpoint	The endpoint of MaxCompute.
MaxCompute Project Name	The name of the MaxCompute project.
AccessKey ID and AccessKey Secret	The AccessKey ID and AccessKey secret used as logon credentials.

Parameter	Description
JDBC Extension Parameters	The extension parameters used to establish a Java Database Connectivity (JDBC) connection to MaxCompute Lightning. In this field, `prepareThreshold=0` is added by default and cannot be deleted. Otherwise, you cannot connect to MaxCompute Lightning.

6. Click **Test Connection**.
7. After the connection passes the connectivity test, click **Complete**.

2.3.2.20. Add a Hive connection

Procedure

1. Log on to the DataWorks console as a workspace administrator.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > Data Integration** to go to the **Data Integration** page.
3. In the left-side navigation pane, choose **Sync Resources > Connections**. On the page that appears, click **Add Connection** in the upper-right corner.
4. In the **Add Connection** dialog box that appears, select **Hive**.
5. Set parameters for the Hive connection.

Parameter	Description
Connection Name	The name of the connection. The name can contain letters, digits, and underscores (_). It must start with a letter.
Description	The description of the connection.
Applicable Environment	The environment in which the connection is used. Valid values: Development and Production.
Hive JDBC Connection	The Java Database Connectivity (JDBC) connection string of Hive, in the format of `jdbc:hive2://ip:port/;serviceDiscoveryMode=xxx;zooKeeperNamespace=xxx;sasl.qop=xxx;auth=xxx;principal=xxx`.
Hive Username	The username used to access Hive.
Hive Password	The password used to access Hive.
JDBC URL	The JDBC URL of the Hive database, in the format of `jdbc:mysql://Server IP:Port/Database`.
Username and Password	The username and password used to connect to the database.
Hive Extension	The extension parameters used to connect to Hive.

6. Click **Test Connection**.

7. After the connection passes the connectivity test, click **Complete**.

2.3.2.21. Add an OSS connection

Alibaba Cloud Object Storage Service (OSS) is a secure and reliable service that enables you to store large amounts of data.

Procedure

1. Log on to the DataWorks console as a workspace administrator.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > Data Integration** to go to the **Data Integration** page.
3. In the left-side navigation pane, choose **Sync Resources > Connections**. On the page that appears, click **Add Connection** in the upper-right corner.
4. In the **Add Connection** dialog box that appears, select **OSS**.
5. Set parameters for the OSS connection.

Parameter	Description
Connection Name	The name of the connection. The name can contain letters, digits, and underscores (_). It must start with a letter.
Description	The description of the connection. The description can be up to 80 characters in length.
Applicable Environment	The environment in which the connection is used. Valid values: **Development** and **Production**. **Note** This parameter is available only when the workspace is in standard mode.
Endpoint	The OSS endpoint, in the format of **http://oss.aliyuncs.com**. The OSS endpoint varies with the region. **Note** If you add the bucket name before the domain name, for example, **http://xxx.oss.aliyuncs.com**, the connection can pass the connectivity test but data synchronization will fail.
Bucket	The name of the OSS bucket. A bucket is a storage space that serves as a container for storing objects. You can create one or more buckets and add one or more objects to each bucket. DataWorks can only search for objects in the specified bucket during data synchronization.
AccessKey ID and AccessKey Secret	The AccessKey ID and AccessKey secret used as logon credentials.

6. Click **Test Connection**.
7. After the connection passes the connectivity test, click **Complete**.

What to do next

Now you have learned how to configure the OSS connection. You can proceed with the next tutorial, such as configuring OSS Reader or Writer. For more information, see Configure the OSS reader and Configure the OSS writer.

2.3.2.22. Add an HDFS connection

DataWorks provides Hadoop Distributed File System (HDFS) Reader and Writer for you to read data from and write data to HDFS connections. You can use the code editor to configure sync nodes for HDFS connections.

Procedure

1. Log on to the DataWorks console as a workspace administrator.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > Data Integration** to go to the **Data Integration** page.
3. In the left-side navigation pane, choose **Sync Resources > Connections**. On the page that appears, click **Add Connection** in the upper-right corner.
4. In the **Add Connection** dialog box that appears, select **HDFS**.
5. Set parameters for the HDFS connection.

Parameter	Description
Connection Name	The name of the connection. The name can contain letters, digits, and underscores (_). It must start with a letter.
Description	The description of the connection. The description can be up to 80 characters in length.
Applicable Environment	The environment in which the connection is used. Valid values: **Development** and **Production**. **Note** This parameter is available only when the workspace is in standard mode.
DefaultFS	The address of the HDFS node, in the format of **hdfs://Server IP:Port**.

6. Click **Test Connection**.
7. After the connection passes the connectivity test, click **Complete**.

What to do next

Now you have learned how to configure the HDFS connection. You can proceed with the next tutorial, such as configuring HDFS Reader or Writer. For more information, see Configure the HDFS reader and Configure the HDFS writer.

2.3.2.23. Add an FTP connection

DataWorks provides File Transfer Protocol (FTP) Reader and Writer for you to read data from and write data to FTP connections. You can use the codeless user interface (UI) or code editor to configure sync nodes for FTP connections.

Procedure

1. Log on to the DataWorks console as a workspace administrator.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > Data Integration** to go to the **Data Integration** page.
3. In the left-side navigation pane, choose **Sync Resources > Connections**. On the page that appears, click **Add Connection** in the upper-right corner.
4. In the **Add Connection** dialog box that appears, select **FTP**.
5. Set parameters for the FTP connection.

Parameter	Description
Connection Name	The name of the connection. The name can contain letters, digits, and underscores (_). It must start with a letter.
Description	The description of the connection. The description can be up to 80 characters in length.
Applicable Environment	The environment in which the connection is used. Valid values: **Development** and **Production**. **Note** This parameter is available only when the workspace is in standard mode.
Protocol	The protocol used by the FTP server. Currently, only FTP and Secure File Transfer Protocol (SFTP) are supported.
Host	The IP address of the FTP server.
Port	The port number of the FTP server. This parameter defaults to 21 if you select FTP as the protocol, and defaults to 22 if you select SFTP.
Username and Password	The username and password used to access the FTP server.
Enable reverse VPC access	Specifies whether to enable reverse Virtual Private Cloud (VPC) access. If you select **Enable reverse VPC access**, you must set **Datasource VPC ID** and **Datasource VPC Region**. You can set **Datasource instanceId(like ECS condition)** and **Datasource IP (IDC condition)** as required.

6. Click **Test Connection**.
7. After the connection passes the connectivity test, click **Complete**.

What to do next

Now you have learned how to configure the FTP connection. You can proceed with the next tutorial, such as configuring FTP Reader or Writer. For more information, see Configure FTP Reader and Configure the FTP writer.

2.3.2.24. Add a MongoDB connection

MongoDB is a document-oriented database that is second only to Oracle and MySQL. DataWorks provides MongoDB Reader and Writer for you to read data from and write data to MongoDB connections. You can use the code editor to configure sync nodes for MongoDB connections.

> **Note** To add a MongoDB connection, you must add relevant IP addresses to the whitelist of the MongoDB instance in the MongoDB console. Separate multiple IP addresses with commas (,).

Procedure

1. Log on to the DataWorks console as a workspace administrator.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > Data Integration** to go to the **Data Integration** page.
3. In the left-side navigation pane, choose **Sync Resources > Connections**. On the page that appears, click **Add Connection** in the upper-right corner.
4. In the **Add Connection** dialog box that appears, select **MongoDB**.
5. Set parameters for the MongoDB connection.

   The MongoDB connection type can be set to **ApsaraDB for RDS** or **User-Created Data Store**.

   The following figure shows the parameters that appear after you set **Connect To** to **ApsaraDB for RDS**.

Parameter	Description
Connect To	The type of the connection. In this example, set the value to **ApsaraDB for RDS**.
Connection Name	The name of the connection. The name can contain letters, digits, and underscores (_). It must start with a letter.
Description	The description of the connection. The description can be up to 80 characters in length.
Applicable Environment	The environment in which the connection is used. Valid values: **Development** and **Production**. **Note** This parameter is available only when the workspace is in standard mode.

Parameter	Description
Instance ID	The ID of the ApsaraDB for MongoDB instance. You can view the ID in the ApsaraDB for MongoDB console.
Database Name	The name of the database you created in the ApsaraDB for MongoDB console. You can also specify the database username and password in the console.
Username and Password	The username and password used to connect to the database.

The following figure shows the parameters that appear after you set **Connect To** to **User-Created Data Store**.

Parameter	Description
Connect To	The type of the connection. In this example, set the value to **User-Created Data Store**.
Connection Name	The name of the connection. The name can contain letters, digits, and underscores (_). It must start with a letter.
Description	The description of the connection. The description can be up to 80 characters in length.
Applicable Environment	The environment in which the connection is used. Valid values: **Development** and **Production**. **Note** This parameter is available only when the workspace is in standard mode.
Address	The endpoint of MongoDB, in the format of Host:Port. To add an endpoint, click **Add Address** and specify the endpoint to add. To add more endpoints, repeat the preceding action. **Note** You must add either public endpoints or internal endpoints. Do not mix public endpoints with internal endpoints.
Database Name	The name of the MongoDB database.
Username and Password	The username and password used to connect to the database.

6. Click **Test Connection**.
7. After the connection passes the connectivity test, click **Complete**.

What to do next

Now you have learned how to configure the MongoDB connection. You can proceed with the next tutorial, such as configuring MongoDB Reader or Writer. For more information, see Configure MongoDB Reader and Configure MongoDB Writer.

2.3.2.25. Add a Memcache connection

DataWorks provides Memcache Writer for you to write data from other connections to Memcache connections. You can use the code editor to configure sync nodes for Memcache connections.

Procedure

1. Log on to the DataWorks console as a workspace administrator.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > Data Integration** to go to the **Data Integration** page.
3. In the left-side navigation pane, choose **Sync Resources > Connections**. On the page that appears, click **Add Connection** in the upper-right corner.
4. In the **Add Connection** dialog box that appears, select **Memcache (OCS)**.
5. Set parameters for the Memcache connection.

Parameter	Description
Connection Name	The name of the connection. The name can contain letters, digits, and underscores (_). It must start with a letter.
Description	The description of the connection. The description can be up to 80 characters in length.
Applicable Environment	The environment in which the connection is used. Valid values: **Development** and **Production**. **Note** This parameter is available only when the workspace is in standard mode.
Proxy Host	The proxy of the Memcache database.
Port	The port number of the Memcache database. Default value: 11211.
Username and Password	The username and password used to connect to the database.

6. Click **Test Connection**.
7. After the connection passes the connectivity test, click **Complete**.

What to do next

Now you have learned how to configure the Memcache connection. You can proceed with the next tutorial, such as configuring Memcache Writer. For more information, see Configure the Memcache (OCS) writer.

2.3.2.26. Add a Redis connection

DataWorks allows you to read data from and write data to Redis connections. You can use the code editor to configure sync nodes for Redis connections.

Redis is a document-oriented in-memory NoSQL database service for persistent storage. Based on its reliable master-replica hot backup mechanism and scalable cluster architecture, Redis can meet business needs that require high read/write performance and flexible capacity configuration.

Procedure

1. Log on to the DataWorks console as a workspace administrator.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > Data Integration** to go to the **Data Integration** page.
3. In the left-side navigation pane, choose **Sync Resources > Connections**. On the page that appears, click **Add Connection** in the upper-right corner.
4. In the **Add Connection** dialog box that appears, select **Redis**.
5. Set parameters for the Redis connection.

   The Redis connection type can be set to **ApsaraDB for RDS** or **User-Created Data Store**. You can select a type as required.

   - The following figure shows the parameters that appear after you set **Connect To** to **ApsaraDB for RDS**.

Parameter	Description
Connect To	The type of the connection. In this example, set the value to **ApsaraDB for RDS**.
Connection Name	The name of the connection. The name can contain letters, digits, and underscores (_). It must start with a letter.
Description	The description of the connection. The description can be up to 80 characters in length.
Applicable Environment	The environment in which the connection is used. Valid values: **Development** and **Production**. **Note** This parameter is available only when the workspace is in standard mode.
Redis Instance ID	The ID of the ApsaraDB for Redis instance. You can view the ID in the ApsaraDB for Redis console.
Redis Password	The password used to access ApsaraDB for Redis. Leave it blank if no password is required.

   - The following figure shows the parameters that appear after you set **Connect To** to **User-Created Data Store**.

Parameter	Description

Parameter	Description
Connect To	The type of the connection. In this example, set the value to **User-Created Data Store**. **Note** If you select this type of connection, you must run sync nodes on custom resource groups.
Connection Name	The name of the connection. The name can contain letters, digits, and underscores (_). It must start with a letter.
Description	The description of the connection. The description can be up to 80 characters in length.
Applicable Environment	The environment in which the connection is used. Valid values: **Development** and **Production**. **Note** This parameter is available only when the workspace is in standard mode.
Server Address	The server IP address and port number of the Redis instance. The default port number is **6379**.
Redis Password	The password used to access Redis.

6. Click **Test Connection**.
7. After the connection passes the connectivity test, click **Complete**.

What to do next

Now you have learned how to configure the Redis connection. You can proceed with the next tutorial, such as configuring Redis Writer. For more information, see Configure the Redis writer.

2.3.2.27. Add a Table Store connection

Table Store is a NoSQL database service built on the Apsara distributed operating system of Alibaba Cloud. It allows you to store and access large amounts of structured data in real time.

Procedure

1. Log on to the DataWorks console as a workspace administrator.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > Data Integration** to go to the **Data Integration** page.
3. In the left-side navigation pane, choose **Sync Resources > Connections**. On the page that appears, click **Add Connection** in the upper-right corner.
4. In the **Add Connection** dialog box that appears, select **Table Store (OTS)**.
5. Set parameters for the Table Store connection.

Parameter	Description
Connection Name	The name of the connection. The name can contain letters, digits, and underscores (_). It must start with a letter.
Description	The description of the connection. The description can be up to 80 characters in length.
Applicable Environment	The environment in which the connection is used. Valid values: **Development** and **Production**. **Note** This parameter is available only when the workspace is in standard mode.
Endpoint	The endpoint of Table Store.
Table Store Instance ID	The ID of the Table Store instance.
AccessKey ID and AccessKey Secret	The AccessKey ID and AccessKey secret used as logon credentials.

6. Click **Test Connection**.
7. After the connection passes the connectivity test, click **Complete**.

What to do next

Now you have learned how to configure the Table Store connection. You can proceed with the next tutorial, such as configuring Table Store Reader. For more information, see Configure the OTS reader.

2.3.2.28. Add a LogHub connection

DataWorks provides LogHub Reader and Writer for you to read data from and write data to LogHub connections.

Procedure

1. Log on to the DataWorks console as a workspace administrator.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > Data Integration** to go to the **Data Integration** page.
3. In the left-side navigation pane, choose **Sync Resources > Connections**. On the page that appears, click **Add Connection** in the upper-right corner.
4. In the **Add Connection** dialog box that appears, select **LogHub**.
5. Set parameters for the LogHub connection.

Parameter	Description
Connection Name	The name of the connection. The name can contain letters, digits, and underscores (_). It must start with a letter.

Parameter	Description
Description	The description of the connection. The description can be up to 80 characters in length.
Applicable Environment	The environment in which the connection is used. Valid values: **Development** and **Production**. **Note** This parameter is available only when the workspace is in standard mode.
LogHub Endpoint	The endpoint of LogHub, for example, `http://cn-shanghai.log.aliyun.com`.
Project	The name of the Log Service project.
AccessKey ID and AccessKey Secret	The AccessKey ID and AccessKey secret used as logon credentials.

6. Click **Test Connection**.
7. After the connection passes the connectivity test, click **Complete**.

What to do next

Now you have learned how to configure the LogHub connection. You can proceed with the next tutorial, such as configuring LogHub Reader or Writer. For more information, see Configure the LogHub reader and Configure LogHub Writer.

2.3.3. Configure data synchronization tasks

2.3.3.1. Configure a sync node by using the codeless UI

This topic describes how to configure a sync node by using the codeless user interface (UI).

To configure a sync node, follow these steps:

1. Add connections.
2. Create a sync node.
3. Select a source connection.
4. Select a destination connection.
5. Map the fields in the source and destination tables.
6. Configure the channel, such as the maximum transmission rate and dirty data check rules.
7. Configure the node properties.

Note The following sections describe the overall procedure. You can click the links in each step to read relevant instructions and then return to the current page to proceed with subsequent steps.

Add connections

Data synchronization is supported between various homogenous and heterogeneous connections. Before you configure a sync node, add required connections in Data Integration. Added connections are listed as options when you configure a sync node. For more information about connection types supported by Data Integration, see Supported data sources.

You can add connections of supported types to Data Integration. For more information about how to add a connection, see Data sources.

> **Note**
> - Data Integration does not support connectivity testing for some connection types. For more information, see Test data store connectivity.
> - Some connections are hosted on the premises. They do not have public IP addresses or network connections cannot be directly established. Such connections will fail the connectivity test. Data Integration allows you to add a custom resource group to resolve these issues. However, if you create sync nodes for such connections, you can only use the code editor. This is because you cannot obtain information such as table schema on the codeless UI if the network connection is unavailable.

Create a sync node

> **Note** This topic describes how to create and configure a sync node by using the codeless UI. Do not switch to the code editor.

1. Log on to the DataWorks console.
2. On the **Data Analytics** tab, move the pointer over the **Create** icon and select **Workflow**.
3. In the **Create Workflow** dialog box that appears, set **Workflow Name** and **Description**. Then, click **Create**.
4. In the left-side navigation pane, click the created workflow. Then, right-click **Data Integration** and choose **Create Data Integration Node > Sync**. In the Create Node dialog box that appears, set **Node Name**.
5. Click **Commit**.

Select a source connection

After the sync node is created, configure the source connection and source table.

> **Note**
> - For more information about how to configure the source connection, see Configure the reader.
> - Incremental data synchronization is required when you configure the source connection for some sync nodes. In this case, you can use the parameter configuration feature of DataWorks to obtain the date and time required by incremental data synchronization.

Select a destination connection

After the source connection is configured, configure the destination connection and destination table.

> **Note**
> - For more information about how to configure the destination connection, see Configure the writer.
> - You can select the writing method for most nodes. For example, the writing method can be overwriting or appending. Supported writing methods vary with the connection type.

Map the fields in the source and destination tables

After the source and destination connections are configured, specify the mapping between the fields in the source and destination tables. You can click **Map Fields with the Same Name**, **Map Fields in the Same Line**, **Delete All Mappings**, and **Auto Layout**.

Button or icon	Description
Map Fields with the Same Name	Click **Map Fields with the Same Name** to establish a mapping between fields with the same name. Note that the data types of the fields must match.
Map Fields in the Same Line	Click **Map Fields in the Same Line** to establish a mapping for fields in the same row. Note that the data types of the fields must match.
Delete All Mappings	Click **Delete All Mappings** to remove mappings that have been established.
Auto Layout	Click Auto Layout. The fields are automatically sorted based on specified rules.
Change Fields	Click the Change Fields icon. In the Change Fields dialog box that appears, you can manually edit fields in the source table. Each field occupies a row. The first and the last blank rows are included, whereas other blank rows are ignored.
Add	• Click Add to add a field. You can enter constants. Each constant must be enclosed in single quotation marks (' '), such as 'abc' and '123'. • You can use scheduling parameters, such as ${bizdate}. • You can enter functions supported by relational databases, such as now() and count(1). • Fields that cannot be parsed are indicated by Unidentified.

> **Note** Make sure that the data type of a source field is the same as or compatible with that of the mapped destination field.

Configure channel control policies

When the preceding steps are completed, configure the channel control policies of the corresponding sync node.

Parameter	Description
Expected Concurrency	The maximum number of concurrent threads to read data from or write data to data storage within the sync node. You can configure the concurrency for a node on the codeless UI.

Parameter	Description
Bandwidth Throttling	Specifies whether to enable bandwidth throttling. You can enable bandwidth throttling and set a maximum transmission rate to avoid heavy read workload of the source. We recommend that you enable bandwidth throttling and set the maximum transmission rate to a proper value.
Dirty Data Records Allowed	The maximum number of dirty data records allowed.
Resource Group	The resource group used for running the sync node. By default, the node runs on the default resource group. If resources are insufficient, you can add a custom resource group and run the sync node on the custom resource group. Set the resource group properly based on network conditions of the connections, resource group usage, and business importance.

Configure the node properties

This section describes how to use scheduling parameters for data filtering.

On the sync node configuration tab, click the **Properties** tab in the right-side navigation pane.

You can declare the scheduling parameters by using ${Variable name}. After a variable is declared, enter the initial value of the variable in the Arguments field. In this example, the initial value of the variable is identified by $[]. The content can be a time expression or a constant.

For example, if you write ${today} in the code and enter today=$[yyyymmdd] in the Arguments field, the value of the time variable is the current date. For more information about how to add and subtract the date, see Parameter configuration.

On the Properties tab, you can configure the properties of the sync node, such as the recurrence, scheduled time, and dependencies. Sync nodes have no ancestor nodes because their corresponding jobs are run before extract, transform, and load (ETL) jobs. We recommend that you specify the root node as their parent node.

Use custom scheduling parameters

To use custom scheduling parameters for the sync node, declare the following parameters in the code:

- bizdate: the timestamp of data to be used by the node. The value is one day before the running date of the node.
- cyctime: the time when the node is run, in the format of yyyymmddhhmiss.
- DataWorks provides the bizdate and cyctime parameters as default system parameters.

After the sync node is configured, save and commit the node.

2.3.3.2. Configure a sync node by using the code editor

This topic describes how to configure a sync node by using the code editor.

To configure a sync node, follow these steps:

1. Add connections.
2. Create a sync node.
3. Apply a template.

4. Configure the reader.
5. Configure the writer.
6. Map the fields in the source and destination tables.
7. Configure the channel, such as the maximum transmission rate and dirty data check rules.
8. Configure the node properties.

Add connections

Data synchronization is supported between various homogenous and heterogeneous connections. Before you configure a sync node, add required connections in Data Integration. Added connections are listed as options when you configure a sync node. For more information about connection types supported by Data Integration, see Supported data sources.

You can add connections of supported types to Data Integration. For more information about how to add a connection, see Data sources.

> **Note** Some connections are hosted on the premises. They do not have public IP addresses or network connections cannot be directly established. Such connections will fail the connectivity test. Data Integration allows you to add a custom resource group to resolve these issues. However, if you create sync nodes for such connections, you can only use the code editor. This is because you cannot obtain information such as table schema on the codeless user interface (UI) if the network connection is unavailable.

Create a sync node

> **Note** This topic describes how to create a sync node by using the codeless UI and configure the sync node by using the code editor.

1. Log on to the DataWorks console.
2. On the **Data Analytics** tab, move the pointer over the **Create** icon and select **Workflow**.
3. In the **Create Workflow** dialog box that appears, set **Workflow Name** and **Description**. Then, click **Create**.
4. In the left-side navigation pane, click the created workflow. Then, right-click **Data Integration** and choose **Create Data Integration Node > Sync**. In the Create Node dialog box that appears, set **Node Name**.
5. Click **Commit**.

Apply a template

1. After the sync node is created, the node configuration tab appears. Click the **Switch to Code Editor** icon in the toolbar.
2. In the **Confirm** dialog box that appears, click **OK** to switch to the code editor.

   > **Note** The code editor supports more features than the codeless UI. For example, you can configure sync nodes in the code editor even when the connectivity test fails.

3. Click the **Apply Template** icon in the toolbar.
4. In the **Apply Template** dialog box that appears, set **Source Connection Type**, **Connection**,

Target Connection Type, and Connection.

5. Click OK.

Configure the reader

After the template is applied, the basic settings of the reader are configured. You can configure the source connection and source table as needed.

```
{"type": "job",
  "version": "2.0",
  "steps": [
    {
      "stepType": "mysql", // The reader type.
      "parameter": {
        "datasource": "MySQL", // The connection name.
        "column": [ // The columns to be synchronized.
          "id",
          "value",
          "table"
        ],
        "socketTimeout": 3600000, // The timeout period for reading data from and writing data to a socket, i
n milliseconds.
        "connection": [
          {
            "datasource": "MySQL", // The connection name.
            "table": [
              "`case`" // The name of the table to be synchronized.
            ]
          }
        ],
        "where": "", // The WHERE clause.
        "splitPk": "", // The shard key.
        "encoding": "UTF-8" // The encoding format.
      },
      "name": "Reader",
      "category": "reader" // Indicates that these settings are related to the reader.
    },
```

The parameters are described as follows:

- type: the type of the sync node. You must set the value to job.
- version: the version number of the sync node. You can set the value to 1.0 or 2.0.

Note

- For more information about how to configure the source connection in the code editor, see Configure the reader.
- Incremental data synchronization is required when you configure the source connection for some sync nodes. In this case, you can use the parameter configuration feature of DataWorks to obtain the date and time required by incremental data synchronization.

Configure the writer

After the reader is configured, you can configure the destination connection and destination table as needed.

```
{
 "stepType": "odps", // The writer type.
 "parameter": {
   "partition": "", // The partitions that the reader reads.
   "truncate": true, // Specifies whether to clear up previous data and import new data when a write operati
on is performed again after failure. Set the value to true to guarantee the idempotence of write operations.
   "compress": false, // Specifies whether to enable compression.
   "datasource": "odps_first", // The connection name.
   "column": [ // The columns to be synchronized.
     "*"
   ],
   "emptyAsNull": false,
   "table": ""
  },
  "name": "Writer",
  "category": "writer" // Indicates that these settings are related to the writer.
 }
],
```

Note

- For more information about how to configure the destination connection in the code editor, see Configure the writer.
- You can select the writing method for most nodes. For example, the writing method can be overwriting or appending. Supported writing methods vary with the connection type.

Map the fields in the source and destination tables

The code editor only supports mapping of fields in the same row. Note that the data types of the fields must match.

> **Note** Make sure that the data type of a source field is the same as or compatible with that of the mapped destination field.

Configure channel control policies

When the preceding steps are completed, configure the channel control policies of the corresponding sync node. The setting parameter specifies the node efficiency, including the settings on the DUM number, thread concurrency, bandwidth throttling, dirty data policy, and resource group.

```
"setting":{
    "errorLimit":{
      "record": "1024" // The maximum number of dirty data records allowed.
    },
    "speed":{
      "throttle": false, // Specifies whether to enable bandwidth throttling.
      "concurrent": 1, // The maximum number of concurrent threads.
    }
  },
```

Setting	Description
Expected concurrency	The maximum number of concurrent threads to read data from or write data to data storage within the sync node. You can configure the concurrency for a node in the code editor.
Bandwidth throttling	Specifies whether to enable bandwidth throttling. You can enable bandwidth throttling and set a maximum transmission rate to avoid heavy read workload of the source. We recommend that you enable bandwidth throttling and set the maximum transmission rate to a proper value.
Dirty data records allowed	The maximum number of dirty data records allowed.
Resource group	The resource group used for running the sync node. By default, the node runs on the default resource group. If resources are insufficient, you can add a custom resource group and run the sync node on the custom resource group. Set the resource group properly based on network conditions of the connections, resource group usage, and business importance.

Configure the node properties

This section describes how to use scheduling parameters for data filtering.

On the sync node configuration tab, click the **Properties** tab in the right-side navigation pane.

On the Properties tab, you can configure the properties of the sync node, such as the recurrence, scheduled time, and dependencies. Sync nodes have no ancestor nodes because their corresponding jobs are run before extract, transform, and load (ETL) jobs. We recommend that you specify the root node as their parent node.

After the sync node is configured, save and commit the node.

2.3.3.3. Configure the reader

2.3.3.3.1. Configure DRDS Reader

Distributed Relational Database Service (DRDS) Reader allows you to read data from DRDS. DRDS Reader connects to a remote DRDS database and runs a SELECT statement to select and read data from the database.

Currently, DRDS Reader only supports MySQL engines. DRDS is a distributed MySQL database service that complies with MySQL protocols in most cases.

Specifically, DRDS Reader connects to a remote DRDS database through Java Database Connectivity (JDBC), generates a SELECT statement based on your configurations, and then sends the statement to the database. The DRDS database runs the statement and returns the result. Then, DRDS Reader assembles the returned data to abstract datasets in custom data types supported by Data Integration, and passes the datasets to a writer.

DRDS Reader generates the SELECT statement based on the table, column, and where parameters that you have configured, and sends the generated SELECT statement to the DRDS database. DRDS does not support all MySQL specifications, such as JOIN statements.

DRDS Reader supports most DRDS data types. Make sure that your data types are supported.

The following table lists the data types supported by DRDS Reader.

Category	DRDS data type
Integer	INT, TINYINT, SMALLINT, MEDIUMINT, and BIGINT
Floating point	FLOAT, DOUBLE, and DECIMAL
String	VARCHAR, CHAR, TINYTEXT, TEXT, MEDIUMTEXT, and LONGTEXT
Date and time	DATE, DATETIME, TIMESTAMP, TIME, and YEAR
Boolean	BIT and BOOLEAN
Binary	TINYBLOB, MEDIUMBLOB, BLOB, LONGBLOB, and VARBINARY

Parameters

Parameter	Description	Required	Default value
datasource	The connection name. It must be identical to the name of the added connection. You can add connections in the code editor.	Yes	None
table	The name of the table to be synchronized.	Yes	None

Parameter	Description	Required	Default value
column	The columns to be synchronized from the source table. The columns are described in a JSON array. The default value is [*], which indicates all columns. • Column pruning is supported. You can select and export specific columns. • Change of the column order is supported. You can export the columns in an order different from that specified in the schema of the table. • Constants are supported. The column names must be arranged in compliance with the SQL syntax supported by MySQL, for example, `["id", "`table`", "1", "'bazhen.csy'", "null", "to_char(a + 1)", "2.3", "true"]`. ○ id: a column name. ○ table: the name of a column that contains reserved keywords. ○ 1: an integer constant. ○ bazhen.csy: a string constant. ○ null: a null pointer. ○ to_char(a + 1): a function expression. ○ 2.3: a floating-point constant. ○ true: a Boolean value. • The column parameter must explicitly specify a set of columns to be synchronized. The parameter cannot be left empty.	Yes	None
where	The WHERE clause. DRDS Reader generates a SELECT statement based on the table, column, and where parameters that you have configured, and uses the generated SELECT statement to select and read data. For example, set this parameter to `STRTODATE('${bdp.system.bizdate}', '%Y%m%d') <= today AND today < DATEADD(STRTODATE('${bdp.system.bizdate}', '%Y%m%d'), interval 1 day)`. • You can use the WHERE clause to synchronize incremental data. • If you do not specify the where parameter or leave it empty, all data is synchronized.	No	None

Configure DRDS Reader by using the codeless UI

1. Configure the connections.

   Configure the source and destination connections for the sync node.

Parameter	Description

Parameter	Description
Connection	The datasource parameter in the preceding parameter description. Select a connection type, and enter the name of a connection that has been configured in DataWorks.
Table	The table parameter in the preceding parameter description.
Filter	The filter condition for the data to be synchronized. Currently, filtering based on the limit keyword is not supported. The SQL syntax is determined by the selected connection.
Shard Key	The shard key. You can use a column in the source table as the shard key. We recommend that you use the primary key or an indexed column. Only integer fields are supported. If data sharding is performed based on the configured shard key, data can be read concurrently to improve data synchronization efficiency. **Note** The Shard Key parameter is displayed only when you configure the source connection for a sync node.

2. Configure field mapping, that is, the column parameter in the preceding parameter description.

   Fields in the source table on the left have a one-to-one mapping with fields in the destination table on the right. You can click **Add** to add a field, or move the pointer over a field and click the **Delete** icon to delete the field.

Parameter	Description
Map Fields with the Same Name	Click **Map Fields with the Same Name** to establish a mapping between fields with the same name. Note that the data types of the fields must match.
Map Fields in the Same Line	Click **Map Fields in the Same Line** to establish a mapping for fields in the same row. Note that the data types of the fields must match.
Delete All Mappings	Click **Delete All Mappings** to remove mappings that have been established.
Auto Layout	Click Auto Layout. The fields are automatically sorted based on specified rules.
Change Fields	Click the Change Fields icon. In the Change Fields dialog box that appears, you can manually edit fields in the source table. Each field occupies a row. The first and the last blank rows are included, whereas other blank rows are ignored.

Parameter	Description
Add	Click Add to add a field. The rules for adding fields are described as follows: ◦ You can enter constants. Each constant must be enclosed in single quotation marks (' '), such as 'abc' and '123'. ◦ You can use scheduling parameters, such as ${bizdate}. ◦ You can enter functions supported by relational databases, such as now() and count(1). ◦ Fields that cannot be parsed are indicated by Unidentified.

3. Configure channel control policies.

Parameter	Description
Expected Concurrency	The maximum number of concurrent threads to read data from or write data to data storage within the sync node. You can configure the concurrency for a node on the codeless user interface (UI).
Bandwidth Throttling	Specifies whether to enable bandwidth throttling. You can enable bandwidth throttling and set a maximum transmission rate to avoid heavy read workload of the source. We recommend that you enable bandwidth throttling and set the maximum transmission rate to a proper value.
Dirty Data Records Allowed	The maximum number of dirty data records allowed.
Resource Group	The resource group used for running the sync node. By default, the node runs on the default resource group. If resources are insufficient, you can add a custom resource group and run the sync node on the custom resource group. Set the resource group properly based on network conditions of the connections, resource group usage, and business importance.

Configure DRDS Reader by using the code editor

In the following code, a node is configured to read data from a DRDS database.

```
{
  "type":"job",
  "version":"2.0", // The version number.
  "steps":[
    {
      "stepType":"drds", // The reader type.
      "parameter":{
        "datasource":"", // The connection name.
        "column":[ // The columns to be synchronized.
          "id",
          "name"
        ],
```

```
            "where":"", // The WHERE clause.
            "table":"", // The name of the table to be synchronized.
            "splitPk": "" // The shard key.
        },
        "name":"Reader",
        "category":"reader"
    },
    {// The following template is used to configure Stream Writer. For more information about how to config
ure other writers, see the corresponding topic.
        "stepType":"stream", // The writer type.
        "parameter":{},
        "name":"Writer",
        "category":"writer"
    }
  ],
  "setting":{
    "errorLimit":{
      "record":"0" // The maximum number of dirty data records allowed.
    },
    "speed":{
      "throttle":false, // Specifies whether to enable bandwidth throttling.
      "concurrent":1, // The maximum number of concurrent threads.
    }
  },
  "order":{
    "hops":[
      {
        "from":"Reader",
        "to":"Writer"
      }
    ]
  }
}:"Writer"
        }
    ]
  }
}
```

Additional instructions

- Consistency

As a distributed database service, DRDS cannot provide a consistent view of multiple tables in multiple databases. Different from MySQL where data is synchronized in a single table of a single database, DRDS Reader cannot extract the snapshot of database and table shards at the same time slice. That is, DRDS Reader extracts different snapshots from different shards. As a result, this cannot guarantee strong consistency for data queries.

- Character encoding

  DRDS supports flexible encoding configurations. You can specify the encoding format for an instance, a field, a table, and a database. The configurations for the field, table, database, and instance are prioritized in descending order. We recommend that you use UTF-8 for a database.

  DRDS Reader uses JDBC, which can automatically convert the encoding of characters. Therefore, you do not need to specify the encoding format.

  If you specify the encoding format for a DRDS database but data is written to the DRDS database in a different encoding format, DRDS Reader cannot recognize this inconsistency and may export garbled characters.

- Incremental data synchronization

  DRDS Reader connects to a database through JDBC and uses a SELECT statement with a WHERE clause to read incremental data in the following ways:

  - For data in batches, incremental add, update, and delete operations (including logically delete operations) are distinguished by timestamps. Specify the WHERE clause based on the timestamp. The timestamp must be later than the latest timestamp in the last synchronization.
  - For streaming data, specify the WHERE clause based on the data record ID. The data record ID must be larger than the maximum ID involved in the last synchronization.

  If incremental data cannot be distinguished, DRDS Reader cannot perform incremental synchronization but can perform full synchronization only.

- Syntax validation

  DRDS Reader allows you to specify custom SELECT statements by using the querySql parameter but does not verify the syntax of the custom SELECT statements.

2.3.3.3.2. Configure HBase Reader

HBase Reader allows you to read data from HBase. HBase Reader connects to a remote HBase database through a Java client of HBase. Then, HBase Reader scans and reads data based on the specified rowkey range, assembles the data to abstract datasets in custom data types supported by Data Integration, and then passes the datasets to a writer.

Data types

The following table lists the data types supported by HBase Reader.

Category	Data Integration data type	HBase data type
Integer	LONG	Short, Int, and Long
Floating point	DOUBLE	Float and Double
String	STRING	Binary_String and String

Category	Data Integration data type	HBase data type
Date and time	DATE	Date
Byte	BYTES	Bytes
Boolean	BOOLEAN	Boolean

Parameters

Parameter	Description	Required	Default value
haveKerberos	Specifies whether Kerberos authentication is required. A value of true indicates that Kerberos authentication is required. **Note** • If the value is true, the following five Kerberos-related parameters must be specified: ◦ kerberosKeytabFilePath ◦ kerberosPrincipal ◦ hbaseMasterKerberosPrincipal ◦ hbaseRegionserverKerberosPrincipal ◦ hbaseRpcProtection • If the value is false, Kerberos authentication is not required and you do not need to specify the preceding parameters.	No	*false*
hbaseConfig	The properties of the HBase cluster, in JSON format. The hbase.zookeeper.quorum parameter is required. It specifies the ZooKeeper ensemble servers. You can also configure other properties, such as those related to the cache and batch for scan operations.	Yes	None
mode	The mode in which data is read from the HBase connection. Valid values: normal and multiVersionFixedColumn.	Yes	None
table	The name of the HBase table from which data is read. The name is case-sensitive.	Yes	None
encoding	The encoding format, by using which binary data stored in byte[] format is converted into strings. Currently, UTF-8 and GBK are supported.	No	UTF-8

Parameter	Description	Required	Default value
column	The HBase columns from which data is read. • In normal mode: The name parameter specifies the name of the column in the HBase table. The format must be columnFamily:columnName except for the rowkey. The type parameter specifies the source data type. The format parameter specifies the date format. The value parameter specifies the column value if the column is a constant column. Example: `"column": [ { "name": "rowkey", "type": "string" }, { "value": "test", "type": "string" } ]` For the column parameter, you must specify the type parameter and specify one of the name and value parameters. • In multiVersionFixedColumn mode: The name parameter specifies the name of the column in the HBase table. The format must be columnFamily:columnName except for the rowkey. The type parameter specifies the source data type. The format parameter specifies the date format. You cannot create constant columns in multiVersionFixedColumn mode. Example: `"column": [ { "name": "rowkey", "type": "string" }, { "name": "info:age", "type": "string" } ]`	Yes	None

Parameter	Description	Required	Default value
maxVersion	The number of versions read by HBase Reader when multiple versions are available. Valid values: -1 and integers greater than 1. A value of -1 indicates that all versions are read.	Required in multiVersionFixedColumn mode	None
range	The rowkey range that HBase Reader reads. • startRowkey: the start rowkey. • endRowkey: the end rowkey. • isBinaryRowkey: the method used to convert the specified start and end rowkeys into the byte[] format. Default value: false. If the value is true, Bytes.toBytesBinary(rowkey) is used. If the value is false, Bytes.toBytes(rowkey) is used. Example: "range": { "startRowkey": "aaa", "endRowkey": "ccc", "isBinaryRowkey":false }	No	None
scanCacheSize	The number of rows read by an HBase client with each remote procedure call (RPC) connection.	No	*256*
scanBatchSize	The number of columns read by an HBase client with each RPC connection.	No	*100*

Configure HBase Reader by using the codeless UI

Currently, the codeless user interface (UI) is not supported for HBase Reader.

Configure HBase Reader by using the code editor

In the following code, a node is configured to read data from an HBase connection in normal mode.

```
{
  "type": "job",
  "version": "2.0", // The version number.
  "steps": [
    {
      "stepType": "hbase", // The reader type.
      "parameter": {
        "mode": "normal",
        "scanCacheSize": 256, // The number of rows read by an HBase client with each RPC connection.
        "scanBatchSize": 256, // The number of columns read by an HBase client with each RPC connection.
        "hbaseVersion": "094x",
```

```
            "datasource": "demo_hbase", // The connection name.
            "column": [
              {
                "name": "info:idx",
                "type": "long"
              },
              {
                "name": "info:age",
                "type": "string"
              },
              {
                "name": "info:birthday",
                "format": "yyyy-MM-dd",
                "type": "date"
              }
            ],
            "range": {
              "startRowKey": "", // The start rowkey.
              "endRowKey": "", // The end rowkey.
              "isBinaryRowKey": false // The method used to convert the specified start and end rowkeys into th
e byte[] format. Default value: false. If the value is true, Bytes.toBytesBinary(rowkey) is used. If the value is f
alse, Bytes.toBytes(rowkey) is used.
            },
            "maxVersion": , // The number of versions read by HBase Reader when multiple versions are available
. Valid values: -1 and integers greater than 1. A value of -1 indicates that all versions are read.
            "encoding": "UTF-8",
            "table": "test" // The name of the HBase table from which data is read. The name is case-sensitive.
          },
          "name": "Reader",
          "category": "reader"
        },
          "tepType": "odps", // The writer type.
          "parameter": {},
          "name": "Writer",
          "category": "writer"
        }
      ],
      "setting": {
      },
      "order": {
```

```
    "hops": [
      {
        "from": "Reader",
        "to": "Writer"
      }
    ]
  }
}
```

In the following code, a node is configured to read data from an HBase connection in multiVersionFixedColumn mode.

```
{
  "type": "job",
  "version": "2.0", // The version number.
  "steps": [
    {
      "stepType": "hbase", // The reader type.
      "parameter": {
          "table": "users", // The name of the HBase table from which data is read. The name is case-sensitive.

          "encoding": "utf-8", // The encoding format, by using which binary data stored in byte[] format is co
nverted into strings. Currently, UTF-8 and GBK are supported.
          "mode": "multiVersionFixedColumn",
          "maxVersion": "-1", // The number of versions read by HBase Reader when multiple versions are ava
ilable. Valid values: -1 and integers greater than 1. A value of -1 indicates that all versions are read.
          "column": [ // The HBase columns from which data is read. The name parameter specifies the name
of the column in the HBase table. The format must be columnFamily:columnName except for the rowkey. Th
e type parameter specifies the source data type. The format parameter specifies the date format. You canno
t create constant columns in multiVersionFixedColumn mode.
            {
              "name": "rowkey",
              "type": "string"
            },
            {
              "name": "info: age",
              "type": "string"
            },
            {
              "name": "info: birthday",
              "type": "date",
              "format": "yyyy-MM-dd"
```

```
                format": "yyyy-MM-dd"
              }
            ],
            "range": { // The rowkey range that HBase Reader reads.
              "startRowkey": "",
              "endRowkey": ""
            }
          }
        },
        "name": "Reader",
        "category": "reader"
      },
      {
        "stepType": "odps", // The writer type.
        "parameter": {},
        "name": "Writer",
        "category": "writer"
      }
    ],
    "setting": {
    },
    "order": {
      "hops": [
        {
          "from": "Reader",
          "to": "Writer"
        }
      ]
    }
}
```

2.3.3.3.3. Configure HDFS Reader

HDFS Reader allows you to read data stored in a Hadoop Distributed File System (HDFS). HDFS Reader connects to an HDFS, reads data from files in the HDFS, converts the data into a format that is readable by Data Integration, and then sends the converted data to a writer.

Examples:

TextFile is the default storage format for creating Hive tables, without data compression. Essentially, a TextFile file is stored in HDFS as text. For Data Integration, the implementation of HDFS Reader is similar to that of OSS Reader.

Optimized Row Columnar File (ORCFile) is an optimized RCFile format. It provides an efficient method for storing Hive data. HDFS Reader uses the OrcSerde class provided by Hive to read and parse ORCFile data.

> **Note**
>
> - Considering that a complex network connection is required between the default resource group and HDFS, we recommend that you use a custom resource group to run sync nodes. Make sure that your custom resource group can access the NameNode and DataNode of HDFS through a network.
> - By default, HDFS uses a network whitelist to guarantee data security. In this case, we recommend that you use a custom resource group to run HDFS sync nodes.
> - If you configure an HDFS sync node in the code editor, the HDFS connection does not need to pass the connectivity test. In this case, you can temporarily ignore connectivity test errors.
> - To synchronize data in Data Integration, you must log on as an administrator. Make sure that you have the permissions to read data from and write data to relevant HDFS files.

Features

Currently, HDFS Reader supports the following features:

- Supports the TextFile, ORCFile, RCFile, SequenceFile, CSV, and Parquet file formats. What is stored in each file must be a logical two-dimensional table.
- Reads data of various types as strings. Supports constants and column pruning.
- Supports recursive reading. Supports regular expressions that contain asterisks (*) and question marks (?).
- Compresses ORCFile files in SNAPPY or ZLIB format.
- Compresses SequenceFile files in LZO format.
- Reads multiple files concurrently.
- Compresses CSV files in GZIP, BZIP2, ZIP, LZO, LZO_DEFLATE, or SNAPPY format.
- Supports Hive 1.1.1 and Hadoop 2.7.1 (compatible with Apache JDK 1.6). HDFS Reader can work properly with Hadoop 2.5.0, Hadoop 2.6.0, and Hive 1.2.0 during testing.

> **Note** Currently, HDFS Reader cannot use concurrent threads to read a single file.

Data types

RCFile

RCFile metadata is stored in databases managed by Hive, and in different formats depending on the data type. However, HDFS Reader cannot query metadata from such databases. If you want to synchronize a file of the RCFile format, you must specify the data type for each column. If the data type is BIGINT, DOUBLE, or FLOAT, specify the data type as BIGINT, DOUBLE, or FLOAT. If the data type is VARCHAR or CHAR, specify the data type as STRING.

RCFile data types are automatically converted into the data types supported by Data Integration. The following table lists the supported data types.

Category	HDFS data type
Integer	TINYINT, SMALLINT, INT, and BIGINT

Category	HDFS data type
Floating point	FLOAT, DOUBLE, and DECIMAL
String	STRING, CHAR, and VARCHAR
Date and time	DATE and TIMESTAMP
Boolean	BOOLEAN
Binary	BINARY

Parquet files

Parquet file data types are automatically converted into the data types supported by Data Integration. The following table lists the supported data types.

Category	HDFS data type
Integer	INT32, INT64, and INT96
Floating point	FLOAT and DOUBLE
String	FIXED_LEN_BYTE_ARRAY
Date and time	DATE and TIMESTAMP
Boolean	BOOLEAN
Binary	BINARY

TextFile, ORCFile, and SequenceFile

TextFile metadata and ORCFile metadata are stored in databases, such as MySQL databases, managed by Hive. However, HDFS Reader cannot query metadata from such databases. If you want to convert data types during data synchronization, you must specify the data types.

TextFile, ORCFile, and SequenceFile data types are automatically converted into the data types supported by Data Integration. The following table lists the supported data types.

Category	HDFS data type
Integer	TINYINT, SMALLINT, INT, and BIGINT
Floating point	FLOAT and DOUBLE
String	STRING, CHAR, VARCHAR, STRUCT, MAP, ARRAY, UNION, and BINARY
Date and time	DATE and TIMESTAMP
Boolean	BOOLEAN

The data types are described as follows:

- LONG: integer strings in HDFS files, such as 123456789.
- DOUBLE: double value strings in HDFS files, such as 3.1415.
- BOOLEAN: Boolean strings in HDFS files, such as true and false. The strings are case-insensitive.
- DATE: date and time strings in HDFS files, such as 2014-12-31 00:00:00.

> **Note** The TIMESTAMP data type of Hive is accurate to nanoseconds. If you convert TIMESTAMP-type Hive data, such as 2015-08-21 22:40:47.397898389, in TextFile and ORCFile files into the DATE type in Data Integration, the converted data is accurate to seconds. If you need nanosecond-scale accuracy, convert TIMESTAMP-type data into the STRING type in Data Integration.

Parameters

Parameter	Description	Required	Default value

Parameter	Description	Required	Default value
path	The path of the file to read. To read multiple files, use a regular expression such as /hadoop/data_201704*. • If you specify a single HDFS file, HDFS Reader uses only one thread to read the file. • If you specify multiple HDFS files, HDFS Reader uses multiple threads. The number of threads is limited by the transmission rate, in Mbit/s. Note The actual number of threads is determined by both the number of HDFS files to be read and the specified transmission rate. • When a path contains a wildcard, HDFS Reader attempts to read all files that match the path. If the path is ended with a slash (/), HDFS Reader reads all files in the specified directory. For example, if you specify the path as /bazhen/, HDFS Reader reads all files in the bazhen directory. Currently, HDFS Reader only supports asterisks (*) and question marks (?) as file name wildcards. The syntax is similar to that of file name wildcards used on the Linux command line. Note • Data Integration considers all the files on a sync node as a single table. Make sure that all the files on each sync node can adapt to the same schema and Data Integration has the permission to read all these files. • Note: When creating Hive tables, you can specify partitions. For example, if you specify partition(day="20150820",hour="09"), a directory named /20150820 and a subdirectory named /09 are created in the corresponding table directory of the HDFS. Therefore, if you need HDFS Reader to read the data of a partition, specify the file path of the partition. For example, if you need HDFS Reader to read all the data in the partition with the date of 20150820 in the table named mytable01, specify the path as follows: "path": "/user/hive/warehouse/mytable01/20150820/*"	Yes	None

Parameter	Description	Required	Default value
defaultFS	The address of the NameNode of the HDFS. If a sync node is run on the default resource group, advanced parameter settings of Hadoop, such as those related to high availability, are not supported.	Yes	None

Parameter	Description	Required	Default value
fileType	The file format. Valid values: text, orc, rc, seq, csv, and parquet. HDFS Reader automatically recognizes the file format and uses corresponding read policies. Before data synchronization, HDFS Reader checks whether all the source files match the specified format. If any source file does not match the format, the sync node fails. The valid values of the fileType parameter are described as follows: • text: the TextFile format. • orc: the ORCFile format. • rc: the RCFile format. • seq: the SequenceFile format. • csv: the common HDFS file format, that is, the logical two-dimensional table. • parquet: the common Parquet file format. **Note** TextFile and ORCFile are different formats. HDFS Reader parses files in the two formats in different ways. After being converted from a composite data type of Hive into the STRING type of Data Integration, the data in a file of the TextFile format can be different from that in the same file of the ORCFile format. Composite data types include MAP, ARRAY, STRUCT, and UNION. The following example uses the conversion from the MAP type to the STRING type as an example: • HDFS Reader converts MAP-type ORCFile data into a string: {job=80, team=60, person=70}. • HDFS Reader converts MAP-type TextFile data into a string: job:80, team:60, person:70. The conversion results show that the data remains unchanged but the formats differ slightly. Therefore, if the data to be synchronized matches a composite data type of Hive, we recommend that you use a uniform file format. Recommendations: • To use a uniform file format, we recommend that you export TextFile tables as ORCFile tables on the Hive client. • If the file format is Parquet, the parquetSchema parameter is required, which specifies the schema of the Parquet table. For the column parameter, you must specify the type parameter and specify one of the index and value parameters.	Yes	None

Parameter	Description	Required	Default value
column	The columns to read. The type parameter specifies the source data type. The index parameter specifies the ID of the column in the source table, starting from 0. The value parameter specifies the column value if the column is a constant column. By default, HDFS Reader reads all data as strings. Specify this parameter as `"column":["*"]`. You can also specify the column parameter in the following way: `{` `"type": "long",` `"index": 0 // The first INT-type column of the source file.` `},` `{` `"type": "string",` `"value": "alibaba" // The value of the current column, that is, a constant "alibaba".` `}`	Yes	None
fieldDelimiter	The column delimiter. To read TextFile data, you must specify the column delimiter. The default delimiter is comma (,). To read ORCFile data, you do not need to specify the column delimiter. The default delimiter is \u0001. • If you need each row to be converted into a column in the destination table, use a string that does not exist in every row, such as \u0001. • Do not use \n as the delimiter.	No	,
encoding	The encoding format of the file to read.	No	UTF-8
nullFormat	The string that represents null. No standard strings can represent null in text files. Therefore, Data Integration provides the nullFormat parameter to define which string represents a null pointer. For example, if you specify nullFormat:"null", Data Integration considers null as a null pointer.	No	None

Parameter	Description	Required	Default value
compress	The compression format. Available compression formats for CSV files are GZIP, BZIP2, ZIP, LZO, LZO_DEFLATE, and SNAPPY. **Note** • Do not mix up LZO with LZO_DEFLATE. • Snappy does not have a uniform stream format. Data Integration currently only supports the most popular two compression formats: hadoop-snappy (Snappy stream format in Hadoop) and framing-snappy (Snappy stream format recommended by Google). • rc indicates the RCFile format. • This parameter is not required for files of the ORCFile format.	No	None

Parameter	Description	Required	Default value
parquetSchema	The schema of the source file. This parameter is required only when the fileType parameter is set to parquet. Format: **message messageTypeName {** **required, dataType, columnName;** **.....;** **}** The format is described as follows: • messageTypeName: the name of the MessageType object. • required: specifies whether the field is required or optional. We recommend that you set the parameter to optional for all fields. • dataType: the data type of the field. Supported data types: BOOLEAN, INT32, INT64, INT96, FLOAT, DOUBLE, BINARY, and FIXED_LEN_BYTE_ARRAY. Select BINARY if the data type is STRING. **Note** Each line, including the last one, must end with a semicolon (;). An example is provided as follows: **message m {** **optional int64 id;** **optional int64 date_id;** **optional binary datetimestring;** **optional int32 dspId;** **optional int32 advertiserId;** **optional int32 status;** **optional int64 bidding_req_num;** **optional int64 imp;** **optional int64 click_num;** **}**	No	None

Parameter	Description	Required	Default value
csvReaderConfig	The configurations for reading CSV files. The parameter value must match the MAP type. A specific CSV reader is used to read data from CSV files, which supports many configurations. The following example provides common configurations: "csvReaderConfig":{ "safetySwitch": false, "skipEmptyRecords": false, "useTextQualifier": false } You can use the following parameters and their default values: boolean caseSensitive = true; char textQualifier = 34; boolean trimWhitespace = true; boolean useTextQualifier = true; // Specifies whether to use escape characters for CSV files. char delimiter = 44; // The delimiter. char recordDelimiter = 0; char comment = 35; boolean useComments = false; int escapeMode = 1; boolean safetySwitch = true; // Specifies whether to limit the length of each column to 100,000 characters. boolean skipEmptyRecords = true; // Specifies whether to skip empty rows. boolean captureRawRecord = true;	No	None

Parameter	Description	Required	Default value
hadoopConfig	The advanced parameter settings of Hadoop, such as those related to high availability. "hadoopConfig":{ "dfs.nameservices": "testDfs", "dfs.ha.namenodes.testDfs": "namenode1,namenode2", "dfs.namenode.rpc-address.youkuDfs.namenode1": "", "dfs.namenode.rpc-address.youkuDfs.namenode2": "", "dfs.client.failover.proxy.provider.testDfs": "org.apache.hadoop.hdfs.server.namenode.ha.ConfiguredFailoverProxyProvider" }	No	None

Configure HDFS Reader by using the codeless UI

Currently, the codeless user interface (UI) is not supported for HDFS Reader.

Configure HDFS Reader by using the code editor

In the following code, a node is configured to read data from an HDFS. For more information about the parameters, see the preceding parameter description.

```
{
  "type": "job",
  "version": "2.0",
  "steps": [
    {
      "stepType": "hdfs", // The reader type.
      "parameter": {
        "path": "", // The path of the file to read.
        "datasource": "", // The connection name.
        "column": [
          {
            "index": 0, // The ID of the column in the source table.
            "type": "string" // The data type.
          },
          {
            "index": 1,
            "type": "long"
          },
          {
```

```
            "index": 2,
            "type": "double"
          },
          {
            "index": 3,
            "type": "boolean"
          },
          {
            "format": "yyyy-MM-dd HH:mm:ss", // The format of the time.
            "index": 4,
            "type": "date"
          }
        ],
        "fieldDelimiter": "," // The column delimiter.
        "encoding": "UTF-8", // The encoding format.
        "fileType": "" // The file format.
      },
      "name": "Reader",
      "category": "reader"
    },
    {// The following template is used to configure the writer. For more information, see the corresponding t
opic.
      "stepType": "stream",
      "parameter": {},
      "name": "Writer",
      "category": "writer"
    }
  ],
  "setting": {
    "errorLimit": {
      "record": "" // The maximum number of dirty data records allowed.
    },
    "speed": {
      "concurrent": 3, // The maximum number of concurrent threads.
      "throttle": false, // Specifies whether to enable bandwidth throttling. A value of false indicates that the
bandwidth is not throttled. A value of true indicates that the bandwidth is throttled. The maximum transmi
ssion rate takes effect only if you set this parameter to true.
    }
  },
  "order": {
    "hops": [
```

```
    "hops": [
      {
        "from": "Reader",
        "to": "Writer"
      }
    ]
  }
}
```

2.3.3.3.4. Configure MaxCompute Reader

This topic describes the data types and parameters supported by MaxCompute Reader and how to configure it by using the codeless user interface (UI) and code editor.

MaxCompute Reader can read data from a MaxCompute database by using the MaxCompute Tunnel service based on the source project, table, partition, and table fields that you have configured.

MaxCompute Reader cannot read views. It can only read partitioned tables and non-partitioned tables. When enabling MaxCompute Reader to read partitioned tables, you must specify the partition information. For example, set pt to 1 and ds to hangzhou for the t0 table. The partition information is not required for non-partitioned tables. Additionally, you can select some or all of the table fields, change the order in which the fields are arranged, and add constant fields and partition key columns. Note that partition key columns are not table fields.

Data types

The following table lists the data types supported by MaxCompute Reader.

Category	Data Integration data type	MaxCompute data type
Integer	LONG	BIGINT, INT, TINYINT, and SMALLINT
Boolean	BOOLEAN	BOOLEAN
Date and time	DATE	DATETIME and TIMESTAMP
Floating point	DOUBLE	FLOAT, DOUBLE, and DECIMAL
Binary	BYTES	BINARY
Complex	STRING	ARRAY, MAP, and STRUCT

Parameters

Parameter	Description	Required	Default value
datasource	The connection name. It must be identical to the name of the added connection. You can add connections in the code editor.	Yes	None

Parameter	Description	Required	Default value
table	The name of the source table. The name is case-insensitive.	Yes	None
partition	The partitions that MaxCompute Reader reads. Linux shell wildcards are supported. An asterisk (*) represents zero or more characters, and a question mark (?) represents that the previous character can be included or not. For example, a partitioned table named test has four partitions: pt=1 and ds=hangzhou, pt=1 and ds=shanghai, pt=2 and ds=hangzhou, and pt=2 and ds=beijing. • If you want to read data from the partition with pt=1 and ds=shanghai, enter `"partition":"pt=1/ds=shanghai"`. • If you want to read data from all the partitions with pt=1, enter `"partition":"pt=1/ds=*"`. • If you want to read data from all the partitions in the test table, enter `"partition":"pt=*/ds=*"`.	Required only for writing data to a partitioned table	None

Parameter	Description	Required	Default value
column	The columns in the source table that MaxCompute Reader reads. Assume that the fields of a table named test are id, name, and age. • To read the fields in turn, enter `"column":["id","name","age"]` or `"column":["*"]`. Note We recommend that you do not set "column": ["*"]. This is because data synchronization may fail if the source table changes in the column order, data type, or number of columns. • To read the name and id fields in turn, enter `"column":["name","id"]`. • You can add a constant field to extracted data for the purpose of proper mapping between source table columns and destination table columns. Each constant must be enclosed in single quotation marks (`''`). For example, if you set `"column":["age","name","'1988-08-08 08:08:08'","id"]`, the data extracted contains an age column, a name column, a constant "1988-08-08 08:08:08", and an id column in turn. The single quotation marks (`''`) are used to identify constant columns. The constant column values exclude the single quotation marks (`''`). Note ◦ MaxCompute Reader does not use SELECT statements to read data. Therefore, you cannot specify function fields. ◦ The column parameter must explicitly specify a set of columns to be synchronized. The parameter cannot be left empty.	Yes	None

Configure MaxCompute Reader by using the codeless UI

On the **DataStudio** page, create a sync node under a workflow and configure the node.

1. Configure the connections.

   Configure the source and destination connections for the sync node.

Parameter	Description
Connection	The datasource parameter in the preceding parameter description. Select a connection type, and enter the name of a connection that has been configured in DataWorks.

Parameter	Description
Table	The table parameter in the preceding parameter description.
Partition Key Column	The partition information. You can click **+Add** on the right to add partition key columns.
Convert Empty Strings to Null	Specifies whether to convert empty strings to null.

> **Note** To synchronize all columns in the source table, enter "column": [""]. The partition parameter supports wildcards and includes one or more partitions.
>
> - `"partition":"pt=20140501/ds=*"` specifies that all ds partitions with pt=20140501 are to be synchronized.
> - `"partition":"pt=top?"` specifies that the partitions with pt=top and pt=to are to be synchronized.
>
> You can specify the partition key columns to be synchronized, such as a partition key column named pt. Assume that the partition key column of a MaxCompute table is pt=${bdp.system.bizdate}. You can configure the column to be synchronized to pt. Ignore it if the column is marked as unidentified. To synchronize all partitions, enter pt=*. To synchronize some of the partitions, specify the corresponding dates.

2. Configure field mapping, that is, the column parameter in the preceding parameter description.

   Fields in the source table on the left have a one-to-one mapping with fields in the destination table on the right. You can click **Add** to add a field, or move the pointer over a field and click the **Delete** icon to delete the field.

Button or icon	Description
Map Fields with the Same Name	Click **Map Fields with the Same Name** to establish a mapping between fields with the same name. Note that the data types of the fields must match.
Map Fields in the Same Line	Click **Map Fields in the Same Line** to establish a mapping for fields in the same row. Note that the data types of the fields must match.
Delete All Mappings	Click **Delete All Mappings** to remove mappings that have been established.
Auto Layout	Click Auto Layout. The fields are automatically sorted based on specified rules.
Change Fields	Click the Change Fields icon. In the Change Fields dialog box that appears, you can manually edit fields in the source table. Each field occupies a row. The first and the last blank rows are included, whereas other blank rows are ignored.

Button or icon	Description
Add	◦ Click Add to add a field. You can enter constants. Each constant must be enclosed in single quotation marks (' '), such as 'abc' and '123'. ◦ You can use scheduling parameters, such as ${bizdate}. ◦ You can enter functions supported by relational databases, such as now() and count(1). ◦ Fields that cannot be parsed are indicated by Unidentified.

3. Configure channel control policies.

Parameter	Description
Expected Concurrency	The maximum number of concurrent threads to read data from or write data to data storage within the sync node. You can configure the concurrency for a node on the codeless UI.
Bandwidth Throttling	Specifies whether to enable bandwidth throttling. You can enable bandwidth throttling and set a maximum transmission rate to avoid heavy read workload of the source. We recommend that you enable bandwidth throttling and set the maximum transmission rate to a proper value.
Dirty Data Records Allowed	The maximum number of dirty data records allowed.
Resource Group	The resource group used for running the sync node. By default, the node runs on the default resource group. If resources are insufficient, you can add a custom resource group and run the sync node on the custom resource group. Set the resource group properly based on network conditions of the connections, resource group usage, and business importance.

Configure MaxCompute Reader by using the code editor

In the following code, a node is configured to read data from a MaxCompute connection. For more information about the parameters, see the preceding parameter description.

```
{
  "type":"job", // The type of the sync node.
  "version":"2.0", // The version number.
  "steps":[
    {
      "stepType":"odps", // The reader type.
      "parameter":{
        "partition":[], // The partitions that MaxCompute Reader reads.
        "isCompress":false, // Specifies whether to enable compression.
        "datasource":"", // The connection name.
        "column":[ // The columns to be synchronized.
          "id"
```

```
            ],
            "emptyAsNull":true,
            "table":"" // The name of the table to be synchronized.
          },
          "name":"Reader",
          "category":"reader"
        },
        {
          "stepType":"stream", // The writer type.
          "parameter":{ // The parameters that you specify for the writer.
          },
          "name":"Writer",
          "category":"writer"
        }
      ],
      "setting":{
        "errorLimit":{
          "record":"0" // The maximum number of dirty data records allowed.
        },
        "speed":{
          "throttle":false, // Specifies whether to enable bandwidth throttling. A value of false indicates that the bandwidth is not throttled. A value of true indicates that the bandwidth is throttled. The maximum transmission rate takes effect only if you set this parameter to true.
          "concurrent":1, // The maximum number of concurrent threads.
        }
      },
      "order":{
        "hops":[
          {
            "from":"Reader", // The source connection of the node.
            "to":"Writer" // The destination connection of the node.
          }
        ]
      }
    }
```

2.3.3.3.5. Configure MongoDB Reader

This topic describes the data types and parameters supported by MongoDB Reader and how to configure it by using the code editor.

MongoDB Reader connects to a remote MongoDB database by using the Java client named MongoClient and reads data from the database. The latest version of MongoDB has improved the locking feature from database locks to document locks. With the powerful functionalities of indexes in MongoDB, MongoDB Reader can efficiently read data from MongoDB databases.

> Note
>
> - If you use ApsaraDB for MongoDB, the MongoDB database has a root account by default. For security concerns, do not use the root account to log on to the MongoDB database when you add a MongoDB connection.
> - JavaScript syntax is not supported for queries.

MongoDB Reader shards data in the MongoDB database according to specified rules, reads data from the database with multiple threads, and then converts the data into a format readable by Data Integration.

Data types

MongoDB Reader supports most MongoDB data types. Make sure that your data types are supported.

The following table lists the data types supported by MongoDB Reader.

Category	MongoDB data type
Long	Int, Long, Document.Int, and Document.Long
Double	Double and Document.Double
String	String, Array, Document.String, Document.Array, and Combine
Date	Date and Document.Date
Boolean	Bool and Document.Bool
Bytes	Bytes and Document.Bytes

Note

- The Document data type is used to store embedded documents. It is also called the Object data type.
- The following content describes how to use the Combine data type:

  When MongoDB Reader reads data from a MongoDB database, it combines and converts multiple fields in MongoDB documents into a JSON string.

  For example, doc1, doc2, and doc3 are three MongoDB documents with different fields, which are represented by keys instead of key-value pairs. The keys a and b represent common fields in all the three documents. The key x_n represents an unfixed field.

  ```
  doc1: a b x_1 x_2
  ```

  ```
  doc2: a b x_2 x_3 x_4
  ```

  ```
  doc3: a b x_5
  ```

  To import the preceding three MongoDB documents to MaxCompute, you must specify the fields to retain, set a name for each combined string, and set the data type of each combined string to COMBINE in the configuration file. Make sure that the name of each combined string is unique among all existing fields in the documents.

  ```
  "column": [
  {
  "name": "a",
  "type": "string",
  },
  {
  "name": "b",
  "type": "string",
  },
  {
  "name": "doc",
  "type": "combine",
  }
  ]
  ```

  The following table lists the output in MaxCompute.

odps_column1	odps_column2
a	b
a	b
a	b

Parameters

Parameter	Description	Required	Default value
datasource	The connection name. It must be identical to the name of the added connection. You can add connections in the code editor.	Yes	None
collectionName	The name of the MongoDB collection.	Yes	None
column	The columns in MongoDB. • name: the name of the column. • type: the data type of the column. • splitter: the delimiter. Specify this parameter only when you need to convert the string to an array. MongoDB supports arrays, but Data Integration does not. The array elements read by MongoDB are joined into a string by using this delimiter.	Yes	None
query	The filter condition for obtaining data from MongoDB. Only data of the time type is supported. For example, you can use the statement `"query":"{'operationTime': {'$gte':ISODate('${last_day}T00:00:00.424+0800')}}"` to obtain data where the time specified by operationTime is not earlier than 00:00 on the day specified by ${last_day}. In the preceding JSON string, ${last_day} is a scheduling parameter of DataWorks. The format is $[yyyy-mm-dd]. You can use comparison operators (such as $gt, $lt, $gte, and $lte), logical operators (such as $and and $or), and functions (such as max, min, sum, avg, and ISODate) supported by MongoDB as needed.	No	None

Configure MongoDB Reader by using the codeless UI

Currently, the codeless user interface (UI) is not supported for MongoDB Reader.

Configure MongoDB Reader by using the code editor

In the following code, a node is configured to read data from a MongoDB database. For more information about the parameters, see the preceding parameter description.

```
{
  "type":"job",
  "version":"2.0", // The version number.
  "steps":[
      "reader": {
      "plugin": "mongodb", // The reader type.
      "parameter": {
        "datasource": "datasourceName", // The connection name.
        "collectionName": "tag_data", // The name of the MongoDB collection.
        "query":"",
```

```
"column": [
    {
      "name": "unique_id", // The field name.
      "type": "string" // The data type.
    },
    {
      "name": "sid",
      "type": "string"
    },
    {
      "name": "user_id",
      "type": "string"
    },
    {
      "name": "auction_id",
      "type": "string"
    },
    {
      "name": "content_type",
      "type": "string"
    },
    {
      "name": "pool_type",
      "type": "string"
    },
    {
      "name": "frontcat_id",
      "type": "array",
      "splitter": ""
    },
    {
      "name": "categoryid",
      "type": "array",
      "splitter": ""
    },
    {
      "name": "gmt_create",
      "type": "string"
    },
    {
      "name": "taglist",
```

```
            "type": "array",
            "splitter": " "
          },
          {
            "name": "property",
            "type": "string"
          },
          {
            "name": "scorea",
            "type": "int"
          },
          {
            "name": "scoreb",
            "type": "int"
          },
          {
            "name": "scorec",
            "type": "int"
          },
      {
            "name": "a.b",
            "type": "document.int"
          },
          {
            "name": "a.b.c",
            "type": "document.array",
            "splitter": " "
          }
        ]
      }
    },
    {
      "stepType":"stream",
      "parameter":{},
      "name":"Writer",
      "category":"writer"
    }
  ],
  "setting":{
    "errorLimit":{
```

```
        "record":"0" // The maximum number of dirty data records allowed.
      },
      "speed":{
        "throttle":false, // Specifies whether to enable bandwidth throttling. A value of false indicates that the bandwidth is not throttled. A value of true indicates that the bandwidth is throttled. The maximum transmission rate takes effect only if you set this parameter to true.
        "concurrent":1, // The maximum number of concurrent threads.
      }
    },
    "order":{
      "hops":[
        {
          "from":"Reader",
          "to":"Writer"
        }
      ]
    }
}
```

> **Note** Currently, you cannot retrieve data elements from arrays.

2.3.3.3.6. Configure Db2 Reader

This topic describes the data types and parameters supported by Db2 Reader and how to configure it by using the code editor.

Db2 Reader allows you to read data from Db2. Db2 Reader connects to a remote Db2 database and runs a SELECT statement to select and read data from the database.

Specifically, Db2 Reader connects to a remote Db2 database through Java Database Connectivity (JDBC), generates a SELECT statement based on your configurations, and then sends the statement to the database. The Db2 database runs the statement and returns the result. Then, Db2 Reader assembles the returned data to abstract datasets in custom data types supported by Data Integration, and passes the datasets to a writer.

- Db2 Reader generates the SELECT statement based on the table, column, and where parameters that you have configured, and sends the generated SELECT statement to the Db2 database.
- If you specify the querySql parameter, Db2 Reader directly sends the value of this parameter to the Db2 database.

Db2 Reader supports most Db2 data types. Make sure that your data types are supported.

The following table lists the data types supported by Db2 Reader.

Category	Db2 data type
Integer	SMALLINT

Category	Db2 data type
Floating point	DECIMAL, REAL, and DOUBLE
String	CHAR, CHARACTER, VARCHAR, GRAPHIC, VARGRAPHIC, LONG VARCHAR, CLOB, LONG VARGRAPHIC, and DBCLOB
Date and time	DATE, TIME, and TIMESTAMP
Boolean	N/A
Binary	BLOB

Parameters

Parameter	Description	Required	Default value
datasource	The connection name. It must be identical to the name of the added connection. You can add connections in the code editor.	Yes	None
jdbcUrl	The JDBC URL for connecting to the Db2 database. In accordance with official Db2 specifications, the URL must be in the `jdbc:db2://ip:port/database` format. You can also specify the information of the attachment facility.	Yes	None
username	The username for connecting to the database.	Yes	None
password	The password for connecting to the database.	Yes	None
table	The name of the table to be synchronized. You can select only one source table for each sync node.	Yes	None

Parameter	Description	Required	Default value
column	The columns to be synchronized from the source table. The columns are described in a JSON array. The default value is [*], which indicates all columns. • Column pruning is supported. You can select and export specific columns. • Change of the column order is supported. You can export the columns in an order different from that specified in the schema of the table. • Constants are supported. The column names must be arranged in compliance with the SQL syntax supported by Db2, for example, `["id", "1", "'const name'", "null", "upper('abc_lower')", "2.3", "true"]`. ○ id: a column name. ○ 1: an integer constant. ○ 'const name': a string constant, which is enclosed in single quotation marks (' '). ○ null: a null pointer. ○ upper('abc_lower'): a function expression. ○ 2.3: a floating-point constant. ○ true: a Boolean value. • The column parameter must explicitly specify a set of columns to be synchronized. The parameter cannot be left empty.	Yes	None
splitPk	The field used for data sharding when Db2 Reader extracts data. If you specify the splitPk parameter, the table is sharded based on the shard key specified by this parameter. Data Integration then runs concurrent threads to synchronize data. This improves efficiency. • We recommend that you set the splitPk parameter to the primary key of the table. Based on the primary key, data can be well distributed to different shards, but not intensively distributed to certain shards. • Currently, the splitPk parameter supports data sharding only for integers but not for other data types such as string, floating point, and date. If you specify this parameter to a column of an unsupported type, Db2 Reader returns an error.	No	""
where	The WHERE clause. Db2 Reader generates a SELECT statement based on the table, column, and where parameters that you have configured, and uses the generated SELECT statement to select and read data. For example, set this parameter to `gmt_create>$bizdate`. You can use the WHERE clause to synchronize incremental data. If you do not specify the where parameter or leave it empty, all data is synchronized.	No	None

Parameter	Description	Required	Default value
querySql	The SELECT statement used for refined data filtering. If you specify this parameter, Data Integration directly filters data based on this parameter. For example, if you want to join multiple tables for data synchronization, set this parameter to `select a,b from table_a join table_b on table_a.id = table_b.id`. If you specify the querySql parameter, Db2 Reader ignores the table, column, and where parameters that you have configured.	No	None
fetchSize	The number of data records to read at a time. This parameter determines the number of interactions between Data Integration and the database and affects reading efficiency. **Note** A value greater than 2048 may lead to out of memory (OOM) during the data synchronization process.	No	*1024*

Configure Db2 Reader by using the codeless UI

Currently, the codeless user interface (UI) is not supported for Db2 Reader.

Configure Db2 Reader by using the code editor

In the following code, a node is configured to read data from a Db2 database.

```
{
  "type":"job",
  "version":"2.0", // The version number.
  "steps":[
    {
      "stepType":"db2", // The reader type.
      "parameter":{
        "password":"", // The password for connecting to the database.
        "jdbcUrl":"", // The JDBC URL for connecting to the Db2 database.
        "column":[
          "id"
        ],
        "where":"", // The WHERE clause.
        "splitPk":"", // The field used for data sharding. If you specify the splitPk parameter, the table is sharded based on the shard key specified by this parameter.
        "table":"", // The name of the table to be synchronized.
        "username":"" // The username for connecting to the database.
```

```
            "username":"" // The username for connecting to the database.
        },
        "name":"Reader",
        "category":"reader"
      },
      {
        "stepType":"stream",
        "parameter":{},
        "name":"Writer",
        "category":"writer"
      }
    ],
    "setting":{
      "errorLimit":{
        "record":"0" // The maximum number of dirty data records allowed.
      },
      "speed":{
        "throttle":false, // Specifies whether to enable bandwidth throttling. A value of false indicates that the bandwidth is not throttled. A value of true indicates that the bandwidth is throttled. The maximum transmission rate takes effect only if you set this parameter to true.
        "concurrent":1, // The maximum number of concurrent threads.
      }
    },
    "order":{
      "hops":[
        {
          "from":"Reader",
          "to":"Writer"
        }
      ]
    }
}
```

Additional instructions

- Data synchronization between primary and secondary databases

  A secondary Db2 database can be deployed for disaster recovery. The secondary database continuously synchronizes data from the primary database based on binlogs. Especially when network conditions are unfavorable, data latency between the primary and secondary databases is unavoidable, which can lead to data inconsistency.

- Concurrency control

Db2 is a relational database management system (RDBMS), which supports strong consistency for data queries. A database snapshot is created before a sync node starts. Db2 Reader reads data from the database snapshot. Therefore, if new data is written to the database during data synchronization, Db2 Reader cannot obtain the new data.

Data consistency cannot be guaranteed when you enable Db2 Reader to run concurrent threads on a single sync node.

Db2 Reader shards the table based on the splitPk parameter and runs multiple concurrent threads to synchronize data. These concurrent threads belong to different transactions. They read data at different time points. This means that the concurrent threads observe different snapshots.

Theoretically, the data inconsistency issue is unavoidable if a single sync node includes multiple threads. However, two workarounds are available:

- Do not enable concurrent threads on a single sync node. Essentially, do not specify the splitPk parameter. In this way, data consistency is guaranteed although data is synchronized at a low efficiency.
- Disable writers to make sure that the data is unchanged during data synchronization. For example, lock the table and disable data synchronization between primary and secondary databases. In this way, data is synchronized efficiently but your ongoing services may be interrupted.

- Character encoding

  Db2 Reader uses JDBC, which can automatically convert the encoding of characters. Therefore, you do not need to specify the encoding format.

- Incremental data synchronization

  Db2 Reader connects to a database through JDBC and uses a SELECT statement with a WHERE clause to read incremental data in the following ways:

  - For data in batches, incremental add, update, and delete operations (including logically delete operations) are distinguished by timestamps. Specify the WHERE clause based on the timestamp. The timestamp must be later than the latest timestamp in the last synchronization.
  - For streaming data, specify the WHERE clause based on the data record ID. The data record ID must be larger than the maximum ID involved in the last synchronization.

  If incremental data cannot be distinguished, Db2 Reader cannot perform incremental synchronization but can perform full synchronization only.

- Syntax validation

  Db2 Reader allows you to specify custom SELECT statements by using the querySql parameter but does not verify the syntax of the custom SELECT statements.

2.3.3.3.7. Configure MySQL Reader

This topic describes the data types and parameters supported by MySQL Reader and how to configure it by using the codeless user interface (UI) and code editor.

MySQL Reader connects to a remote MySQL database through Java Database Connectivity (JDBC), generates a SELECT statement based on your configurations, and then sends the statement to the database. The MySQL database runs the statement and returns the result. Then, MySQL Reader assembles the returned data to abstract datasets in custom data types supported by Data Integration, and passes the datasets to a writer.

In short, MySQL Reader connects to a remote MySQL database and runs a SELECT statement to select and read data from the database.

MySQL Reader can read tables and views. For table fields, you can specify all or some of the columns in sequence, adjust the column order, specify constant fields, and configure MySQL functions, such as now().

Data types

The following table lists the data types supported by MySQL Reader.

Category	MySQL data type
Integer	INT, TINYINT, SMALLINT, MEDIUMINT, and BIGINT
Floating point	FLOAT, DOUBLE, and DECIMAL
String	VARCHAR, CHAR, TINYTEXT, TEXT, MEDIUMTEXT, and LONGTEXT
Date and time	DATE, DATETIME, TIMESTAMP, TIME, and YEAR
Boolean	BIT and BOOLEAN
Binary	TINYBLOB, MEDIUMBLOB, BLOB, LONGBLOB, and VARBINARY

> **Note**
>
> - Data types that are not listed in the table are not supported.
> - MySQL Reader considers tinyint(1) as the INTEGER type.
> - Currently, MySQL Reader does not support MySQL 8.0 or later.

Parameters

Parameter	Description	Required	Default value
datasource	The connection name. It must be identical to the name of the added connection. You can add connections in the code editor.	Yes	None
table	The name of the table to be synchronized. You can select only one source table for each sync node.	Yes	None

Parameter	Description	Required	Default value
column	The columns to be synchronized from the source table. The columns are described in a JSON array. The default value is [*], which indicates all columns. • Column pruning is supported. You can select and export specific columns. • Change of the column order is supported. You can export the columns in an order different from that specified in the schema of the table. • Constants are supported. The column names must be arranged in compliance with the SQL syntax supported by MySQL, for example, `["id","table","1","'mingya.wmy'","'null'","to_char(a+1)","2.3","true"]`. ◦ id: a column name. ◦ table: the name of a column that contains reserved keywords. ◦ 1: an integer constant. ◦ 'mingya.wmy': a string constant, which is enclosed in single quotation marks (' '). ◦ null: ▪ '' '' indicates an empty value. ▪ null indicates a null value. ▪ 'null' indicates the string null. ◦ to_char(a + 1): a function expression. ◦ 2.3: a floating-point constant. ◦ true: a Boolean value. • The column parameter must explicitly specify a set of columns to be synchronized. The parameter cannot be left empty.	Yes	None

Parameter	Description	Required	Default value
splitPk	The field used for data sharding when MySQL Reader extracts data. If you specify the splitPk parameter, the table is sharded based on the shard key specified by this parameter. Data Integration then runs concurrent threads to synchronize data. This improves efficiency. • We recommend that you set the splitPk parameter to the primary key of the table. Based on the primary key, data can be well distributed to different shards, but not intensively distributed to certain shards. • Currently, the splitPk parameter supports data sharding only for integers but not for other data types such as string, floating point, and date. If you specify this parameter to a column of an unsupported type, MySQL Reader ignores the splitPk parameter and synchronizes data through a single thread. • If you do not specify the splitPk parameter or leave it empty, Data Integration synchronizes data through a single thread.	No	None
where	The WHERE clause. For example, set this parameter to `gmt_create>$bizdate` . • You can use the WHERE clause to synchronize incremental data. If you do not specify the where parameter or leave it empty, all data is synchronized. • Do not set the where parameter to limit 10, which does not conform to the constraints of MySQL on the SQL WHERE clause.	No	None
querySql (only available in the code editor)	The SELECT statement used for refined data filtering. If you specify this parameter, Data Integration directly filters data based on this parameter. For example, if you want to join multiple tables for data synchronization, set this parameter to `select a,b from table_a join table_b on table_a.id = table_b.id` . The priority of the querySql parameter is higher than those of the table, column, where, and splitPk parameters. If you specify the querySql parameter, MySQL Reader ignores the table, column, where, and splitPk parameters that you have configured. The datasource parameter parses information, including the username and password, from this parameter.	No	None

Parameter	Description	Required	Default value
singleOrMulti (applicable only to database and table sharding)	Specifies whether to shard the database or table. After you switch from the codeless UI to the code editor, the following configuration is automatically generated: `"singleOrMulti":"multi"`. However, if you use the code editor since the beginning, the configuration is not automatically generated and you must manually specify this parameter. If you do not specify this parameter or leave it empty, MySQL Reader can only read data from the first shard.	Yes	*multi*

Configure MySQL Reader by using the codeless UI

1. Configure the connections.

   Configure the source and destination connections for the sync node.

Parameter	Description
Connection	The datasource parameter in the preceding parameter description. Select a connection type, and enter the name of a connection that has been configured in DataWorks.
Table	The table parameter in the preceding parameter description.
Filter	The filter condition for the data to be synchronized. Currently, filtering based on the limit keyword is not supported. The SQL syntax is determined by the selected connection.
Shard Key	The shard key. You can use a column in the source table as the shard key. We recommend that you use the primary key or an indexed column. Only integer fields are supported. If data sharding is performed based on the configured shard key, data can be read concurrently to improve data synchronization efficiency. **Note** The Shard Key parameter is displayed only when you configure the source connection for a sync node.

2. Configure field mapping, that is, the column parameter in the preceding parameter description.

   Fields in the source table on the left have a one-to-one mapping with fields in the destination table on the right. You can click **Add** to add a field, or move the pointer over a field and click the **Delete** icon to delete the field.

Parameter	Description
Map Fields with the Same Name	Click **Map Fields with the Same Name** to establish a mapping between fields with the same name. Note that the data types of the fields must match.

Parameter	Description
Map Fields in the Same Line	Click **Map Fields in the Same Line** to establish a mapping for fields in the same row. Note that the data types of the fields must match.
Delete All Mappings	Click **Delete All Mappings** to remove mappings that have been established.
Auto Layout	Click Auto Layout. The fields are automatically sorted based on specified rules.
Change Fields	Click the Change Fields icon. In the Change Fields dialog box that appears, you can manually edit fields in the source table. Each field occupies a row. The first and the last blank rows are included, whereas other blank rows are ignored.
Add	◦ Click Add to add a field. You can enter constants. Each constant must be enclosed in single quotation marks (' '), such as 'abc' and '123'. ◦ You can use scheduling parameters, such as ${bizdate}. ◦ You can enter functions supported by relational databases, such as now() and count(1). ◦ Fields that cannot be parsed are indicated by Unidentified.

3. Configure channel control policies.

Parameter	Description
Expected Concurrency	The maximum number of concurrent threads to read data from or write data to data storage within the sync node. You can configure the concurrency for a node on the codeless UI.
Bandwidth Throttling	Specifies whether to enable bandwidth throttling. You can enable bandwidth throttling and set a maximum transmission rate to avoid heavy read workload of the source. We recommend that you enable bandwidth throttling and set the maximum transmission rate to a proper value.
Dirty Data Records Allowed	The maximum number of dirty data records allowed.
Resource Group	The resource group used for running the sync node. By default, the node runs on the default resource group. If resources are insufficient, you can add a custom resource group and run the sync node on the custom resource group. Set the resource group properly based on network conditions of the connections, resource group usage, and business importance.

Configure MySQL Reader by using the code editor

In the following code, a node is configured to read data from a database or table that is not sharded. For more information about the parameters, see the preceding parameter description.

```
{
  "type":"job",
  "version":"2.0", // The version number.
```

```
"steps":[
  {
    "stepType":"mysql", // The reader type.
    "parameter":{
      "column":[ // The columns to be synchronized.
        "id"
      ],
      "connection":[
        {  "querysql":["select a,b from join1 c join join2 d on c.id = d.id;"], // Specify the querySql parameter in the connection parameter as a string.
          "datasource":"", // The connection name.
          "table":[
            "xxx" // The name of the table to be synchronized.
          ]
        }
      ],
      "where":"", // The WHERE clause.
      "splitPk":"", // The shard key.
      "encoding":"UTF-8" // The encoding format.
    },
    "name":"Reader",
    "category":"reader"
  },
  {
    "stepType":"stream",
    "parameter":{},
    "name":"Writer",
    "category":"writer"
  }
],
"setting":{
  "errorLimit":{
    "record":"0" // The maximum number of dirty data records allowed.
  },
  "speed":{
    "throttle":false, // Specifies whether to enable bandwidth throttling. A value of false indicates that the bandwidth is not throttled. A value of true indicates that the bandwidth is throttled. The maximum transmission rate takes effect only if you set this parameter to true.
    "concurrent":1, // The maximum number of concurrent threads.
  }
},
```

```
  "order":{
    "hops":[
      {
        "from":"Reader",
        "to":"Writer"
      }
    ]
  }
}
```

In the following code, a node is configured to read data from a database or table that is sharded. For more information about the parameters, see the preceding parameter description.

> **Note** In the case of database and table sharding, MySQL Reader can read multiple MySQL tables with the same schema.

```
{
  "type": "job",
  "version": "1.0",
  "configuration": {
    "reader": {
      "plugin": "mysql",
      "parameter": {
        "connection": [
          {
            "table": [
              "tbl1",
              "tbl2",
              "tbl3"
            ],
            "datasource": "datasourceName1"
          },
          {
            "table": [
              "tbl4",
              "tbl5",
              "tbl6"
            ],
            "datasource": "datasourceName2"
          }
        ],
        "singleOrMulti": "multi",
        "splitPk": "db_id",
        "column": [
          "id", "name", "age"
        ],
        "where": "1 < id and id < 100"
      }
    },
    "writer": {
    }
  }
}
```

2.3.3.3.8. Configure Oracle Reader

This topic describes the data types and parameters supported by Oracle Reader and how to configure it by using the codeless user interface (UI) and code editor.

Oracle Reader allows you to read data from Oracle. Oracle Reader connects to a remote Oracle database and runs a SELECT statement to select and read data from the database.

Specifically, Oracle Reader connects to a remote Oracle database through Java Database Connectivity (JDBC), generates a SELECT statement based on your configurations, and then sends the statement to the database. The Oracle database runs the statement and returns the result. Then, Oracle Reader assembles the returned data to abstract datasets in custom data types supported by Data Integration, and passes the datasets to a writer.

- Oracle Reader generates the SELECT statement based on the table, column, and where parameters that you have configured, and sends the generated SELECT statement to the Oracle database.
- If you specify the querySql parameter, Oracle Reader directly sends the value of this parameter to the Oracle database.

Data types

Oracle Reader supports most Oracle data types. Make sure that your data types are supported.

The following table lists the data types supported by Oracle Reader.

Category	Oracle data type
Integer	NUMBER, ROWID, INTEGER, INT, and SMALLINT
Floating point	NUMERIC, DECIMAL, FLOAT, DOUBLE PRECISION, and REAL
String	LONG, CHAR, NCHAR, VARCHAR, VARCHAR2, NVARCHAR2, CLOB, NCLOB, CHARACTER, CHARACTER VARYING, CHAR VARYING, NATIONAL CHARACTER, NATIONAL CHAR, NATIONAL CHARACTER VARYING, NATIONAL CHAR VARYING, and NCHAR VARYING
Date and time	TIMESTAMP and DATE
Boolean	BIT and BOOLEAN
Binary	BLOB, BFILE, RAW, and LONG RAW

Parameters

Parameter	Description	Required	Default value
datasource	The connection name. It must be identical to the name of the added connection. You can add connections in the code editor.	Yes	None
table	The name of the table to be synchronized.	Yes	None

Parameter	Description	Required	Default value
column	The columns to be synchronized from the source table. The columns are described in a JSON array. The default value is [*], which indicates all columns. • Column pruning is supported. You can select and export specific columns. • Change of the column order is supported. You can export the columns in an order different from that specified in the schema of the table. • Constants are supported. The column names must be arranged in JSON format. `["id", "1", "'mingya.wmy'", "null", "to_char(a + 1)", "2.3", "true"]` ◦ id: a column name. ◦ 1: an integer constant. ◦ 'mingya.wmy': a string constant, which is enclosed in single quotation marks (' '). ◦ null: a null pointer. ◦ to_char(a + 1): a function expression. ◦ 2.3: a floating-point constant. ◦ true: a Boolean value. • The column parameter must be specified.	Yes	None
splitPk	The field used for data sharding when Oracle Reader extracts data. If you specify the splitPk parameter, the table is sharded based on the shard key specified by this parameter. Data Integration then runs concurrent threads to synchronize data. This improves efficiency. • We recommend that you set the splitPk parameter to the primary key of the table. Based on the primary key, data can be well distributed to different shards, but not intensively distributed to certain shards. • The data types supported by the splitPk parameter include INTEGER, STRING, FLOAT, and DATE. • If you do not specify the splitPk parameter or leave it empty, Oracle Reader synchronizes data through a single thread.	No	None
where	The WHERE clause. Oracle Reader generates a SELECT statement based on the table, column, and where parameters that you have configured, and uses the generated SELECT statement to select and read data. For example, set this parameter to row_number() or `id>2 and sex=1`. • You can use the WHERE clause to synchronize incremental data. • If you do not specify the where parameter or leave it empty, all data is synchronized.	No	None

Parameter	Description	Required	Default value
querySql (only available in the code editor)	The SELECT statement used for refined data filtering. If you specify this parameter, Data Integration directly filters data based on this parameter. For example, if you want to join multiple tables for data synchronization, set this parameter to `select a,b from table_a join table_b on table_a.id = table_b.id`. If you specify the querySql parameter, Oracle Reader ignores the table, column, and where parameters that you have configured.	No	None
fetchSize	The number of data records to read at a time. This parameter determines the number of interactions between Data Integration and the database and affects reading efficiency. **Note** A value greater than 2048 may lead to out of memory (OOM) during the data synchronization process.	No	1024

Configure Oracle Reader by using the codeless UI

1. Configure the connections.

   Configure the source and destination connections for the sync node.

Parameter	Description
Connection	The datasource parameter in the preceding parameter description. Select a connection type, and enter the name of a connection that has been configured in DataWorks.
Table	The table parameter in the preceding parameter description.
Filter	The filter condition for the data to be synchronized. Currently, filtering based on the limit keyword is not supported. The SQL syntax is determined by the selected connection.
Shard Key	The shard key. You can use a column in the source table as the shard key. We recommend that you use the primary key or an indexed column. Only integer fields are supported. If data sharding is performed based on the configured shard key, data can be read concurrently to improve data synchronization efficiency. **Note** The Shard Key parameter is displayed only when you configure the source connection for a sync node.

2. Configure field mapping, that is, the column parameter in the preceding parameter description.

   Fields in the source table on the left have a one-to-one mapping with fields in the destination table on the right. You can click **Add** to add a field, or move the pointer over a field and click the **Delete** icon to delete the field.

Parameter	Description
Map Fields with the Same Name	Click **Map Fields with the Same Name** to establish a mapping between fields with the same name. Note that the data types of the fields must match.
Map Fields in the Same Line	Click **Map Fields in the Same Line** to establish a mapping for fields in the same row. Note that the data types of the fields must match.
Delete All Mappings	Click **Delete All Mappings** to remove mappings that have been established.
Auto Layout	Click Auto Layout. The fields are automatically sorted based on specified rules.
Change Fields	Click the Change Fields icon. In the Change Fields dialog box that appears, you can manually edit fields in the source table. Each field occupies a row. The first and the last blank rows are included, whereas other blank rows are ignored.
Add	◦ Click Add to add a field. You can enter constants. Each constant must be enclosed in single quotation marks (' '), such as 'abc' and '123'. ◦ You can use scheduling parameters, such as ${bizdate}. ◦ You can enter functions supported by relational databases, such as now() and count(1). ◦ Fields that cannot be parsed are indicated by Unidentified.

3. Configure channel control policies.

Parameter	Description
Expected Concurrency	The maximum number of concurrent threads to read data from or write data to data storage within the sync node. You can configure the concurrency for a node on the codeless UI.
Bandwidth Throttling	Specifies whether to enable bandwidth throttling. You can enable bandwidth throttling and set a maximum transmission rate to avoid heavy read workload of the source. We recommend that you enable bandwidth throttling and set the maximum transmission rate to a proper value.
Dirty Data Records Allowed	The maximum number of dirty data records allowed.
Resource Group	The resource group used for running the sync node. By default, the node runs on the default resource group. If resources are insufficient, you can add a custom resource group and run the sync node on the custom resource group. Set the resource group properly based on network conditions of the connections, resource group usage, and business importance.

Configure Oracle Reader by using the code editor

In the following code, a node is configured to read data from an Oracle database.

```
{
```

```
{
  "type":"job",
  "version":"2.0", // The version number.
  "steps":[
    {
      "stepType":"oracle",
      "parameter":{
        "fetchSize":1024, // The number of data records to read at a time.
        "datasource":"", // The connection name.
        "column":[ // The columns to be synchronized.
          "id",
          "name"
        ],
        "where":"", // The WHERE clause.
        "splitPk":"", // The shard key.
        "table":"" // The name of the table to be synchronized.
      },
      "name":"Reader",
      "category":"reader"
    },
    {// The following template is used to configure Stream Writer. For more information about how to config
ure other writers, see the corresponding topic.
      "stepType":"stream",
      "parameter":{},
      "name":"Writer",
      "category":"writer"
    }
  ],
  "setting":{
    "errorLimit":{
      "record":"0" // The maximum number of dirty data records allowed.
    },
    "speed":{
      "throttle":false, // Specifies whether to enable bandwidth throttling. A value of false indicates that the
bandwidth is not throttled. A value of true indicates that the bandwidth is throttled. The maximum transmi
ssion rate takes effect only if you set this parameter to true.
      "concurrent":1, // The maximum number of concurrent threads.
    }
  },
  "order":{
    "hops":[
```

```
      {
        "from":"Reader",
        "to":"Writer"
      }
    ]
  }
} "to":"Writer"
      }
    ]
  }
}
```

Additional instructions

- Data synchronization between primary and secondary databases

  A secondary Oracle database can be deployed for disaster recovery. The secondary database continuously synchronizes data from the primary database based on binlogs. Especially when network conditions are unfavorable, data latency between the primary and secondary databases is unavoidable, which can lead to data inconsistency.

- Concurrency control

  Oracle is a relational database management system (RDBMS), which supports strong consistency for data queries. A database snapshot is created before a sync node starts. Oracle Reader reads data from the database snapshot. Therefore, if new data is written to the database during data synchronization, Oracle Reader cannot obtain the new data.

  Data consistency cannot be guaranteed when you enable Oracle Reader to run concurrent threads on a single sync node.

  Oracle Reader shards the table based on the splitPk parameter and runs multiple concurrent threads to synchronize data. These concurrent threads belong to different transactions. They read data at different time points. This means that the concurrent threads observe different snapshots.

  Theoretically, the data inconsistency issue is unavoidable if a single sync node includes multiple threads. However, two workarounds are available:

  - Do not enable concurrent threads on a single sync node. Essentially, do not specify the splitPk parameter. In this way, data consistency is guaranteed although data is synchronized at a low efficiency.
  - Disable writers to make sure that the data is unchanged during data synchronization. For example, lock the table and disable data synchronization between primary and secondary databases. In this way, data is synchronized efficiently but your ongoing services may be interrupted.

- Character encoding

  Oracle Reader uses JDBC, which can automatically convert the encoding of characters. Therefore, you do not need to specify the encoding format.

- Incremental data synchronization

  Oracle Reader connects to a database through JDBC and uses a SELECT statement with a WHERE clause to read incremental data in the following ways:

  - For data in batches, incremental add, update, and delete operations (including logically delete operations) are distinguished by timestamps. Specify the WHERE clause based on the timestamp. The timestamp must be later than the latest timestamp in the last synchronization.
  - For streaming data, specify the WHERE clause based on the data record ID. The data record ID must be larger than the maximum ID involved in the last synchronization.

  If incremental data cannot be distinguished, Oracle Reader cannot perform incremental synchronization but can perform full synchronization only.

- Syntax validation

  Oracle Reader allows you to specify custom SELECT statements by using the querySql parameter but does not verify the syntax of the custom SELECT statements.

2.3.3.3.9. Configure OSS Reader

This topic describes the data types and parameters supported by Object Storage Service (OSS) Reader and how to configure it by using the codeless user interface (UI) and code editor.

OSS Reader can read data stored in OSS. OSS Reader connects to OSS through the official OSS Java SDK, reads data from OSS, converts the data into a format that is readable by Data Integration, and then sends the converted data to a writer.

OSS stores unstructured data only. Currently, OSS Reader supports the following features:

- Reads TXT objects that store logical two-dimensional tables. OSS Reader can read only TXT objects.
- Reads data stored in formats similar to CSV with custom delimiters.
- Reads data of various types as strings. Supports constants and column pruning.
- Supports recursive reading and object name-based filtering.
- Supports the following object compression formats: GZIP, BZIP2, and ZIP.

  > **Note** You cannot compress multiple objects into one package.

- Reads multiple objects concurrently.

Currently, OSS Reader does not support the following features:

- Uses concurrent threads to read an uncompressed object.
- Uses concurrent threads to read a compressed object.

OSS Reader supports the following OSS data types: Bigint, Double, String, Datatime, and Boolean.

Parameters

Parameter	Description	Required	Default value
datasource	The connection name. It must be identical to the name of the added connection. You can add connections in the code editor.	Yes	None

Parameter	Description	Required	Default value
object	The name of the OSS object to read. You can specify multiple object names. For example, if a bucket has a folder named yunshi and this folder contains an object named ll.txt, you can set this parameter to yunshi/ll.txt. • If you specify a single OSS object, OSS Reader uses only one thread to read the object. Concurrent multi-thread reading of a single uncompressed object is coming soon. • If you specify multiple OSS objects, OSS Reader uses multiple threads to read these objects. The actual number of threads is determined by the number of channels. • When a name contains a wildcard, OSS Reader attempts to read all objects that match the name. For example, if you set the value to abc[0-9], OSS Reader reads objects abc0 to abc9. We recommend that you do not use wildcards because wildcards may cause out of memory (OOM). **Note** • Data Integration considers all the objects on a sync node as a single table. Make sure that all the objects on each sync node can adapt to the same schema. • Control the number of objects stored in a single directory. If a directory contains too many objects, an OOM error may be returned. In this case, store the objects in different directories and then synchronize data.	Yes	None

Parameter	Description	Required	Default value
column	The columns to read. The type parameter specifies the source data type. The index parameter specifies the ID of the column in the source table, starting from 0. The value parameter specifies the column value if the column is a constant column. By default, OSS Reader reads all data as strings. You can specify the column parameter in the following way: `json` `"column": ["*"]` You can also specify the column parameter in the following way: `json` `"column":` `{` `"type": "long",` `"index": 0 // The first INT-type column of the source object.` `},` `{` `"type": "string",` `"value": "alibaba" // The value of the current column, that is, a constant "alibaba".` `}` **Note** For the column parameter, you must specify the type parameter and specify one of the index and value parameters.	Yes	By default, OSS Reader reads all data as strings.
fieldDelimiter	The column delimiter. **Note** You must specify the column delimiter for OSS Reader. The default delimiter is comma (,). The default setting for the column delimiter on the codeless UI is comma (,), too.	Yes	,

Parameter	Description	Required	Default value
compress	The compression format of the object. By default, this parameter is left empty, that is, objects are not compressed. OSS Reader supports the following object compression formats: GZIP, BZIP2, and ZIP.	No	*By default, objects are not compressed.*
encoding	The encoding format of the object to read.	No	*UTF-8*
nullFormat	The string that represents null. No standard strings can represent null in TXT objects. Therefore, Data Integration provides the nullFormat parameter to define which string represents a null pointer. For example, if you specify `nullFormat="null"`, Data Integration considers null as a null pointer. You can use the following formula to escape empty strings: \N=\\N.	No	None
skipHeader	Specifies whether to skip the header (if exists) of a CSV-like object. The skipHeader parameter is not supported for compressed objects.	No	*false*
csvReaderConfig	The configurations for reading CSV objects. The parameter value must match the MAP type. A specific CSV reader is used to read data from CSV objects, which supports many configurations.	No	None

Configure OSS Reader by using the codeless UI

1. Configure the connections.

   Configure the source and destination connections for the sync node.

Parameter	Description
Connection	The datasource parameter in the preceding parameter description. Select a connection type, and enter the name of a connection that has been configured in DataWorks.
Object Name Prefix	The object parameter in the preceding parameter description. **Note** If an OSS object is named based on the date, for example, named as aaa/20171024abc.txt, you can set the object parameter to aaa/${bdp.system.bizdate}abc.txt.
Field Delimiter	The fieldDelimiter parameter in the preceding parameter description. The default delimiter is comma (,).
Encoding	The encoding parameter in the preceding parameter description. The default encoding format is UTF-8.

Parameter	Description
Null String	The nullFormat parameter in the preceding parameter description. Enter a string that represents null. If the source connection contains the string, the string is replaced with null.
Compression Format	The compress parameter in the preceding parameter description. By default, objects are not compressed.
Include Header	The skipHeader parameter in the preceding parameter description. The default value is No.

2. Configure field mapping, that is, the column parameter in the preceding parameter description.

   Fields in the source table on the left have a one-to-one mapping with fields in the destination table on the right. You can click **Add** to add a field, or move the pointer over a field and click the **Delete** icon to delete the field.

Parameter	Description
Map Fields with the Same Name	Click **Map Fields with the Same Name** to establish a mapping between fields with the same name. Note that the data types of the fields must match.
Map Fields in the Same Line	Click **Map Fields in the Same Line** to establish a mapping for fields in the same row. Note that the data types of the fields must match.
Delete All Mappings	Click **Delete All Mappings** to remove mappings that have been established.

3. Configure channel control policies.

Parameter	Description
Expected Concurrency	The maximum number of concurrent threads to read data from or write data to data storage within the sync node. You can configure the concurrency for a node on the codeless UI.
Bandwidth Throttling	Specifies whether to enable bandwidth throttling. You can enable bandwidth throttling and set a maximum transmission rate to avoid heavy read workload of the source. We recommend that you enable bandwidth throttling and set the maximum transmission rate to a proper value.
Dirty Data Records Allowed	The maximum number of dirty data records allowed.
Resource Group	The resource group used for running the sync node. By default, the node runs on the default resource group. If resources are insufficient, you can add a custom resource group and run the sync node on the custom resource group. Set the resource group properly based on network conditions of the connections, resource group usage, and business importance.

Configure OSS Reader by using the code editor

In the following code, a node is configured to read data from OSS. For more information about the parameters, see the preceding parameter description.

```
{
  "type":"job",
  "version":"2.0", // The version number.
  "steps":[
    {
      "stepType":"oss", // The reader type.
      "parameter":{
        "nullFormat":"", // The string that represents null.
        "compress":"", // The compression format.
        "datasource":"", // The connection name.
        "column":[ // The columns to be synchronized.
          {
            "index":0, // The ID of the column in the source table.
            "type":"string" // The data type.
          },
          {
            "index":1,
            "type":"long"
          },
          {
            "index":2,
            "type":"double"
          },
          {
            "index":3,
            "type":"boolean"
          },
          {
            "format":"yyyy-MM-dd HH:mm:ss", // The format of the time.
            "index":4,
            "type":"date"
          }
        ],
        "skipHeader":"", // Specifies whether to skip the header (if exists) of a CSV-like object.
        "encoding":"", // The encoding format.
        "fieldDelimiter":",", // The column delimiter.
        "fileFormat": "", // The format of the object saved by OSS Reader.
        "Object":[] // The name of the OSS object to read.
      }
```

```
        },
        "name":"Reader",
        "category":"reader"
      },
      {
        "stepType":"stream",
        "parameter":{},
        "name":"Writer",
        "category":"writer"
      }
    ],
    "setting":{
      "errorLimit":{
        "record":"" // The maximum number of dirty data records allowed.
      },
      "speed":{
        "throttle":false, // Specifies whether to enable bandwidth throttling. A value of false indicates that the bandwidth is not throttled. A value of true indicates that the bandwidth is throttled. The maximum transmission rate takes effect only if you set this parameter to true.
        "concurrent":1, // The maximum number of concurrent threads.
      }
    },
    "order":{
      "hops":[
        {
          "from":"Reader",
          "to":"Writer"
        }
      ]
    }
}
```

2.3.3.3.10. Configure FTP Reader

This topic describes the data types and parameters supported by File Transfer Protocol (FTP) Reader and how to configure it by using the codeless user interface (UI) and code editor.

FTP Reader allows you to read data from a remote FTP server. FTP Reader connects to an FTP server, reads data from the server, converts the data into a format that is readable by Data Integration, and then sends the converted data to a writer.

FTP Reader can read only FTP files that store logical two-dimensional tables, for example, text information in CSV format.

FTP servers store unstructured data only. Currently, FTP Reader supports the following features:

- Reads TXT files that store logical two-dimensional tables. FTP Reader can read only TXT files.
- Reads data stored in formats similar to CSV with custom delimiters.
- Reads data of various types as strings. Supports constants and column pruning.
- Supports recursive reading and file name-based filtering.
- Supports the following file compression formats: GZIP, BZIP2, ZIP, LZO, and LZO_DEFLATE.
- Reads multiple files concurrently.

Currently, FTP Reader does not support the following features:

- Uses concurrent threads to read an uncompressed file.
- Uses concurrent threads to read a compressed file.

The data types of remote FTP files are defined by FTP Reader.

Data Integration data type	FTP file data type
LONG	LONG
DOUBLE	DOUBLE
STRING	STRING
BOOLEAN	BOOLEAN
DATE	DATE

Parameters

Parameter	Description	Required	Default value
datasource	The connection name. It must be identical to the name of the added connection. You can add connections in the code editor.	Yes	None

Parameter	Description	Required	Default value
path	The path of the FTP file to read. You can specify multiple FTP file paths. • If you specify a single FTP file, FTP Reader uses only one thread to read the file. Concurrent multi-thread reading of a single uncompressed file is coming soon. • If you specify multiple FTP files, FTP Reader uses multiple threads to read these files. The actual number of threads is determined by the number of channels. • When a path contains a wildcard, FTP Reader attempts to read all files that match the path. If the path is ended with a slash (/), FTP Reader reads all files in the specified directory. For example, if you specify the path as /bazhen/, FTP Reader reads all files in the bazhen directory. Currently, FTP Reader only supports asterisks (*) as file name wildcards. **Note** • We recommend that you do not use asterisks (*) because this may cause out of memory (OOM) on a Java virtual machine (JVM). • Data Integration considers all the files on a sync node as a single table. Make sure that all the files on each sync node can adapt to the same schema and Data Integration has the permission to read all these files. • Make sure that the data format is similar to CSV. • An error occurs if no readable files exist in the specified path.	Yes	None

Parameter	Description	Required	Default value
column	The columns to read. The type parameter specifies the source data type. The index parameter specifies the ID of the column in the source table, starting from 0. The value parameter specifies the column value if the column is a constant column. By default, FTP Reader reads all data as strings. Specify this parameter as `"column":["*"]`. You can also specify the column parameter in the following way: `{ "type": "long", "index": 0 // The first INT-type column of the source file. }, { "type": "string", "value": "alibaba" // The value of the current column, that is, a constant "alibaba". }` For the column parameter, you must specify the type parameter and specify one of the index and value parameters.	Yes	By default, FTP Reader reads all data as strings.
fieldDelimiter	The column delimiter. **Note** You must specify the column delimiter for FTP Reader. The default delimiter is comma (,). The default setting for the column delimiter on the codeless UI is comma (,), too.	Yes	,
skipHeader	Specifies whether to skip the header (if exists) of a CSV-like file. The skipHeader parameter is not supported for compressed files.	No	false
encoding	The encoding format of the file to read.	No	*UTF-8*
nullFormat	The string that represents null. No standard strings can represent null in text files. Therefore, Data Integration provides the nullFormat parameter to define which string represents a null pointer. For example, if you specify `nullFormat:"null"`, Data Integration considers null as a null pointer.	No	None

Parameter	Description	Required	Default value
markDoneFileName	The name of the file used to indicate that the sync node can start. Data Integration checks whether the file exists before data synchronization. If the file does not exist, Data Integration checks again later. Data Integration starts the sync node only after the file is detected.	No	None
maxRetryTime	The maximum number of checks for the file used to indicate that the sync node can start. By default, 60 checks are allowed. Data Integration checks for the file every 1 minute. The whole process lasts at most 60 minutes.	No	*60*
csvReaderConfig	The configurations for reading CSV files. The parameter value must match the MAP type. A specific CSV reader is used to read data from CSV files, which supports many configurations.	No	None
fileFormat	The format of the file saved by FTP Reader. By default, FTP Reader converts the data into a two-dimensional table and stores the table in a CSV file. If you specify binary as the file format, Data Integration converts data into the binary format for replication and transmission. Generally, you need to specify this parameter only when you want to replicate the complete directory structure between storage systems such as FTP and Object Storage Service (OSS).	No	None

Configure FTP Reader by using the codeless UI

1. Configure the connections.

   Configure the source and destination connections for the sync node.

Parameter	Description
Connection	The datasource parameter in the preceding parameter description. Select a connection type, and enter the name of a connection that has been configured in DataWorks.
File Path	The path parameter in the preceding parameter description.
File Type	The format of the file saved by FTP Reader. The default format is CSV.
Field Delimiter	The fieldDelimiter parameter in the preceding parameter description. The default delimiter is comma (,).
Encoding	The encoding parameter in the preceding parameter description. The default encoding format is *UTF-8*.
Null String	The nullFormat parameter in the preceding parameter description, which defines a string that represents the null value.
Compression Format	The compression format. By default, files are not compressed.

Parameter	Description
Include Header	The skipHeader parameter in the preceding parameter description. The default value is *No*.

2. Configure field mapping, that is, the column parameter in the preceding parameter description.

   Fields in the source table on the left have a one-to-one mapping with fields in the destination table on the right. You can click **Add** to add a field, or move the pointer over a field and click the **Delete** icon to delete the field.

Parameter	Description
Map Fields with the Same Name	Click **Map Fields with the Same Name** to establish a mapping between fields with the same name. Note that the data types of the fields must match.
Map Fields in the Same Line	Click **Map Fields in the Same Line** to establish a mapping for fields in the same row. Note that the data types of the fields must match.
Delete All Mappings	Click **Delete All Mappings** to remove mappings that have been established.

3. Configure channel control policies.

Parameter	Description
Expected Concurrency	The maximum number of concurrent threads to read data from or write data to data storage within the sync node. You can configure the concurrency for a node on the codeless UI.
Bandwidth Throttling	Specifies whether to enable bandwidth throttling. You can enable bandwidth throttling and set a maximum transmission rate to avoid heavy read workload of the source. We recommend that you enable bandwidth throttling and set the maximum transmission rate to a proper value.
Dirty Data Records Allowed	The maximum number of dirty data records allowed.
Resource Group	The resource group used for running the sync node. By default, the node runs on the default resource group. If resources are insufficient, you can add a custom resource group and run the sync node on the custom resource group. Set the resource group properly based on network conditions of the connections, resource group usage, and business importance.

Configure FTP Reader by using the code editor

In the following code, a node is configured to read data from an FTP server.

```
{
  "type":"job",
  "version":"2.0", // The version number.
  "steps":[
    {
```

```
        "stepType":"ftp", // The reader type.
        "parameter":{
          "path":[], // The file path.
          "nullFormat":"", // The string that represents null.
          "compress":"", // The compression format.
          "datasource":"", // The connection name.
          "column":[ // The columns to be synchronized.
            {
              "index":0, // The ID of the column in the source table.
              "type":"" // The data type.
            }
          ],
          "skipHeader":"", // Specifies whether to skip the file header.
          "fieldDelimiter":",", // The column delimiter.
          "encoding":"UTF-8", // The encoding format.
          "fileFormat":"csv" // The format of the file saved by FTP Reader.
        },
        "name":"Reader",
        "category":"reader"
      },
      {// The following template is used to configure the writer. For more information, see the corresponding t
opic.
        "stepType":"stream",
        "parameter":{},
        "name":"Writer",
        "category":"writer"
      }
    ],
    "setting":{
      "errorLimit":{
        "record":"0" // The maximum number of dirty data records allowed.
      },
      "speed":{
        "throttle":false, // Specifies whether to enable bandwidth throttling. A value of false indicates that the
bandwidth is not throttled. A value of true indicates that the bandwidth is throttled. The maximum transmi
ssion rate takes effect only if you set this parameter to true.
        "concurrent":1, // The maximum number of concurrent threads.
      }
    },
    "order":{
      "hops":[
```

```
    "hops":[
      {
        "from":"Reader",
        "to":"Writer"
      }
    ]
  }
}
```

2.3.3.3.11. Configure Table Store Reader

This topic describes the data types and parameters supported by Table Store Reader and how to configure it by using the code editor.

Table Store Reader can read incremental data from Table Store based on the specified range. Currently, Table Store Reader can read incremental data in the following ways:

- Reads data from the entire table.
- Reads data based on the specified range.
- Reads data from the specified shard.

Table Store is a NoSQL database service built on the Apsara distributed operating system that allows you to store and access large amounts of structured data in real time. Table Store organizes data into instances and tables. Using data sharding and load balancing technologies, Table Store seamlessly expands the data scale.

Table Store Reader connects to the Table Store server through the official Table Store Java SDK and reads data from the server. Then, Table Store Reader converts the data into a format that is readable by Data Integration based on the official data synchronization protocols, and sends the converted data to a writer.

Table Store Reader splits a sync node into concurrent tasks based on the table range to synchronize data in a Table Store table. Each thread is responsible for running a task.

Table Store Reader supports all Table Store data types. The following table lists the data types supported by Table Store Reader.

Category	Table Store data type
Integer	INTEGER
Floating point	DOUBLE
String	STRING
Boolean	BOOLEAN
Binary	BINARY

> **Note** Table Store does not support data of the DATE type. Applications use the LONG-type UNIX timestamp to indicate the time.

Parameters

Parameter	Description	Required	Default value
endpoint	The endpoint of the Table Store server.	Yes	None
accessId	The AccessKey ID for accessing Table Store.	Yes	None
accessKey	The AccessKey secret for accessing Table Store.	Yes	None
instanceName	The name of the Table Store instance. The instance is an entity for you to use and manage Table Store. After you activate the Table Store service, you must create an instance in the console before creating and managing tables. Instances are the basic unit for managing Table Store resources. All access control and resource measurement for applications are completed at the instance level.	Yes	None
table	The name of the source table. You can specify only one table as the source table. Multi-table synchronization is not required for Table Store.	Yes	None
column	The columns to be synchronized from the source table. The columns are described in a JSON array. Table Store is a NoSQL database service. You must specify column names for Table Store Reader to read data. • You can specify common columns. For example, you can specify {"name":"col1"} for Table Store Reader to read data in column 1. • You can specify certain columns to read. Table Store Reader only reads specified columns. • You can specify constant columns. For example, you can specify {"type":"STRING", "value":"DataX"} to read the column in which data is of the STRING type and the data value is DataX. The type parameter specifies the constant type. The supported types are STRING, INT, DOUBLE, BOOLEAN, BINARY, INF_MIN, and INF_MAX. If the constant type is BINARY, the constant value must be Base64-encoded. INF_MIN indicates the minimum value specified by Table Store, and INF_MAX indicates the maximum value specified by Table Store. If you set the type to INF_MIN or INF_MAX, do not set the value. Otherwise, errors may occur. • You cannot specify a function or custom expression, because Table Store does not provide functions or expressions similar to those of SQL. Table Store Reader cannot read columns that contain functions or expressions.	Yes	None
	The Table Store table range from which data is to be read. You		

Parameter	Description	Required	Default value
begin and end	can specify both or neither of the two parameters. The begin and end parameters define the value ranges of primary key columns in the Table Store table. Make sure that you specify the value ranges for all primary key columns in the table. If you do not need to limit a range, specify the parameters as {"type":"INF_MIN"} and {"type":"INF_MAX"}. For example, to read certain data from a Table Store table with the primary key of [DeviceID, SellerID], specify the begin and end parameters in the following way: `"range":{ "begin":[{"type":"INF_MIN"}, // The minimum value of the DeviceID field. {"type":"INT", "value":"0"} // The minimum value of the SellerID field.], "end":[{"type":"INF_MAX"}, // The maximum value of the DeviceID field. {"type":"INT", "value":"9999"} // The maximum value of the SellerID field.] }` To read all data from the table, specify the begin and end parameters in the following way: `"range":{ "begin":[{"type":"INF_MIN"}, // The minimum value of the DeviceID field. {"type":"INF_MIN"} // The minimum value of the SellerID field.], "end":[{"type":"INF_MAX"}, // The maximum value of the DeviceID field. {"type":"INF_MAX"} // The maximum value of the SellerID field.] }`	Yes	None

Parameter	Description	Required	Default value

Parameter	Description	Required	Default value
split	The custom rule for data sharding. This parameter is an advanced setting. We recommend that you do not set this parameter. If data is unevenly distributed in a Table Store table and the automatic sharding feature of Table Store Reader fails to work, you can customize a sharding rule. The sharding rule specified by the split parameter must fall in the range specified by the begin and end parameters and must be the values of partition key columns. That is, you only need to specify the values of partition key columns instead of the values of primary key columns in the split parameter. To read data from a Table Store table with the primary key of [DeviceID, SellerID], specify the following parameters:	No	None

Parameter	Description	Required	Default value
"range": { "begin": { {"type":"INF_MIN"} // The minimum value of the DeviceID field. {"type":"INF_MIN"} // The minimum value of the SellerID field. }, "end": { {"type":"INF_MAX"}, // The maximum value of the DeviceID field. {"type":"INF_MAX"} // The maximum value of the SellerID field. }, // The specified sharding rule. If you specify a sharding rule, the sync node is split into concurrent tasks based on the values of the begin, end, and split parameters. Data is sharded only based on the partition key, that is, the first column of the primary key. // The data type of the partition key can be INF_MIN, INF_MAX, STRING, or INT. "split":[{"type":"STRING", "value":"1"}, {"type":"STRING", "value":"2"}, {"type":"STRING", "value":"3"}, {"type":"STRING", "value":"4"}, {"type":"STRING", "value":"5"}] }			

Configure Table Store Reader by using the codeless UI

Currently, the codeless user interface (UI) is not supported for Table Store Reader.

Configure Table Store Reader by using the code editor

In the following code, a node is configured to read data from a Table Store table.

```
{
  "type":"job",
  "version":"2.0", // The version number.
  "steps":[
    {
      "stepType":"ots", // The reader type.
      "parameter":{
        "datasource":"", // The connection name.
        "column":[ // The columns to be synchronized.
          {
            "name":"column1" // The name of the column.
          },
          {
            "name":"column2"
          },
          {
            "name":"column3"
          },
          {
            "name":"column4"
          },
          {
            "name":"column5"
          }
        ],
        "range":{
          "split":[
            {
              "type":"INF_MIN"
            },
            {
              "type":"STRING",
              "value":"splitPoint1"
```

```
            "value":"splitPoint1"
          },
          {
            "type":"STRING",
            "value":"splitPoint2"
          },
          {
            "type":"STRING",
            "value":"splitPoint3"
          },
          {
            "type":"INF_MAX"
          }
        ],
        "end":[
          {
            "type":"INF_MAX"
          },
          {
            "type":"INF_MAX"
          },
          {
            "type":"STRING",
            "value":"end1"
          },
          {
            "type":"INT",
            "value":"100"
          }
        ],
        "begin":[
          {
            "type":"INF_MIN"
          },
          {
            "type":"INF_MIN"
          },
          {
            "type":"STRING",
            "value":"begin1"
          },
```

```
            {
              "type":"INT",
              "value":"0"
            }
          ]
        },
        "table":"" // The name of the table to be synchronized.
      },
      "name":"Reader",
      "category":"reader"
    },
    {
      "stepType":"stream",
      "parameter":{},
      "name":"Writer",
      "category":"writer"
    }
  ],
  "setting":{
    "errorLimit":{
      "record":"0" // The maximum number of dirty data records allowed.
    },
    "speed":{
      "throttle":false, // Specifies whether to enable bandwidth throttling. A value of false indicates that the bandwidth is not throttled. A value of true indicates that the bandwidth is throttled. The maximum transmission rate takes effect only if you set this parameter to true.
      "concurrent":1, // The maximum number of concurrent threads.
    }
  },
  "order":{
    "hops":[
      {
        "from":"Reader",
        "to":"Writer"
      }
    ]
  }
}
```

2.3.3.3.12. Configure PostgreSQL Reader

This topic describes the data types and parameters supported by PostgreSQL Reader and how to configure it by using the codeless user interface (UI) and code editor.

PostgreSQL Reader connects to a remote PostgreSQL database and runs a SELECT statement to select and read data from the database. ApsaraDB for Relational Database Service (RDS) provides the PostgreSQL storage engine.

Specifically, PostgreSQL Reader connects to a remote PostgreSQL database through Java Database Connectivity (JDBC), generates a SELECT statement based on your configurations, and then sends the statement to the database. The PostgreSQL database runs the statement and returns the result. Then, PostgreSQL Reader assembles the returned data to abstract datasets in custom data types supported by Data Integration, and passes the datasets to a writer.

- PostgreSQL Reader generates the SELECT statement based on the table, column, and where parameters that you have configured, and sends the generated SQL statement to the PostgreSQL database.
- If you specify the querySql parameter, PostgreSQL Reader directly sends the value of this parameter to the PostgreSQL database.

Data types

PostgreSQL Reader supports most PostgreSQL data types. Make sure that your data types are supported.

The following table lists the data types supported by PostgreSQL Reader.

Category	PostgreSQL data type
Integer	bigint, bigserial, integer, smallint, and serial
Floating point	double, precision, money, numeric, and real
String	varchar, char, text, bit, and inet
Date and time	date, time, and timestamp
Boolean	boolean
Binary	bytea

> **Note**
>
> - Data types that are not listed in the table are not supported.
> - You can convert the money, inet, and bit types by using syntax such as `a_inet::varchar`.

Parameters

Parameter	Description	Required	Default value
datasource	The connection name. It must be identical to the name of the added connection. You can add connections in the code editor.	Yes	None
table	The name of the table to be synchronized.	Yes	None
column	The columns to be synchronized from the source table. The columns are described in a JSON array. The default value is [*], which indicates all columns. • Column pruning is supported. You can select and export specific columns. • Change of the column order is supported. You can export the columns in an order different from that specified in the schema of the table. • Constants are supported. The column names must be arranged in compliance with the SQL syntax supported by MySQL, for example, `["id", "table","1", "'mingya.wmy'", "'null'", "to_char(a+1)", "2.3", "true"]`. ○ id: a column name. ○ table: the name of a column that contains reserved keywords. ○ 1: an integer constant. ○ 'mingya.wmy': a string constant, which is enclosed in single quotation marks (' '). ○ 'null': a string. ○ to_char(a+1): a function expression. ○ 2.3: a floating-point constant. ○ true: a Boolean value. • The column parameter must explicitly specify a set of columns to be synchronized. The parameter cannot be left empty.	Yes	None
splitPk	The field used for data sharding when PostgreSQL Reader extracts data. If you specify the splitPk parameter, the table is sharded based on the shard key specified by this parameter. Data Integration then initiates concurrent sync threads, which improves efficiency. • We recommend that you set the splitPk parameter to the primary key of the table. Based on the primary key, data can be well distributed to different shards, but not intensively distributed to certain shards. • Currently, the splitPk parameter supports data sharding only for integers but not for other data types such as string, floating point, and date. If you specify this parameter to a column of an unsupported type, PostgreSQL Reader ignores the splitPk parameter and synchronizes data through a single thread. • If you do not specify the splitPk parameter or leave it empty, Data Integration synchronizes data through a single thread.	No	None

Parameter	Description	Required	Default value
where	The WHERE clause. PostgreSQL Reader generates a SELECT statement based on the table, column, and where parameters that you have configured, and uses the generated SELECT statement to select and read data. For example, set this parameter to `id>2 and sex=1`. • You can use the WHERE clause to synchronize incremental data. • If you do not specify the where parameter or leave it empty, all data is synchronized.	No	None
querySql (only available in the code editor)	The SELECT statement used for refined data filtering. If you specify this parameter, Data Integration directly filters data based on this parameter. For example, if you want to join multiple tables for data synchronization, set this parameter to `select a,b from table_a join table_b on table_a.id = table_b.id`. If you specify the querySql parameter, PostgreSQL Reader ignores the table, column, where, and splitPk parameters that you have configured.	No	None
fetchSize	The number of data records to read at a time. This parameter determines the number of interactions between Data Integration and the database and affects reading efficiency. **Note** A value larger than 2048 may lead to the out of memory (OOM) error during the data synchronization process.	No	*512*

Configure PostgreSQL Reader by using the codeless UI

1. Configure the connections.

   Configure the source and destination connections for the sync node.

Configuration item	Description
Connection	The datasource parameter in the preceding parameter description. Select a connection type, and enter the name of a connection that has been configured in DataWorks.
Table	The table parameter in the preceding parameter description.
Filter	The filter condition for the data to be synchronized. Currently, filtering based on the limit keyword is not supported. The SQL syntax is determined by the selected connection.

Configuration item	Description
Shard Key	The shard key. You can use a column in the source table as the shard key. We recommend that you use the primary key or an indexed column. Only integer fields are supported. If data sharding is performed based on the configured shard key, data can be read concurrently to improve data synchronization efficiency. **Note** The Shard Key parameter is displayed only when you configure the source connection for a sync node.

2. Configure field mapping, that is, the column parameter in the preceding parameter description.

   Fields in the source table on the left have a one-to-one mapping with fields in the destination table on the right. You can click **Add** to add a field, or move the pointer over a field and click the **Delete** icon to delete the field.

Configuration item	Description
Map Fields with the Same Name	Click **Map Fields with the Same Name** to establish a mapping between fields with the same name. Note that the data types of the fields must match.
Map Fields in the Same Line	Click **Map Fields in the Same Line** to establish a mapping for fields in the same row. Note that the data types of the fields must match.
Delete All Mappings	Click **Delete All Mappings** to remove mappings that have been established.
Auto Layout	Click Auto Layout. The fields are automatically sorted based on specified rules.
Change Fields	Click the Change Fields icon. In the Change Fields dialog box that appears, you can manually edit fields in the source table. Each field occupies a row. The first and the last blank rows are included, whereas other blank rows are ignored.
Add	○ Click Add to add a field. You can enter constants. Each constant must be enclosed in single quotation marks (' '), such as 'abc' and '123'. ○ You can use scheduling parameters, such as ${bizdate}. ○ You can enter functions supported by relational databases, such as now() and count(1). ○ Fields that cannot be parsed are indicated by Unidentified.

3. Configure channel control policies.

Configuration item	Description
Expected Concurrency	The maximum number of concurrent threads to read data from or write data to data storage within the sync node. You can configure the concurrency for a node on the codeless UI.

Configuration item	Description
Bandwidth Throttling	Specifies whether to enable bandwidth throttling. You can enable bandwidth throttling and set a maximum transmission rate to avoid heavy read workload of the source. We recommend that you enable bandwidth throttling and set the maximum transmission rate to a proper value.
Dirty Data Records Allowed	The maximum number of dirty data records allowed.
Resource Group	The resource group used for running the sync node. By default, the node runs on the default resource group. If resources are insufficient, you can add a custom resource group and run the sync node on the custom resource group. Set the resource group properly based on network conditions of the connections, resource group usage, and business importance.

Configure PostgreSQL Reader by using the code editor

In the following code, a node is configured to read data from a PostgreSQL database.

```
{
  "type":"job",
  "version":"2.0",// The version number.
  "steps":[
    {
      "stepType":"postgresql",// The reader type.
      "parameter":{
        "datasource":"",// The connection name.
        "column":[// The columns to be synchronized.
          "col1",
          "col2"
        ],
        "where":"",// The WHERE clause.
        "splitPk":"",// The shard key based on which the table is sharded. Data Integration initiates concurrent threads to synchronize data.
        "table":""// The name of the table to be synchronized.
      },
      "name":"Reader",
      "category":"reader"
    },
    {// The following template is used to configure the writer. For more information, see the corresponding topic.
      "stepType":"stream",
      "parameter":{},
      "name":"Writer",
      "category":"writer"
```

```
    }
  ],
  "setting":{
    "errorLimit":{
      "record":"0"// The maximum number of dirty data records allowed.
    },
    "speed":{
      "throttle":false,// Specifies whether to enable bandwidth throttling. A value of false indicates that the bandwidth is not throttled. A value of true indicates that the bandwidth is throttled. The maximum transmission rate takes effect only if you set this parameter to true.
      "concurrent":1,// The maximum number of concurrent threads.
    }
  },
  "order":{
    "hops":[
      {
        "from":"Reader",
        "to":"Writer"
      }
    ]
  }
}
```

Additional instructions

- Data synchronization between primary and secondary databases

  A secondary PostgreSQL database can be deployed for disaster recovery. The secondary database continuously synchronizes data from the primary database based on binlogs. Especially when network conditions are unfavorable, data latency between the primary and secondary databases is unavoidable, which can lead to data inconsistency.

- Concurrency control

  PostgreSQL is a relational database management system (RDBMS), which supports strong consistency for data queries. A database snapshot is created before a sync node starts. PostgreSQL Reader reads data from the database snapshot. Therefore, if new data is written to the database during data synchronization, the reader cannot obtain the new data.

  Data consistency cannot be guaranteed when you enable PostgreSQL Reader to run concurrent threads on a single sync node.

  PostgreSQL Reader shards the table based on the splitPk parameter and runs multiple concurrent threads to synchronize data. These concurrent threads belong to different transactions. They read data at different time points. This means that the concurrent threads observe different snapshots.

  Theoretically, the data inconsistency issue is unavoidable if a single sync node includes multiple threads. However, two workarounds are available:

  - Do not enable concurrent threads on a single sync node. Essentially, do not specify the splitPk parameter. In this way, data consistency is guaranteed although data is synchronized at a low efficiency.
  - Disable writers to make sure that the data is unchanged during data synchronization. For example, lock the table and disable data synchronization between primary and secondary databases. In this way, data is synchronized efficiently but your ongoing services may be interrupted.

- Character encoding

  A PostgreSQL database supports only EUC_CN and UTF-8 encoding formats for simplified Chinese characters. PostgreSQL Reader uses JDBC, which can automatically convert the encoding of characters. Therefore, you do not need to specify the encoding format.

  If you specify the encoding format for a PostgreSQL database but data is written to the PostgreSQL database in a different encoding format, PostgreSQL Reader cannot recognize this inconsistency and may export garbled characters.

- Incremental data synchronization

  PostgreSQL Reader connects to a database through JDBC and uses a SELECT statement with a WHERE clause to read incremental data in the following ways:

  - For data in batches, incremental add, update, and delete operations (including logically delete operations) are distinguished by timestamps. Specify the WHERE clause based on the timestamp. The timestamp must be later than the latest timestamp in the last synchronization.
  - For streaming data, specify the WHERE clause based on the data record ID. The data record ID must be larger than the maximum ID involved in the last synchronization.

  If incremental data cannot be distinguished, PostgreSQL Reader cannot perform incremental synchronization but can perform full synchronization only.

- Syntax validation

  PostgreSQL Reader allows you to specify custom SELECT statements by using the querySql parameter but does not verify the syntax of the custom SELECT statements.

2.3.3.3.13. Configure SQL Server Reader

This topic describes the data types and parameters supported by SQL Server Reader and how to configure it by using the codeless user interface (UI) and code editor.

SQL Server Reader connects to a remote SQL Server database and runs a SELECT statement to select and read data from the database.

Specifically, SQL Server Reader connects to a remote SQL Server database through Java Database Connectivity (JDBC), generates a SELECT statement based on your configurations, and then sends the statement to the database. The SQL Server database runs the statement and returns the result. Then, SQL Server Reader assembles the returned data to abstract datasets in custom data types supported by Data Integration, and passes the datasets to a writer.

- SQL Server Reader generates the SELECT statement based on the table, column, and where parameters that you have configured, and sends the generated SELECT statement to the SQL Server database.
- If you specify the querySql parameter, SQL Server Reader directly sends the value of this parameter to the SQL Server database.

SQL Server Reader supports most SQL Server data types. Make sure that your data types are supported.

The following table lists the data types supported by SQL Server Reader.

Category	SQL Server data type
Integer	bigint, int, smallint, and tinyint
Floating point	float, decimal, real, and numeric
String	char, nchar, ntext, nvarchar, text, varchar, nvarchar (max), and varchar (max)
Date and time	date, datetime, and time
Boolean	bit
Binary	binary, varbinary, varbinary (max), and timestamp

Parameters

Parameter	Description	Required	Default value
datasource	The connection name. It must be identical to the name of the added connection. You can add connections in the code editor.	Yes	None
table	The name of the table to be synchronized. You can select only one source table for each sync node.	Yes	None

Parameter	Description	Required	Default value
column	The columns to be synchronized from the source table. The columns are described in a JSON array. The default value is [*], which indicates all columns. • Column pruning is supported. You can select and export specific columns. • Change of the column order is supported. You can export the columns in an order different from that specified in the schema of the table. • Constants are supported. The column names must be arranged in compliance with the SQL syntax supported by MySQL, for example, `["id", "table","1", "'mingya.wmy'", "'null'", "to_char(a+1)", "2.3", "true"]`. ○ id: a column name. ○ table: the name of a column that contains reserved keywords. ○ 1: an integer constant. ○ 'mingya.wmy': a string constant, which is enclosed in single quotation marks (' '). ○ 'null': a string. ○ to_char(a + 1): a function expression. ○ 2.3: a floating-point constant. ○ true: a Boolean value. • The column parameter must explicitly specify a set of columns to be synchronized. The parameter cannot be left empty.	Yes	None
splitPk	The field used for data sharding when SQL Server Reader extracts data. If you specify the splitPk parameter, the table is sharded based on the shard key specified by this parameter. Data Integration then runs concurrent threads to synchronize data. This improves efficiency. • We recommend that you set the splitPk parameter to the primary key of the table. Based on the primary key, data can be well distributed to different shards, but not intensively distributed to certain shards. • Currently, the splitPk parameter supports data sharding only for integers but not for other data types such as string, floating point, and date. If you specify this parameter to a column of an unsupported type, SQL Server Reader returns an error.	No	None

Parameter	Description	Required	Default value
where	The WHERE clause. SQL Server Reader generates a SELECT statement based on the table, column, and where parameters that you have configured, and uses the generated SELECT statement to select and read data. For example, set this parameter to limit 10 during a test. For example, if you need to synchronize data generated on the current day, set this parameter to `gmt_create > $bizdate`. • You can use the WHERE clause to synchronize incremental data. • If you do not specify the where parameter or leave it empty, all data is synchronized.	No	None
querySql	The SELECT statement used for refined data filtering. Specify this parameter in the following format: `"querysql" : "SELECT statement",`. If you specify this parameter, Data Integration directly filters data based on this parameter. For example, if you want to join multiple tables for data synchronization, set this parameter to `select a,b from table_a join table_b on table_a.id = table_b.id`. If you specify the querySql parameter, SQL Server Reader ignores the table, column, and where parameters that you have configured.	No	None
fetchSize	The number of data records to read at a time. This parameter determines the number of interactions between Data Integration and the database and affects reading efficiency. **Note** A value larger than 2048 may lead to the out of memory (OOM) error during the data synchronization process.	No	*1024*

Configure SQL Server Reader by using the codeless UI

1. Configure the connections.

   Configure the source and destination connections for the sync node.

Configuration item	Description
Connection	The datasource parameter in the preceding parameter description. Select a connection type, and enter the name of a connection that has been configured in DataWorks.
Table	The table parameter in the preceding parameter description.
Filter	The filter condition for the data to be synchronized. Currently, filtering based on the limit keyword is not supported. The SQL syntax is determined by the selected connection.

Configuration item	Description
Shard Key	The shard key. You can use a column in the source table as the shard key. We recommend that you use the primary key or an indexed column.

2. Configure field mapping, that is, the column parameter in the preceding parameter description.

   Fields in the source table on the left have a one-to-one mapping with fields in the destination table on the right. You can click **Add** to add a field, or move the pointer over a field and click the **Delete** icon to delete the field.

Configuration item	Description
Map Fields with the Same Name	Click **Map Fields with the Same Name** to establish a mapping between fields with the same name. Note that the data types of the fields must match.
Map Fields in the Same Line	Click **Map Fields in the Same Line** to establish a mapping for fields in the same row. Note that the data types of the fields must match.
Delete All Mappings	Click **Delete All Mappings** to remove mappings that have been established.
Auto Layout	Click Auto Layout. The fields are automatically sorted based on specified rules.
Change Fields	Click the Change Fields icon. In the Change Fields dialog box that appears, you can manually edit fields in the source table. Each field occupies a row. The first and the last blank rows are included, whereas other blank rows are ignored.
Add	◦ Click Add to add a field. You can enter constants. Each constant must be enclosed in single quotation marks (' '), such as 'abc' and '123'. ◦ You can use scheduling parameters, such as ${bizdate}. ◦ You can enter functions supported by relational databases, such as now() and count(1). ◦ Fields that cannot be parsed are indicated by Unidentified.

3. Configure channel control policies.

Configuration item	Description
Expected Concurrency	The maximum number of concurrent threads to read data from or write data to data storage within the sync node. You can configure the concurrency for a node on the codeless UI.
Bandwidth Throttling	Specifies whether to enable bandwidth throttling. You can enable bandwidth throttling and set a maximum transmission rate to avoid heavy read workload of the source. We recommend that you enable bandwidth throttling and set the maximum transmission rate to a proper value.
Dirty Data Records Allowed	The maximum number of dirty data records allowed.

Configuration item	Description
Resource Group	The resource group used for running the sync node. By default, the node runs on the default resource group. If resources are insufficient, you can add a custom resource group and run the sync node on the custom resource group. Set the resource group properly based on network conditions of the connections, resource group usage, and business importance.

Configure SQL Server Reader by using the code editor

In the following code, a node is configured to read data from an SQL Server database.

```
{
  "type":"job",
  "version":"2.0",// The version number.
  "steps":[
    {
      "stepType":"sqlserver",// The reader type.
      "parameter":{
        "datasource":"",// The connection name.
        "column":[// The columns to be synchronized.
          "id",
          "name"
        ],
        "where":"",// The WHERE clause.
        "splitPk":"",// The shard key based on which the table is sharded.
        "table":""// The name of the table to be synchronized.
      },
      "name":"Reader",
      "category":"reader"
    },
    {// The following template is used to configure the writer. For more information, see the corresponding t
opic.
      "stepType":"stream",
      "parameter":{},
      "name":"Writer",
      "category":"writer"
    }
  ],
  "setting":{
    "errorLimit":{
      "record":"0"// The maximum number of dirty data records allowed.
    },
    "speed":{
```

```
    "speed":{
      "throttle":false,// Specifies whether to enable bandwidth throttling. A value of false indicates that the bandwidth is not throttled. A value of true indicates that the bandwidth is throttled. The maximum transmission rate takes effect only if you set this parameter to true.
      "concurrent":1,// The maximum number of concurrent threads.
    }
  },
  "order":{
    "hops":[
      {
        "from":"Reader",
        "to":"Writer"
      }
    ]
  }
}
```

If you want to use the querySql parameter to specify a SELECT statement to query data, see the following sample code in the script of SQL Server Reader. Assume that the SQL Server connection is sql_server_source, the table to be queried is dbo.test_table, and the column to be queried is name.

```
{
  "stepType": "sqlserver",
  "parameter": {
    "querySql": "select name from dbo.test_table",
    "datasource": "sql_server_source",
    "column": [
      "name"
    ],
    "where": "",
    "splitPk": "id"
  },
  "name": "Reader",
  "category": "reader"
},
```

Additional instructions

- Data synchronization between primary and secondary databases

  A secondary SQL Server database can be deployed for disaster recovery. The secondary database continuously synchronizes data from the primary database based on binlogs. Especially when network conditions are unfavorable, data latency between the primary and secondary databases is unavoidable, which can lead to data inconsistency.

- Concurrency control

  SQL Server is a relational database management system (RDBMS), which supports strong consistency for data queries. A database snapshot is created before a sync node starts. SQL Server Reader reads data from the database snapshot. Therefore, if new data is written to the database during data synchronization, the reader cannot obtain the new data.

  Data consistency cannot be guaranteed when you enable SQL Server Reader to run concurrent threads on a single sync node.

  SQL Server Reader shards the table based on the splitPk parameter and runs multiple concurrent threads to synchronize data. These concurrent threads belong to different transactions. They read data at different time points. This means that the concurrent threads observe different snapshots.

  Theoretically, the data inconsistency issue is unavoidable if a single sync node includes multiple threads. However, two workarounds are available:

  - Do not enable concurrent threads on a single sync node. Essentially, do not specify the splitPk parameter. In this way, data consistency is guaranteed although data is synchronized at a low efficiency.
  - Disable writers to make sure that the data is unchanged during data synchronization. For example, lock the table and disable data synchronization between primary and secondary databases. In this way, data is synchronized efficiently but your ongoing services may be interrupted.

- Character encoding

  SQL Server Reader uses JDBC, which can automatically convert the encoding of characters. Therefore, you do not need to specify the encoding format.

- Incremental data synchronization

  SQL Server Reader connects to a database through JDBC and uses a SELECT statement with a WHERE clause to read incremental data in the following ways:

  - For data in batches, incremental add, update, and delete operations (including logically delete operations) are distinguished by timestamps. Specify the WHERE clause based on the timestamp. The timestamp must be later than the latest timestamp in the last synchronization.
  - For streaming data, specify the WHERE clause based on the data record ID. The data record ID must be larger than the maximum ID involved in the last synchronization.

  If incremental data cannot be distinguished, SQL Server Reader cannot perform incremental synchronization but can perform full synchronization only.

- Syntax validation

  SQL Server Reader allows you to specify custom SELECT statements by using the querySql parameter but does not verify the syntax of the custom SELECT statements.

2.3.3.3.14. Configure LogHub Reader

This topic describes the data types and parameters supported by LogHub Reader and how to configure it by using the codeless user interface (UI) and code editor.

As an all-in-one real-time data logging service, Log Service provides features to collect, consume, deliver, query, and analyze log data. It can comprehensively improve the capabilities to process and analyze numerous logs. LogHub Reader consumes real-time log data in LogHub by using the Java SDK for Log Service, converts the data to a format that is readable by the Data Integration service, and sends the converted data to the writer.

Implementation

LogHub Reader consumes real-time log data in LogHub by using the following version of Java SDK for Log Service:

```
<dependency>
  <groupId>com.aliyun.openservices</groupId>
  <artifactId>aliyun-log</artifactId>
  <version>0.6.7</version>
</dependency>
```

In Log Service, Logstore is a basic unit for collecting, storing, and querying log data. Logstore read and write logs are stored on a shard. Each Logstore consists of several shards, each of which is defined by a left-closed and right-open interval of MD5 so that intervals do not overlap each other. The range of all intervals covers all the allowed MD5 values. Each shard can independently provide some services.

LogHub Reader consumes log data in shards by following this process (GetCursor and BatchGetLog APIs):

- Obtain a cursor based on the time range.
- Read logs based on the cursor and step parameters and return the next cursor.
- Keep moving the cursor to consume logs.
- Split and perform concurrent tasks based on shards.

Data types

The following table lists the data types supported by LogHub Reader.

Data Integration data type	LogHub data type
STRING	STRING

Parameters

Parameter	Description	Required	Default value
endpoint	The Log Service endpoint, which is a URL for accessing a project and log data. It varies depending on the Alibaba Cloud region where the project resides and the project name.	Yes	None
accessId	The AccessKey ID for accessing Log Service.	Yes	None
accessKey	The AccessKey secret for accessing Log Service.	Yes	None

Parameter	Description	Required	Default value
project	The name of the project. A project is the basic unit for managing resources in Log Service. You can exercise access control at the project level, and isolate resources among different projects.	Yes	None
logstore	The name of the Logstore. A Logstore is the basic unit for collecting, storing, and querying log data in Log Service.	Yes	None
batchSize	The number of entries queried from Log Service at a time.	No	*128*
column	The column name in each log entry. You can configure a column that stores metadata in a source table of LogHub in such a way that the metadata in this column is inserted into the destination table. Supported metadata includes the log topic, unique identifier of the collection machine, host name, path, and log time. **Note** The column name is case-sensitive.	Yes	None
beginDateTime	The start time of data consumption, that is, the time when log data arrives at LogHub. This parameter defines the left boundary of an interval (left-closed and right-open) in the format of yyyyMMddHHmmss, for example, 20180111013000. The parameter can work with the scheduling time parameter in DataWorks. **Note** You need to specify the beginDateTime and endDateTime parameters to determine the time range for consuming data.	You must specify either this parameter or the beginTimestampMillis parameter.	None
endDateTime	The end time of data consumption in the format of yyyyMMddHHmmss, such as 20180111013010. This parameter defines the right boundary of an interval (left-closed and right-open) and can work with the scheduling time parameter in DataWorks. **Note** Make sure that the intervals overlap. That is, the time specified by endDateTime of the previous interval is the same as or later than the time specified by beginDateTime of the next interval. If the intervals do not overlap, data may not be pulled in some regions.	You must specify either this parameter or the endTimestampMillis parameter.	None

Parameter	Description	Required	Default value
beginTimestampMillis	The start time of data consumption. This parameter specifies the left boundary of the interval (left-closed and right-open), measured in milliseconds. **Note** You must specify both the beginTimestampMillis and endTimestampMillis parameters to determine the time range. The value -1 indicates the position where the cursor starts in Log Service (CursorMode.BEGIN). We recommend that you specify the beginDateTime parameter.	You must specify either this parameter or the beginDateTime parameter.	None
endTimestampMillis	The end time of data consumption, measured in milliseconds. This parameter defines the right boundary of the left-closed and right-open interval. **Note** You must specify both the beginTimestampMillis and endTimestampMillis parameters to determine the time range. The value -1 indicates the position where the cursor ends in Log Service (CursorMode.END). We recommend that you specify the endDateTime parameter.	You must specify either this parameter or the endDateTime parameter.	None

Configure LogHub Reader by using the codeless UI

1. Configure the connections.

   Configure the source and destination connections for the sync node.

Configuration item	Description
Connection	The datasource parameter in the preceding parameter description. Select a connection type, and enter the name of a connection that has been configured in DataWorks.
Logstore	The name of the target Logstore.
Start Time	The start time of data consumption, that is, the time when log data arrives at LogHub. This parameter defines the left boundary of an interval (left-closed and right-open) in the format of yyyyMMddHHmmss, for example, 20180111013000. The parameter can work with the scheduling time parameter in DataWorks.

Configuration item	Description
End Time	The end time of data consumption in the format of yyyyMMddHHmmss, such as 20180111013010. This parameter defines the right boundary of an interval (left-closed and right-open) and can work with the scheduling time parameter in DataWorks.
Number of Entries Read Per Batch	The number of entries queried from Log Service at a time.

2. Configure field mapping, that is, the column parameter in the preceding parameter description.

   Fields in the source table on the left have a one-to-one mapping with fields in the destination table on the right. You can click **Add** to add a field, or move the pointer over a field and click the **Delete** icon to delete the field.

Configuration item	Description
Map Fields with the Same Name	Click **Map Fields with the Same Name** to establish a mapping between fields with the same name. Note that the data types of the fields must match.
Map Fields in the Same Line	Click **Map Fields in the Same Line** to establish a mapping for fields in the same row. Note that the data types of the fields must match.
Delete All Mappings	Click **Delete All Mappings** to remove mappings that have been established.
Auto Layout	Click Auto Layout. The fields are automatically sorted based on specified rules.
Change Fields	Click the Change Fields icon. In the Change Fields dialog box that appears, you can manually edit fields in the source table. Each field occupies a row. The first and the last blank rows are included, whereas other blank rows are ignored.
Add	◦ Click Add to add a field. You can enter constants. Each constant must be enclosed in single quotation marks (' '), such as 'abc' and '123'. ◦ You can use scheduling parameters, such as ${bizdate}. ◦ You can enter functions supported by relational databases, such as now() and count(1). ◦ Fields that cannot be parsed are indicated by Unidentified.

3. Configure channel control policies.

Configuration item	Description
Expected Concurrency	The maximum number of concurrent threads to read data from or write data to data storage within the sync node. You can configure the concurrency for a node on the codeless UI.

Configuration item	Description
Bandwidth Throttling	Specifies whether to enable bandwidth throttling. You can enable bandwidth throttling and set a maximum transmission rate to avoid heavy read workload of the source. We recommend that you enable bandwidth throttling and set the maximum transmission rate to a proper value.
Dirty Data Records Allowed	The maximum number of dirty data records allowed.
Resource Group	The resource group used for running the sync node. By default, the node runs on the default resource group. If resources are insufficient, you can add a custom resource group and run the sync node on the custom resource group. Set the resource group properly based on network conditions of the connections, resource group usage, and business importance.

Configure LogHub Reader by using the code editor

In the following code, a node is configured to read data from Log Service. For more information about the parameters, see the preceding parameter description.

```
{
 "type":"job",
 "version":"2.0",// The version number.
 "steps":[
   {
     "stepType":"loghub",// The reader type.
     "parameter":{
       "datasource":"",// The connection name.
       "column":[// The columns to be synchronized.
         "col0",
         "col1",
         "col2",
         "col3",
         "col4",
         "=Topic",// The log topic.
         "HostName",// The host name.
         "Path",// The path.
         "LogTime"// The log time.
       ],
       "beginDateTime":"",// The start time of data consumption.
       "batchSize":"",// The number of entries that are queried from Log Service at a time.
       "endDateTime":"",// The end time of data consumption.
       "fieldDelimiter":",",// The column delimiter.
       "encoding":"UTF-8",// The encoding format.
       "logstore":"// The name of the target Logstore.
```

```
    },
    "name":"Reader",
    "category":"reader"
  },
  {
    "stepType":"stream",
    "parameter":{},
    "name":"Writer",
    "category":"writer"
  }
],
"setting":{
  "errorLimit":{
    "record":"0"// The maximum number of dirty data records allowed.
  },
  "speed":{
    "throttle":false,// Specifies whether to enable bandwidth throttling. A value of false indicates that the b
andwidth is not throttled. A value of true indicates that the bandwidth is throttled. The maximum transmiss
ion rate takes effect only if you set this parameter to true.
    "concurrent":1,// The maximum number of concurrent threads.
  }
},
"order":{
  "hops":[
    {
      "from":"Reader",
      "to":"Writer"
    }
  ]
}
}
```

Note If the metadata in JSON format is prefixed by tag, delete the tag prefix. For example, change `__tag__:__client_ip__` to `__client_ip__`.

2.3.3.3.15. Configure the OTSReader-Internal reader

Table Store (previously known as OTS) is a NoSQL database service built on the Apsara distributed system, enabling you to store and access large amounts of structured data in real time. Table Store organizes data into instances and tables that can seamlessly scale by using data partitioning and load balancing.

OTSReader-Internal is used to export data for the OTS Internal model, and the OTS reader is used to export data for the OTS Public model.

The OTS Internal model supports multi-version columns, so OTSReader-Internal also provides two modes of exporting data:

- Multi-version mode: Table Store supports the storage of multiple versions of columns, and this mode allows you to export data of multiple versions.

  This reader converts a cell into a 4-tuple of a one-dimensional table: PrimaryKey (columns 1 to 4), ColumnName, Timestamp, and Value. This process is similar to that for the multi-version mode of the HBase reader. Each {primary key, column name, timestamp, value} tuple is sent to the writer as four columns in DataX records.
- Normal mode: This mode allows you to export the latest version of each column in each row, which is the same as the normal mode of the HBase reader.

The OTS reader connects to Table Store server and reads data by using the official Java SDK. The OTS reader optimizes the read process by providing features such as performing retry attempts when a timeout or exceptional occurs.

Currently, the OTSReader-Internal reader supports all data types of Table Store.

Data Integration data type	Table Store data type
Long	Integer
Double	Double
String	String
Boolean	Boolean
Bytes	Binary

Parameters

Parameter	Description	Required	Default value
mode	The mode in which data is read. Valid values: normal | multiVersion.	Yes	None
endpoint	The endpoint of the Table Store server.	Yes	None
accessId	The AccessKey ID for accessing Table Store.	Yes	None
accessKey	The AccessKey Secret for accessing Table Store.	Yes	None

Parameter	Description	Required	Default value
instanceName	The name of the Table Store instance. The Table Store service is managed based on instances. To create and manage tables after you enable the Table Store service, you must create instances on its console. An instance is also the basic unit for managing Table Store resources. Table Store exercises access control and measures resources at the instance level.	Yes	None
table	The name of the table to be extracted. You can enter only one table name. In Table Store, you do not need to synchronize data among tables.	Yes	None
range	The range of the exported data: [begin,end). • If the value of the begin parameter is smaller than that for the end parameter, data is read in a positive sequence. • If the value of the begin parameter is smaller than that for the end parameter, data is read in an inverted sequence. • The value of the begin parameter cannot be equal to that for the end parameter. • The following value types are supported: string, integer, and binary. Binary data is passed in as Base64 strings in binary format. INF_MIN represents an infinitely small value and INF_MAX represents an infinitely large value.	No	By default, data is read from the beginning of the table to the end of the table.

Parameter	Description	Required	Default value
range: {"begin "}	The starting range of the exported data. Enter an empty array, PK prefix, or complete primary key. When data is read in a positive sequence, the default PK suffix is INF_MIN. When data is read in an inverted sequence, default PK suffix is INF_MAX. An example is described as follows: If your table has two primary keys with the types of string and integer, specify this parameter in any of the following three formats: • []: indicates that data is read from the beginning of the table. • [{"type": "string", "value ": "a"}]: indicates that data is read from [{"type": "string ", "value": "a"},{"type": "INF_MIN"}]. • [{"type": "string", "value": "a"},{"type": "INF_MIN"}] The JSON format does not support binary data. For the primary key column with the type of binary, to pass in binary data, you must use the Java Base64.encodeBase64String method to convert binary data into a string, and then enter the string for the value parameter. An example is described as follows (Java): • `byte[] bytes = "hello".getBytes();` : Create binary data. The byte value of the hello string is used. • `String inputValue = Base64.encodeBase64String(bytes)` : Use Base64 encoding schemes to convert binary data into a string. Run the preceding code, and then the string "aGVsbG8=" is returned for the inputValue parameter. Finally, enter the string for the value parameter: {"type":"binary","value" : "aGVsbG8="}.	No	Data is read from the beginning of the table.

Parameter	Description	Required	Default value
range: {"end"}	The end range of the exported data. Enter an empty array, PK prefix, or complete primary key. When data is read in a positive sequence, the default PK suffix is INF_MIN. When data is read in an inverted sequence, default PK suffix is INF_MAX. An example is described as follows: If your table has two primary keys with the types of string and integer, specify this parameter in any of the following three formats: • []: indicates that data is read from the beginning of the table. • [{"type": "string", "value ": "a"}]: indicates from [{"type": "string ", "value": "a"} to {"type": "INF_MIN"}]. • [{"type": "string", "value": "a"}, {"type": "INF_MIN"}]. The JSON format does not support binary data. For the primary key column with the type of binary, to pass in binary data, you must use the Java Base64.encodeBase64String method to convert binary data into a string, and then enter the string for the value parameter. An example is described as follows (Java): • `byte[] bytes = "hello".getBytes();` : Create binary data. The byte value of the hello string is used. • `String inputValue = Base64.encodeBase64String(bytes)` : Use Base64 encoding schemes to convert binary data into a string. Run the preceding code, and then the string "aGVsbG8=" is returned for the inputValue parameter. Finally, enter the string for the value parameter: {"type":"binary","value" : "aGVsbG8="}.	No	Data is read until the end of the table.
range: {"split"}	If an excessively large number of data needs to be exported, you can perform concurrent export tasks. This parameter allows you to split the data in the current range and perform concurrent tasks based on the specified split points. **Note** • The value for the split parameter must be the shard key (the first column of PrimaryKey), and the value type must be the same as that of the partition key. • The specified value must fall within the value range of the begin and end parameters. • The values for the split parameter must be sorted in the descending or ascending order based on the data reading sequence that is determined by values of begin and end parameters.	No	No split point is specified by default.

Parameter	Description	Required	Default value
column	The columns to be exported. Both regular and constant columns can be exported. Mode: You can export multiple versions of columns. Regular column format: {"name":"{your column name}"}		
timeRange (only applicable to the multi-version mode)	The time range of the requested data: [begin,end). **Note** The value for the begin parameter must be smaller than that for the end parameter.	No	The data of all versions is read by default.
timeRange: {"begin"} (only applicable to the multi-version mode)	The start time of the time range for reading data. Value range: 0 to LONG_MAX.	No	0
timeRange: {"end"} (only application to the multi-version mode)	The end time of the time range for reading data. Value range: 0 to LONG_MAX.	No	Long Max(9223372036854775806L)
maxVersion (only applicable to the multi-version mode)	The specified version. Value range: 1 to INT32_MAX.	No	The data of all versions is read by default.

Configure the OTSReader-Internal reader in wizard mode

Currently, development in wizard mode is not supported.

Configure the OTSReader-Internal reader in script mode

Multi-version mode

```
{
  "type": "job",
  "version": "1.0",
  "configuration": {
    "reader": {
      "plugin": "otsreader-internalreader ",
```

```
"parameter": {
  "mode": "multiversion ",
  "endpoint": "",
  "accessId": "",
  "accessKey": "",
  "instanceName":"",
  "table": "<table>",
  "range": {
    "begin": [
      {
        "type": "string",
        "value": "a"
      },
      {
        "type": "INF_MIN"
      }
    ],
    "end": [
      {
        "type": "string",
         "value": "g"
      },
      {
        "type": "INF_MAX"
      }
    ],
    "split":[
      {
        "type": "string",
         "value": "b"
      },
      {
        "type": "string",
        "value": "c"
      }
    ]
  },
  "column": [
    {
       "name": "attr1"
    }
```

```
          ],
          "timeRange": {
            "begin": 1400000000,
            "end": 1600000000
          },
          "maxVersion": 10
        }
      }
    },
    "writer": {}
}
```

Normal mode

```
{
  "type": "job",
  "version": "1.0",
  "configuration": {
    "reader": {
      "plugin": "otsreader-internalreader ",
      "parameter": {
        "mode": "normal",
        "endpoint": "",
        "accessId": "",
        "accessKey": "",
        "instanceName":"",
        "table": "<table>",
        "range": {
          "begin": [
            {
              "type": "string",
              "value": "a"
            },
            {
              "type": "INF_MIN"
            }
          ],
          "end": [
            {
              "type": "string",
               "value": "g"
```

```
            },
            {
              "type": "INF_MAX"
            }
          ],
          "split":[
            {
              "type": "string",
               "value": "b"
            },
            {
              "type": "string",
              "value": "c"
            }
          ]
        },
        "column": [
          {
            "name": "pk1"
          },
          {
            "name": "pk2"
          },
          {
             "name": "attr1"
          },
          {
            "type": "string",
            "value": ""
          },
          {
            "type": "int",
            "value": ""
          },
          {
            "type": "double",
            "value": ""
          },
          {
            "type": "binary",
             "value": "aGVsbG8="
```

```
            }
          ]
        }
      }
    },
    "writer": {}
}
```

2.3.3.3.16. Configure OTSStream Reader

This topic describes the data types and parameters supported by OTSStream Reader and how to configure it by using the code editor.

OTSStream Reader is mainly used for exporting the incremental data of Table Store. Incremental data can be considered as operation logs that include data and operation information.

Unlike plug-ins for exporting full data, OTSStream Reader only supports the multi-version mode. You cannot export the data of specified columns when using OTSStream Reader for exporting incremental data. This restriction is related to the implementation of exporting incremental data. The following section describes the implementation process.

Before using OTSStream Reader, make sure that the Stream feature is enabled. You can enable this feature when creating the table or using the UpdateTable operation in the SDK.

The method for enabling Stream is described as follows:

```
SyncClient client = new SyncClient("", "", "", "");
Enable this feature when creating a table.
CreateTableRequest createTableRequest = new CreateTableRequest(tableMeta);
createTableRequest.setStreamSpecification(new StreamSpecification(true, 24)); // The value 24 indicates th
at the incremental data is retained for 24 hours.
client.createTable(createTableRequest);
If this feature is not enabled when the table is created, enable it by using the UpdateTable operation.
UpdateTableRequest updateTableRequest = new UpdateTableRequest("tableName");
updateTableRequest.setStreamSpecification(new StreamSpecification(true, 24));
client.updateTable(updateTableRequest);
```

Implementation

You can enable the Stream feature and set the expiration time by using the UpdateTable operation in the SDK. After the Stream feature is enabled, the Table Store server saves your operation logs additionally. Each partition has a sequential operation log queue. Each operation log is removed by garbage collection after the specified expiration time.

The Table Store SDK provides several Stream APIs for reading these operation logs. OTSStream Reader obtains incremental data by using these APIs, transforms incremental data into multiple 6-tuples (pk, colName, version, colValue, opType, and sequenceInfo), and imports them into MaxCompute.

Exported data format

In the multi-version mode of Table Store, table data is organized in a three-level architecture: row, column, and version. One row can have multiple columns. The column name is not fixed, and each column can have multiple versions. Each version has a specific timestamp (the version number).

You can perform read/write operations by using Table Store APIs. Table Store stores the incremental data by storing the records of recent write and modify operations on table data. Incremental data can be considered as a set of operation records.

Table Store supports the following three types of modify operations:

- PutRow: writes a row. If the row already exists, it is overwritten.
- UpdateRow: updates a row without changing other data of the original row. You can add column values, overwrite column values if the corresponding version of the column already exists, delete all the versions of a column, or delete a version of a column.
- DeleteRow: deletes a row.

Table Store generates incremental data records based on each type of operations. OTSStream Reader reads these records and exports the data in the format of DataX.

Table Store supports dynamic columns and the multi-version mode. Therefore, a row exported by OTSStream Reader corresponds to a version of a column rather than a row in Table Store. A row in Table Store may correspond to multiple exported rows. Each exported row includes the primary key value, column name, timestamp of the version for the column (version number), value of the version, and operation type. If the isExportSequenceInfo parameter is set to true, time series information is also included.

When the data is transformed into the DataX format, the following four types of operations are defined:

- U (UPDATE): Writes a version of a column.
- DO (DELETE_ONE_VERSION): Deletes a version of a column.
- DA (DELETE_ALL_VERSION): Deletes all the versions of a column. Delete all the versions of the corresponding column according to the primary key and the column name.
- DR (DELETE_ROW): Deletes a row. Delete all the data of the row according to the primary key.

In the following example, the table has two primary key columns: pkName1 and pkName2.

pkName1	pkName2	columnName	timestamp	columnValue	opType
pk1_V1	pk2_V1	col_a	1441803688001	col_val1	U
pk1_V1	pk2_V1	col_a	1441803688002	col_val2	U
pk1_V1	pk2_V1	col_b	1441803688003	col_val3	U
pk1_V2	pk2_V2	col_a	1441803688000	-	DO
pk1_V2	pk2_V2	col_b	-	-	DA

pkName1	pkName2	columnName	timestamp	columnValue	opType
pk1_V3	pk2_V3	-	-	-	DR
pk1_V3	pk2_V3	col_a	1441803688005	col_val1	U

In this example, seven rows are exported, corresponding to three rows in the Table Store table. The primary keys for the three rows are (pk1_V1, pk2_V1), (pk1_V2, pk2_V2), and (pk1_V3, pk2_V3).

- For the row whose primary key is (pk1_V1, pk2_V1), three operations are included: writing two versions of column col_a and one version of column col_b.
- For the row whose primary key is (pk1_V2, pk2_V2), two operations are included: deleting one version of column col_a and deleting all versions of column col_b.
- For the row whose primary key is (pk1_V3, pk2_V3), two operations are included: deleting the row and writing one version of column col_a.

Data types supported by OTSStream Reader

Currently, OTSStream Reader supports all Table Store data types. The following table lists the data types supported by OTSStream Reader.

Category	OTSStream data type
Integer	INTEGER
Floating point	DOUBLE
String	STRING
Boolean	BOOLEAN
Binary	BINARY

Parameters

Parameter	Description	Required	Default value
dataSource	The connection name. It must be identical to the name of the added connection. You can add connections in the code editor.	Yes	None
dataTable	The name of the table from which incremental data is exported. You must enable the Stream feature for a table when creating the table, or by calling the UpdateTable operation after creating the table.	Yes	None

Parameter	Description	Required	Default value
statusTable	The name of the table used by OTSStream Reader to store status records. These records help to filter out the data that is not covered by the target range and improve export efficiency. A statusTable is the table to store status records. If no such table exists, the reader automatically creates one. When a task of exporting batch data is completed, you do not need to delete the table. The status records in the table can be used for the next export task. • You do not need to manually create a statusTable. You only need to provide a table name. The reader attempts to create a statusTable under your instance. If no such table exists, the reader automatically creates one. If such a table already exists, the reader determines whether the Meta of the table is proper. If not, an exception is thrown. • When an export task is completed, you do not need to delete the table. The status of the table can be used for the next export task. • The table enables TTL and data expires automatically. Therefore, the data volume is small. • You can use a statusTable to store status records of multiple dataTables that are managed by the same instance. The status records are independent of each other. In conclusion, you must configure a name such as TableStoreStreamReaderStatusTable. Note that the name must not be the same as that for any business-related table.	Yes	None
startTimestampMillis	The start time (included) in milliseconds of the incremental data. • The Reader plugin finds a point corresponding to startTimestampMillis from the statusTable, and starts to read and export data from this point. • If the reader cannot find the corresponding point, it starts to read incremental data retained by the system from the first entry, and skip the data which is written later than startTimestampMillis.	No	None
endTimestampMillis	The end time (excluded) in milliseconds of the incremental data. • The reader exports data from the time specified by the startTimestampMillis parameter and ends at the data entry with a timestamp that is later than or equal to endTimestampMillis. • If the reader has read all the incremental data, it stops reading data even before the time specified by the endTimestampMillis parameter.	No	None
date	The date when data is exported. The format is yyyyMMdd, for example, 20151111. You must specify this parameter or the startTimestampMillis and endTimestampMillis parameters. For example, Alibaba Cloud Data Process Center performs scheduling only at the day level. Therefore, the date parameter is provided.	No	None

Parameter	Description	Required	Default value
isExportSequenceInfo	Specifies whether to export time-series information. Time-series information includes the time when data is written. The default value is *false*, indicating that time series information is not exported.	No	None
maxRetries	The maximum number of retries for each request of reading incremental data from Table Store. The default value is 30. Retries are performed at certain intervals. The total time of 30 retries is approximately 5 minutes. Generally, you can keep the default settings.	No	None
startTimeString	The left boundary of the time range (left-closed and right-open) of incremental data, measured in milliseconds in the format of `yyyymmddhh24miss`.	No	None
endTimeString	The right boundary of the time range (left-closed and right-open) of incremental data, measured in milliseconds in the format of `yyyymmddhh24miss`.	No	None
mode	The export mode. If this parameter is set to single_version_and_update_only, data is exported by row. By default, data is not exported by column.	No	None

Configure OTSStream Reader by using the codeless UI

Currently, the codeless user interface (UI) is not supported for OTSStream Reader.

Configure OTSStream Reader by using the code editor

In the following code, a node is configured to export the incremental data of Table Store. For more information about the parameters, see the preceding parameter description.

```
{
  "type":"job",
  "version":"2.0",// The version number.
  "steps":[
    {
      "stepType":"otsstream",// The reader type.
      "parameter":{
        "statusTable":"TableStoreStreamReaderStatusTable",// The name of the table that stores status records.
        "maxRetries":30,// The maximum number of retries on each request of reading incremental data from Table Store. It is set to 30 by default.
        "isExportSequenceInfo":false,// Specifies whether to export the time series information.
        "datasource":"$srcDatasource",// The connection.
        "startTimeString":"${startTime}",// The start time (included) of the incremental data.
```

```
            "table":"",// The name of the table to be synchronized.
            "endTimeString":"${endTime}"// The end time (excluded) of the incremental data.
          },
          "name":"Reader",
          "category":"reader"
        },
        {
          "stepType":"stream",
          "parameter":{},
          "name":"Writer",
          "category":"writer"
        }
      ],
      "setting":{
        "errorLimit":{
          "record":"0"// The maximum number of dirty data records allowed.
        },
        "speed":{
          "throttle":false,// Specifies whether to enable bandwidth throttling. A value of false indicates that the bandwidth is not throttled. A value of true indicates that the bandwidth is throttled. The maximum transmission rate takes effect only if you set this parameter to true.
          "concurrent":1,// The maximum number of concurrent threads.
        }
      },
      "order":{
        "hops":[
          {
            "from":"Reader",
            "to":"Writer"
          }
        ]
      }
    }
```

2.3.3.3.17. Configure the RDBMS reader

The relational database management system (RDBMS) reader connects to a remote RDBMS data source and runs SELECT statements to select and read data from the data source. The RDBMS reader is a common reader that enables reading data from DM, DB2, PPAS, or Sybase. If you need the RDBMS reader to read data from a data source, register the driver for the corresponding data source type.

Specifically, the RDBMS reader connects to a remote RDBMS data source over JDBC. Then, it generates SELECT statements based on your configurations and sends the statements to the data source. After the data source successfully runs the statements, the RDBMS reader retrieves the results, formats the results based on the data types defined in the corresponding data integration task, and sends the formatted results to the writer.

The RDBMS reader generates SQL statements based on the table, column, and where parameters, and sends the generated SQL statements to the RDBMS data source. The RDBMS reader directly sends the querySql parameter setting to the RDBMS data source.

The RDBMS reader supports most common data types such as integer, floating point, and string. Since still some data types are not supported, verify that your data types are supported.

Parameters

Parameter	Description	Required	Default value
	The JDBC connectivity URL, used to connect to the data source. The format must be in accordance with official specifications. You can also specify the information of the attachment facility. The format varies with the data source type. The RDBMS selects an appropriate driver for data reading based on the format. • Format for DM data sources: jdbc:dm://ip:port/database • Format for DB2 data sources: jdbc:db2://ip:port/database • Format for PPAS data sources: jdbc:edb://ip:port/database You can enable the RDBMS reader to support a new data source type by using the following methods: • Switch to the directory of the RDBMS reader, ${DATAX_HOME}/plugin/reader/rdbmsreader. ${DATAX_HOME} indicates the main directory of DataX. • Add the driver of your database to the drivers array in the plugin.json file of the plugin.json directory. The RDBMS reader automatically selects an appropriate driver for connecting to a database. { "name": "rdbmsreader", "class": "com.alibaba.datax.plugin.reader.rdbmsreader.RdbmsReader", "description": "useScene: prod. mechanism: Jdbc connection using the database, execute select sql, retrieve data from the ResultSet. warn: The more you know about the database, the less problems you encounter.", "developer": "alibaba", "drivers": ["dm.jdbc.driver.DmDriver", "com.ibm.db2.jcc.DB2Driver", "com.sybase.jdbc3.jdbc.SybDriver", "com.edb.Driver"		

Parameter	Description	Required	Default value
jdbcUrl	] } ``` - Add the package of the driver to the libs subdirectory of the rdbms reader directory. ``` $tree . |-- libs | |-- Dm7JdbcDriver16.jar | |-- commons-collections-3.0.jar | |-- commons-io-2.4.jar | |-- commons-lang3-3.3.2.jar | |-- commons-math3-3.1.1.jar | |-- datax-common-0.0.1-SNAPSHOT.jar | |-- datax-service-face-1.0.23-20160120.024328-1.jar | |-- db2jcc4.jar | |-- druid-1.0.15.jar | |-- edb-jdbc16.jar | |-- fastjson-1.1.46.sec01.jar | |-- guava-r05.jar | |-- hamcrest-core-1.3.jar | |-- jconn3-1.0.0-SNAPSHOT.jar | |-- logback-classic-1.0.13.jar | |-- logback-core-1.0.13.jar | |-- plugin-rdbms-util-0.0.1-SNAPSHOT.jar | `-- slf4j-api-1.7.10.jar |-- plugin.json |-- plugin_job_template.json `-- rdbmsreader-0.0.1-SNAPSHOT.jar	Yes	None
username	The username used to connect to the data source.	Yes	None
password	The password used to connect to the data source.	Yes	None
table	The name of the source table.	Yes	None

Parameter	Description	Required	Default value
column	The source table columns to be synchronized. Arrange the column names in a JSON array. The default value is [*], which indicates all columns in the source table. • You can also select some of the columns to synchronize. • You can enter the column names in an order that is different from that specified by the schema of the source table. • Constants are supported. Use the JSON format. For example, `["id","1","'bazhen.csy'","null","to_char(a + 1)","2.3","true"]`. ○ id: The name of a regular column. ○ 1: An integer constant. ○ 'bazhen.csy': A string constant. ○ null: A null pointer. ○ to_char(a + 1): A function expression. ○ 2.3: A floating-point constant. ○ true: A Boolean constant.	Yes	None
splitPk	If you specify the splitPk parameter, the table is sharded based on the shard key indicated by this parameter. The RDBMS reader then initiates concurrent data synchronization threads, which improves efficiency. • We recommend that you set the splitPk parameter to the primary key. The table is sharded most evenly if it is sharded based on the primary key. • Currently, you can only specify the splitPk parameter to an integer-type column. If you specify this parameter to a column of another type, the RDBMS reader returns an error. • If you do not specify this parameter, the table is not sharded and the RDBMS reader synchronizes all data with only one thread.	No	An empty string
where	The WHERE clause. The RDBMS reader generates SQL statements based on the table and column information and WHERE clauses you have configured, and uses the generated SQL statements for data filtering and reading. For example, set this parameter to limit 10 during a test. If you need to synchronize data generated on the current day, set this parameter to gmt_create>$bizdate. • The WHERE clause can be used to incremental synchronization. • If you leave the WHERE clause unspecified, all data is synchronized.	No	None

Parameter	Description	Required	Default value
querySql	The SQL statement used for refined data filtering. If you specify this parameter, the RDBMS reader ignores the table, column, and where parameters and uses this parameter for data filtering. For example, if you need to join multiple tables for data synchronization, set this parameter to `select a,b from table_a join table_b on table_a.id = table_b.id`.	No	None
fetchSize	The number of data records read per batch. This parameter determines the number of interactions between the reader and the database and affects reading efficiency. **Note** A value larger than 2048 can lead to OOM during the data synchronization process.	No	1024

Configure the RDBMS reader in wizard mode

Currently, wizard mode is not supported for the RDBMS reader.

Configure the RDBMS reader in script mode

In the following script, a task is configured to write data to an RDBMS data source.

```
{
  "job": {
    "setting": {
      "speed": {
        "byte": 1048576
      },
      "errorLimit": {
        "record": 0,
        "percentage": 0.02
      }
    },
    "content": [
      {
        "reader": {
          "name": "rdbmsreader",
          "parameter": {
            "username": "xxx",
            "password": "xxx",
            "column": [
              "id",
```

```
            "name"
          ],
          "splitPk": "pk",
          "connection": [
            {
              "table": [
                "table"
              ],
              "jdbcUrl": [
                "jdbc:dm://ip:port/database"
              ]
            }
          ],
          "fetchSize": 1024,
          "where": "1 = 1"
        }
      },
      "writer": {
        "name": "streamwriter",
        "parameter": {
          "print": true
        }
      }
    }
  ]
}
```

In the following script, a task is configured to synchronize data from a custom SQL data source to a MaxCompute data source.

```
{
  "job": {
    "setting": {
      "speed": {
        "byte": 1048576
      },
      "errorLimit": {
        "record": 0,
        "percentage": 0.02
      }
```

```
    },
    "content": [
      {
        "reader": {
          "name": "rdbmsreader",
          "parameter": {
            "username": "xxx",
            "password": "xxx",
            "column": [
              "id",
              "name"
            ],
            "splitPk": "pk",
            "connection": [
              {
                "querySql": [
                  "SELECT * from dual"
                ],
                "jdbcUrl": [
                  "jdbc:dm://ip:port/database"
                ]
              }
            ],
            "fetchSize": 1024,
            "where": "1 = 1"
          }
        },
        "writer": {
          "name": "streamwriter",
          "parameter": {
            "print": true
          }
        }
      }
    ]
  }
}
```

2.3.3.3.18. Configure Stream Reader

This topic describes the data types and parameters supported by Stream Reader and how to configure it by using the code editor.

Stream Reader automatically generates data from the memory. It is mainly used for performance testing for data synchronization and basic functional testing.

The following table lists the data types supported by Stream Reader.

Data type	Description
String	A sequence of characters.
Long	A long integer.
Date	A value that represents dates.
Boolean	A Boolean data type that has one of two possible values.
Bytes	An 8-bit signed two's complement integer.

Parameters

Parameter	Description	Required	Default value
column	The column data and type of the source data. Multiple columns can be configured. You can set to generate random strings and specify the range. The example is as follows: `"column" : [ { "random": "8,15" }, { "random": "10,10" } ]` The parameters are described as follows: • "random": "8, 15": generates a random string that is 8 to 15 bytes in length. • "random": "10, 10": generates a 10-byte random string.	Yes	None
sliceRecordCount	The number of columns generated repeatedly.	Yes	None

Configure Stream Reader by using the codeless UI

Currently, the codeless user interface (UI) is not supported for Stream Reader.

Configure Stream Reader by using the code editor

In the following code, a node is configured to read data from the memory and then write the data to Stream Reader.

```
{
  "type":"job",
  "version":"2.0",// The version number.
  "steps":[
    {
      "stepType":"stream",// The reader type.
      "parameter":{
        "column":[// The columns to be synchronized.
          {
            "type":"string",// The data type.
            "value":"field" // The value.
          },
          {
            "type":"long",
            "value":100
          },
          {
            "dateFormat":"yyyy-MM-dd HH:mm:ss",// The format of the time.
            "type":"date",
            "value":"2014-12-12 12:12:12"
          },
          {
            "type":"bool",
            "value":true
          },
          {
            "type":"bytes",
            "value":"byte string"
          }
        ],
        "sliceRecordCount":"100000"// The number of columns repeatedly generated.
      },
      "name":"Reader",
      "category":"reader"
    },
    {// The following template is used to configure the writer. For more information, see the corresponding t
opic.
```

```
        "stepType":"stream",
        "parameter":{},
        "name":"Writer",
        "category":"writer"
      }
    ],
    "setting":{
      "errorLimit":{
        "record":"0"// The maximum number of dirty data records allowed.
      },
      "speed":{
        "throttle":false,// Specifies whether to enable bandwidth throttling. A value of false indicates that the bandwidth is not throttled. A value of true indicates that the bandwidth is throttled. The maximum transmission rate takes effect only if you set this parameter to true.
        "concurrent":1,// The maximum number of concurrent threads.
      }
    },
    "order":{
      "hops":[
        {
          "from":"Reader",
          "to":"Writer"
        }
      ]
    }
}
```

2.3.3.3.19. Configure Hive Reader

Parameters

Parameter	Description	Required	Default value
column	The fields to read. Example: `"column": ["id", "name"]`.	Yes	None
table	The name of the Hive table to read. The name is case sensitive.	Yes	None

Parameter	Description	Required	Default value
partition	The partition information of the table to read. The last-level partition must be specified. For example, if you want to read data from a three-level partition table, set this parameter to a value that contains the last-level partition information, such as pt=20150101/type=1/biz=2.	Yes	None

Configure Hive Reader by using the code editor

In the following code, a node is configured to read data from a Hive data store.

```
{
  "type":"job",
  "version":"2.0",// The version number.
  "steps":[
    {
      "stepType":"stream",
      "parameter":{},
      "name":"Writer",
      "category":"writer"
    },
    {
      "stepType":"hive", // The reader type. The name is the same as that in MaxCompute.
      "parameter":{
        "parameter":{
          "column": [// The columns to be synchronized.
            "id",
            "name"
          ],
          "table": "student_tmp_2", // The name of the table to be synchronized.
          "partition": "academy=yx/class=001", // The partition settings.
          "datasource": "hive_demo"
        }
      },
      "name":"Reader",
      "category":"reader"
    }
  ],
  "setting":{
  },
  "order":{
    "hops":[// Synchronize data from the reader to the writer.
      {
        "from":"Reader",
        "to":"Writer"
      }
    ]
  }
}
```

2.3.3.3.20. Configure Elasticsearch Reader

This topic describes the working principles, features, and parameters of Elasticsearch Reader.

Working principles

- Elasticsearch Reader reads data from Elasticsearch by slicing scroll queries. The slices are processed by multiple threads of a data synchronization node.
- Data types are converted based on the mapping configuration of Elasticsearch.

Basic settings

```
{
  "order":{
    "hops":[
      {
        "from":"Reader",
        "to":"Writer"
      }
    ]
  },
  "setting":{
    "errorLimit":{
      "record":"0" // The maximum number of dirty data records allowed.
    },
    "jvmOption":"",
    "speed":{
      "concurrent":3,
      "throttle":false
    }
  },
  "steps":[
    {
      "category":"reader",
      "name":"Reader",
      "parameter":{
        "column":[ // The fields to read.
          "id",
          "name"
        ],
        "endpoint":"", // The endpoint.
        "index":"", // The index name.
        "password":"", // The password.
```

```
            "scroll":"", // The scroll ID.
            "search":"", // The search criteria. The value is the same as the Elasticsearch query that uses the _search API.
            "type":"default",
            "username":"" // The username.
          },
          "stepType":"elasticsearch"
        },
        {
          "category":"writer",
          "name":"Writer",
          "parameter":{},
          "stepType":"stream"
        }
      ],
      "type":"job",
      "version":"2.0" // The version number.
    }
```

Advanced features

- Supports storing all data of an Elasticsearch document in one column.

  You can create a column to store all data of an Elasticsearch document.

- Supports converting semi-structured data to structured data.

Item	Description
Background	Data in Elasticsearch is deeply nested. Elasticsearch may contain fields of various types and lengths and may use Chinese names. To facilitate data computing and storage in downstream businesses, Elasticsearch Reader supports converting semi-structured data to structured data.
Principle	Elasticsearch Reader flattens nested JSON data obtained from Elasticsearch to single-dimensional data based on the paths of properties in the JSON data. Then, Elasticsearch Reader maps the single-dimensional data to structured tables. In this way, Elasticsearch data in a complex structure is converted to multiple structured tables.

Item	Description
Solution	◦ Elasticsearch Reader converts nested JSON data to single-dimensional data by using the following path formats: ▪ Property ▪ Property.Child property ▪ Property[0].Child property ◦ If a property has multiple child properties, Elasticsearch Reader traverses all data of the property and splits the data to multiple tables or multiple rows in the following format: Property[*].Child property ◦ Elasticsearch Reader merges data in a string array to one property in the following format and removes duplicates: Property[] where duplicates are removed ◦ Elasticsearch Reader merges multiple properties to one property in the following format: Property 1,Property 2 ◦ Elasticsearch Reader presents optional properties in the following format: Property 1|Property 2

Parameters

Parameter	Description	Required	Default value
endpoint	The endpoint of Elasticsearch.	Yes	None
username	The username for HTTP authentication.	No	Empty string
password	The password for HTTP authentication.	No	Empty string
index	The index name in Elasticsearch.	Yes	None
type	The type name in the index of Elasticsearch.	No	Index name
pageSize	The number of data records to read at a time.	No	*100*
search	The query parameter of Elasticsearch.	Yes	None

Parameter	Description	Required	Default value
scroll	The scroll parameter of Elasticsearch, which sets the timestamp of the snapshot taken for a scroll.	Yes	None
sort	The field based on which the returned results are sorted.	No	None
retryCount	The number of retries after a failure.	No	*300*
connTimeOut	The connection timeout of the client.	No	*600,000*
readTimeOut	The data reading timeout of the client.	No	*600,000*
multiThread	Specifies whether to use multiple threads for an HTTP request.	No	*true*
column	The fields to read.	Yes	None
full	Specifies whether to create a column to record all data of an Elasticsearch document.	No	*false*
multi	Specifies whether to split an array to multiple rows. If you enable this feature, you need to specify additional settings.	No	*false*

Additional settings:

```
"full":false,
    "multi":{
     "multi":true,
     "key":"crn_list[*]"
    }
```

2.3.3.3.21. Configure Vertica Reader

Parameters

Parameter	Description	Required	Default value
datasource	The connection name. It must be identical to the name of the added connection. You can add connections in the code editor.	Yes	None
table	The name of the table to be synchronized. You can select only one source table for each sync node.	Yes	None
column	The columns to be synchronized from the source table. The columns are described in a JSON array. The default value is [*], which indicates all columns. • Column pruning is supported. You can select and export specific columns. • Change of the column order is supported. You can export the columns in an order different from that specified in the schema of the table. • Constants are supported. The column names must be arranged in compliance with the SQL syntax supported by MySQL, for example, `["id", "table","1", "'mingya.wmy'", "'null'", "to_char(a+1)", "2.3", "true"]`. ○ id: a column name. ○ table: the name of a column that contains reserved keywords. ○ 1: an integer constant. ○ 'mingya.wmy': a string constant, which is enclosed in single quotation marks (' '). ○ 'null': a string. ○ to_char(a + 1): a function expression. ○ 2.3: a floating-point constant. ○ true: a Boolean value. • The column parameter must explicitly specify a set of columns to be synchronized. The parameter cannot be left empty.	Yes	None
splitPk	The field used for data sharding when Vertica Reader extracts data. If you specify the splitPk parameter, the table is sharded based on the shard key specified by this parameter. Data Integration then runs concurrent threads to synchronize data. This improves efficiency. • We recommend that you set the splitPk parameter to the primary key of the table. Based on the primary key, data can be well distributed to different shards, but not intensively distributed to certain shards. • Currently, the splitPk parameter supports data sharding only for integers but not for other data types such as string, floating point, and date. If you specify this parameter to a column of an unsupported type, Vertica Reader returns an error.	No	None

Parameter	Description	Required	Default value
where	The WHERE clause. Vertica Reader generates a SELECT statement based on the column, table, and where parameters that you have configured, and uses the generated SELECT statement to select and read data. For example, set this parameter to limit 10 during a test. For example, if you need to synchronize data generated on the current day, set this parameter to `gmt_create > $bizdate`. • You can use the WHERE clause to synchronize incremental data. • If you do not specify the where parameter or leave it empty, all data is synchronized.	No	None
querySql	The SELECT statement used for refined data filtering. Specify this parameter in the following format: `"querysql" : "SELECT statement",`. If you specify this parameter, Data Integration directly filters data based on this parameter. For example, if you want to join multiple tables for data synchronization, set this parameter to `select a,b from table_a join table_b on table_a.id = table_b.id`. If you specify the querySql parameter, Vertica Reader ignores the table, column, and where parameters that you have configured.	No	None
fetchSize	The number of data records to read at a time. This parameter determines the number of interactions between Data Integration and the database and affects reading efficiency. **Note** A value larger than 2048 may lead to the out of memory (OOM) error during the data synchronization process.	No	*1024*

Configure Vertica Reader by using the codeless UI

Currently, the codeless user interface (UI) is not supported for Vertica Reader.

Configure Vertica Reader by using the code editor

```
{
  "type":"job",
  "version":"2.0",// The version number.
  "steps":[
    {
      "stepType":"vertica",// The reader type.
      "parameter":{
        "datasource":"",// The connection name.
        "column":[// The columns to be synchronized.
          "id",
          "name"
```

```
            ],
            "where":"",// The WHERE clause.
            "splitPk":"",// The shard key based on which the table is sharded.
            "table":""// The name of the table to be synchronized.
        },
        "name":"Reader",
        "category":"reader"
    },
    {
        "stepType":"stream",
        "parameter":{},
        "name":"Writer",
        "category":"writer"
    }
  ],
  "setting":{
    "errorLimit":{
        "record":"0"// The maximum number of dirty data records allowed.
    },
    "speed":{
        "throttle":false,// Specifies whether to enable bandwidth throttling. A value of false indicates that the
bandwidth is not throttled. A value of true indicates that the bandwidth is throttled. The maximum transmi
ssion rate takes effect only if you set this parameter to true.
        "concurrent":1,// The maximum number of concurrent threads.
    }
  },
  "order":{
    "hops":[
      {
        "from":"Reader",
        "to":"Writer"
      }
    ]
  }
}
```

2.3.3.3.22. Configure GBase Reader

This topic describes how GBase Reader reads data and how to configure a sync node to read data from a GBase database.

GBase Reader connects to a remote GBase database through the MySQL Java Database Connectivity (JDBC) Driver, generates SQL statements based on your configurations, and then reads data from the remote GBase database. Then, GBase Reader assembles the returned data to abstract datasets in custom data types supported by Data Integration, and passes the datasets to a writer.

Parameters

Parameter	Description	Required	Default value
datasource	The connection name. It must be identical to the name of the added connection. You can add connections in the code editor.	Yes	None
table	The name of the table to be synchronized. You can select only one source table for each sync node.	Yes	None
column	The columns to be synchronized from the source table. The columns are described in a JSON array. The default value is [*], which indicates all columns. • Column pruning is supported. You can select and export specific columns. • Change of the column order is supported. You can export the columns in an order different from that specified in the schema of the table. • Constants are supported. The column names must be arranged in compliance with the SQL syntax supported by MySQL, for example, `["id","table","1","'mingya.wmy'","'null'","to_char(a+1)","2.3","true"]`. ◦ id: a column name. ◦ table: the name of a column that contains reserved keywords. ◦ 1: an integer constant. ◦ 'mingya.wmy': a string constant, which is enclosed in single quotation marks (' '). ◦ null: ▪ '' '' indicates an empty value. ▪ null indicates a null value. ▪ 'null' indicates the string null. ◦ to_char(a+1): a function expression. ◦ 2.3: a floating-point constant. ◦ true: a Boolean value. • The column parameter must explicitly specify a set of columns to be synchronized. The parameter cannot be left empty.	Yes	None

Parameter	Description	Required	Default value
splitPk	The field used for data sharding when GBase Reader extracts data. If you specify the splitPk parameter, the table is sharded based on the shard key specified by this parameter. Data Integration then runs concurrent threads to synchronize data. This improves efficiency. • We recommend that you set the splitPk parameter to the primary key of the table. Based on the primary key, data can be well distributed to different shards, but not intensively distributed to certain shards. • Currently, the splitPk parameter supports data sharding only for integers but not for other data types such as string, floating point, and date. If you specify this parameter to a column of an unsupported type, GBase Reader ignores the splitPk parameter and synchronizes data through a single thread. • If you do not specify the splitPk parameter or leave it empty, Data Integration synchronizes data through a single thread.	No	None
where	The WHERE clause. For example, set this parameter to `gmt_create>$bizdate` . • You can use the WHERE clause to synchronize incremental data. If you do not specify the where parameter or leave it empty, all data is synchronized. • Do not set the where parameter to limit 10, which does not conform to the constraints of MySQL on the SQL WHERE clause.	No	None
querySql (only available in the code editor)	The SELECT statement used for refined data filtering. If you specify this parameter, Data Integration directly filters data based on this parameter. For example, if you want to join multiple tables for data synchronization, set this parameter to `select a,b from table_a join table_b on table_a.id = table_b.id` . The priority of the querySql parameter is higher than those of the table, column, where, and splitPk parameters. If you specify the querySql parameter, GBase Reader ignores the table, column, where, and splitPk parameters that you have configured. The datasource parameter parses information, including the username and password, from this parameter.	No	None

Configure GBase Reader by using the codeless UI

Currently, the codeless user interface (UI) is not supported for GBase Reader.

Configure GBase Reader by using the code editor

In the following code, a node is configured to read data from a GBase database.

```
{
  "type":"job",
  "version":"2.0",// The version number.
  "steps":[
    {
      "stepType":"gbase // The reader type.
      "parameter":{
        "column":[// The columns to be synchronized.
          "id"
        ],
        "connection":[
          {  "querysql":["select a,b from join1 c join join2 d on c.id = d.id;"], // Specify the querySql parameter
in the connection parameter as a string.
            "datasource":"",// The connection name.
            "table":[// The name of the table to be synchronized.
              "xxx"
            ]
          }
        ],
        "where":"",// The WHERE clause.
        "splitPk":"",// The shard key.
        "encoding":"UTF-8"// The encoding format.
      },
      "name":"Reader",
      "category":"reader"
    },
    {
      "stepType":"stream",
      "parameter":{},
      "name":"Writer",
      "category":"writer"
    }
  ],
  "setting":{
    "errorLimit":{
      "record":"0"// The maximum number of dirty data records allowed.
    },
    "speed":{
```

```
        "throttle":false,// Specifies whether to enable bandwidth throttling. A value of false indicates that the bandwidth is not throttled. A value of true indicates that the bandwidth is throttled. The maximum transmission rate takes effect only if you set this parameter to true.
        "concurrent":1,// The maximum number of concurrent threads.
      }
    },
    "order":{
      "hops":[
        {
          "from":"Reader",
          "to":"Writer"
        }
      ]
    }
}
```

2.3.3.4. Configure the writer

2.3.3.4.1. Configure AnalyticDB Writer

AnalyticDB Writer allows you to write data to AnalyticDB in two modes.

- Load Data: Data is transferred from a data source to AnalyticDB.
  - Benefit: When you need to transfer more than 10 million records, data can be written to AnalyticDB at a high speed.
  - Shortfall: Authorization from the third-party system is required.
- Insert Ignore: Data is directly written to AnalyticDB.
  - Benefit: When you need to transfer fewer than 10 million records, data can be written to AnalyticDB at a high speed.
  - Shortfall: This mode is not suitable for writing a large amount of data to AnalyticDB.

You must configure a connection before configuring AnalyticDB Writer.

The following table lists the data types supported by AnalyticDB Writer.

Category	AnalyticDB data type
Integer	INT, TINYINT, SMALLINT, and BIGINT
Floating point	FLOAT and DOUBLE
String	VARCHAR
Date and time	DATE
Boolean	BOOLEAN

Prerequisites

- Before writing data in Load Data mode from a MaxCompute table to AnalyticDB, you must grant the Describe and Select permissions on the table to the account that performs the operation in MaxCompute.

  For more information about the accounts that perform the write operation in Apsara Stack, see the configuration documents. Typically, the account is test1000000009@aliyun.com.

  Run the following command to grant permissions to the account:

  ```
  USE projectname; -- The MaxCompute project to which the table belongs.
  ADD USER ALIYUN$xxxx@aliyun.com; -- The Apsara Stack account.
  GRANT Describe,Select ON TABLE table_name TO USER ALIYUN$xxxx@aliyun.com; -- The table on which permissions are granted and the Apsara Stack account to be granted the permissions.
  ```

  To protect your data security, the operator must be the owner of the MaxCompute project or table to be written to AnalyticDB.

- You can use AnalyticDB Writer to write data only from a MaxCompute connection to AnalyticDB. To use other connections, you must write data to MaxCompute before transferring the data to AnalyticDB.

Parameters

Parameter	Description	Required	Default value
url	The AnalyticDB URL, in the format of ip:port.	Yes	None
schema	The name of the AnalyticDB schema.	Yes	None
username	The username of the AnalyticDB account, which is the AccessKey ID.	Yes	None
password	The password of the AnalyticDB account, which is the AccessKey secret.	Yes	None
datasource	The connection name. It must be identical to the name of the added connection. You can add connections in the code editor.	Yes	None
table	The name of the destination table.	Yes	None

Parameter	Description	Required	Default value
partition	The partition name of the destination table. If the destination table is partitioned, this parameter is required. If you write data from MaxCompute to AnalyticDB in Load Data mode, the parameter can be configured as follows. Take two-level partitions as an example: • "partition":["pt=*, ds=*"] (Read data from all the partitions in the table.) • "partition":["pt=1, ds=*"] (Read data from all the secondary partitions of the primary partition pt=1 in the table.) • "partition":["pt=1, ds=hangzhou"] (Read data from the secondary partition ds=hangzhou of the primary partition pt=1 in the table.)	No	None
writeMode	The mode in which data is written to AnalyticDB. Load Data and Insert Ignore modes are supported. If a record with the same primary key already exists, the statements in Insert Ignore mode can be executed, but the new record is discarded.	Yes	None
column	The list of fields in the destination table. The value can be ["*"] or a list of specific fields such as ["a", "b", "c"].	Yes	None
overWrite	Indicates whether to overwrite the destination table when data is written to AnalyticDB. The value true indicates that the table is overwritten. The value false indicates that the table is not overwritten and the data is appended. This value takes effect only if the writeMode parameter is set to Load.	Yes	None
lifeCycle	The time-to-live (TTL) of an AnalyticDB temporary table. This value takes effect only if the writeMode parameter is set to Load.	Yes	None
suffix	The URL suffix that forms part of a custom connection string. The AnalyticDB URL is in the format of ip:port, which changes to a Java Database Connectivity (JDBC) connection string when you access AnalyticDB. For example, configure the suffix as autoReconnect=true&failOverReadOnly=false&maxReconnects=10.	No	None
opIndex	The index of the Operation Type column corresponding to the source database connected to AnalyticDB. The value starts from 0. This value takes effect only if the writeMode parameter is set to stream.	The parameter is required only if the writeMode parameter is set to stream.	None

Parameter	Description	Required	Default value
batchSize	The number of records to write to AnalyticDB per batch.	The parameter is required and takes effect only if the writeMode parameter is set to Insert.	None
bufferSize	The size of the DataX data buffer, which is designed to improve the performance of AnalyticDB. Data from the source database is sorted in the buffer before being committed to AnalyticDB. The data is sorted based on the AnalyticDB partition column so that data is organized in an order that is friendlier to the AnalyticDB server. Data in the buffer is committed to AnalyticDB in batches based on the batchSize parameter. We recommend that you set the bufferSize value to a multiple of batchSize. This parameter is required and takes effect	only if the writeMode parameter is set to Insert.	This feature is disabled by default.

Configure AnalyticDB Writer by using the codeless UI

1. Configure the connections.

   Configure the source and destination connections for the sync node.

Configuration item	Description
Connection	The datasource parameter in the preceding parameter description. Select a connection type, and enter the name of a connection that has been configured in DataWorks.
Table	The table parameter in the preceding parameter description.
Import mode	The writeMode parameter in the preceding parameter description.

2. Configure field mapping, that is, the column parameter in the preceding parameter description.

   Fields in the source table on the left have a one-to-one mapping with fields in the destination table on the right.

3. Configure channel control policies.

Configure AnalyticDB Writer by using the code editor

```
{
  "type":"job",
  "version":"2.0",
  "steps":[
    {
      "stepType":"stream",
      "parameter":{
      "name":"Reader",
      "category":"reader"
    },
    {
      "stepType":"ads",// The writer type.
      "parameter":{
        "partition:" ",// The partition name of the destination table.
        "datasource":"",// The connection name.
        "column":[// The columns to be synchronized.
          "id"
        ],
        "writeMode":"insert",// The write mode.
        "batchSize":"256",// The number of data records to write at a time.
        "table":"",// The name of the table to be synchronized.
        "overWrite":"true"// Indicates whether to overwrite the destination table when data is written to AnalyticDB. The value true indicates that the table is overwritten. The value false indicates that the table is not overwritten and the data is appended. This value takes effect only if the writeMode parameter is set to Load.
      },
      "name":"Writer",
      "category":"writer"
    }
  ],
  "setting":{
    "errorLimit":{
      "record":"0"// The maximum number of dirty data records allowed.
    },
    "speed":{
      "throttle":false,// Specifies whether to enable bandwidth throttling. A value of false indicates that the bandwidth is not throttled. A value of true indicates that the bandwidth is throttled. The maximum transmission rate takes effect only if you set this parameter to true.
      "concurrent":1,// The maximum number of concurrent threads.
```

```
    }
  },
  "order":{
    "hops":[
      {
        "from":"Reader",
        "to":"Writer"
      }
    ]
  }
}
```

2.3.3.4.2. Configure DataHub Writer

This topic describes the data types and parameters supported by DataHub Writer and how to configure it by using the code editor.

DataHub is a real-time data distribution platform designed to process streaming data. You can publish and subscribe applications to streaming data in DataHub and distribute the data to other platforms. This allows you to easily analyze streaming data and build applications based on the streaming data.

Based on the Apsara system of Alibaba Cloud, DataHub features high availability, low latency, high scalability, and high throughput. Seamlessly integrated with Realtime Compute, DataHub allows you to easily use SQL to analyze streaming data. DataHub can also distribute streaming data to Alibaba Cloud services such as MaxCompute and OSS.

> **Note** Strings can only be UTF-8 encoded. The size of each string must not exceed 1 MB.

Parameter configuration

The source is connected to the destination through a single channel. Therefore, the channel type configured for the writer must be the same as that configured for the reader. Generally, channels are categorized into two types: memory andfile. The following configuration sets the channel type to file:

```
"agent.sinks.dataXSinkWrapper.channel": "file"
```

Parameters

Parameter	Description	Required	Default value
accessId	The AccessKey ID for accessing DataHub.	Yes	None
accessKey	The AccessKey secret for accessing DataHub.	Yes	None
endpoint	The endpoint of DataHub.	Yes	None

Parameter	Description	Required	Default value
maxRetryCount	The maximum number of retries if a task fails.	No	None
mode	The mode for writing strings.	Yes	None
parseContent	The data that has been parsed.	Yes	None
project	The organizational unit in DataHub. Each project contains one or more topics. **Note** DataHub projects are independent from MaxCompute projects. Projects created in MaxCompute cannot be used in DataHub.	Yes	None
topic	The minimum unit for data subscription and publication. You can use topics to distinguish different types of streaming data.	Yes	None
maxCommitSize	The amount of data, in MB, that DataHub Writer buffers before sending it to the destination. This mechanism aims to improve writing efficiency. The default value is 1048576, in KB, that is, 1 MB.	No	*1048576*
batchSize	The number of data records that DataHub Writer buffers before sending them to the destination. This mechanism aims to improve writing efficiency. The default value is 1024.	No	*1,024*
maxCommitInterval	The maximum interval at which DataHub Writer sends data to the destination. When an interval ends, DataHub Writer sends buffered data even if the data amount does not reach the preceding two thresholds. The default value is 30000, in milliseconds, that is, 30 seconds.	No	*30,000*
parseMode	The mode for parsing log entries. Valid values: *default* and *csv*. The value default indicates that no log parsing is required. The value csv indicates that a delimiter is inserted between fields for each log entry.	No	*default*

Configure DataHub Writer by using the codeless UI

Currently, the codeless UI is not supported for DataHub Writer.

Configure DataHub Writer by using the code editor

In the following code, a node is configured to read data from the memory and then write the data to DataHub.

```
{
  "type": "job",
```

```
  "type": "job",
  "version": "2.0", // The version number.
  "steps": [
    {
      "stepType": "stream",
      "parameter": {},
      "name": "Reader",
      "category": "reader"
    },
    {
      "stepType": "datahub", // The writer type.
      "parameter": {
        "datasource": "", // The connection name.
        "topic": "",// The minimum unit for data subscription and publication. You can use topics to distinguish different types of streaming data.
        "maxRetryCount":500,// The maximum number of retries if a task fails.
        "maxCommitSize": 1048576// The amount of data, in MB, that DataHub Writer buffers before sending it to the destination.
        "shardId": "xxxxxx" // The shard of the DataHub topic.
      },
      "name": "Writer",
      "category": "writer"
    }
  ],
  "setting": {
    "errorLimit": {
      "record": "" // The maximum number of dirty data records allowed.
    },
    "speed": {
      "concurrent": 20, // The maximum number of concurrent threads.
      "throttle": false, // The value false indicates that the bandwidth is not throttled. The value true indicates that the bandwidth is throttled. The maximum transmission rate takes effect only if you set this parameter to true.
    }
  },
  "order": {
    "hops": [
      {
        "from": "Reader",
        "to": "Writer"
      }
```

```
    ]
  }
}
```

2.3.3.4.3. Configure Db2 Writer

This topic describes the data types and parameters supported by Db2 Writer and how to configure it by using the code editor.

Db2 Writer allows you to write data to tables stored in Db2 databases. Specifically, Db2 Writer connects to a remote Db2 database through Java Database Connectivity (JDBC), and runs an `INSERT INTO` statement to write data to the Db2 database. Internally, data is submitted to Db2 database in batches.

Db2 Writer is designed for extract-transform-load (ETL) developers to import data from data warehouses to Db2 databases. Db2 Writer can also be used as a data migration tool by users such as database administrators (DBAs).

Db2 Writer obtains data from a Data Integration reader, and writes the data to the destination database by running the `INSERT INTO` statement. If a primary key conflict or unique index conflict occurs, data cannot be written to the conflicting rows. To improve performance, Db2 Writer makes `batch updates with the PreparedStatement method` and sets the `rewriteBatchedStatements` parameter to true. In this way, Db2 Writer buffers data, and submits a write request when the amount of data in the buffer reaches a specific threshold.

> **Note** A sync node that uses Db2 Writer must have at least the permission to run the `INSERT INTO` statement. Whether other permissions are required depends on the SQL statements specified in the preSql and postSql parameters when you configure the node.

Db2 Writer supports most Db2 data types. Make sure that your data types are supported.

The following table lists the data types supported by Db2 Writer.

Category	Db2 data type
Integer	SMALLINT
Floating point	DECIMAL, REAL, and DOUBLE
String	CHAR, CHARACTER, VARCHAR, GRAPHIC, VARGRAPHIC, LONG VARCHAR, CLOB, LONG VARGRAPHIC, and DBCLOB
Date and time	DATE, TIME, and TIMESTAMP
Boolean	N/A
Binary	BLOB

Parameters

Parameter	Description	Required	Default value
jdbcUrl	The JDBC URL for connecting to the Db2 database. In accordance with official Db2 specifications, the URL must be in the jdbc:db2://ip:port/database format. You can also specify the information of the attachment facility.	Yes	None
username	The username for connecting to the Db2 database.	Yes	None
password	The password for connecting to the Db2 database.	Yes	None
table	The name of the destination table.	Yes	None
column	The columns in the destination table to which data is written. Separate the columns with a comma (,). Example: "column": ["id", "name", "age"]. Set the value to an asterisk (*) if data is written to all the columns in the destination table. That is, set the column parameter as follows: "column": ["*"] .	Yes	None
preSql	The SQL statement to run before the sync node is run. For example, you can clear outdated data before data synchronization. Currently, you can run only one SQL statement on the codeless user interface (UI), and multiple SQL statements in the code editor.	No	None
postSql	The SQL statement to run after the sync node is run. For example, you can add a timestamp after data synchronization. Currently, you can run only one SQL statement on the codeless UI, and multiple SQL statements in the code editor.	No	None
batchSize	The number of data records to write at a time. Setting this parameter can greatly reduce the interactions between Data Integration and the Db2 database over the network, and increase the throughput. However, an excessively large value may lead to the out of memory (OOM) error during the data synchronization process.	No	*1024*

Configure Db2 Writer by using the codeless UI

Currently, the codeless UI is not supported for Db2 Writer.

Configure Db2 Writer by using the code editor

In the following code, a node is configured to write data to a Db2 database.

```
{
  "type":"job",
  "version":"2.0",// The version number.
  "steps":[
    {
      "stepType":"stream",
      "parameter":{},
```

```
      "name":"Reader",
      "category":"reader"
    },
    {
      "stepType":"db2",// The writer type.
      "parameter":{
        "postSql":[],// The SQL statement to run after the sync node is run.
        "password":"",// The password for connecting to the Db2 database.
        "jdbcUrl":"jdbc:db2://ip:port/database",// The JDBC URL for connecting to the Db2 database.
        "column":[
          "id"
        ],
        "batchSize":1024,// The number of data records to write at a time.
        "table":"", // The name of the destination table.
        "username":"", // The username for connecting to the Db2 database.
        "preSql":[]// The SQL statement to run before the sync node is run.
      },
      "name":"Writer",
      "category":"writer"
    }
  ],
  "setting":{
    "errorLimit":{
      "record":"0"// The maximum number of dirty data records allowed.
    },
    "speed":{
      "throttle":false,// Specifies whether to enable bandwidth throttling. A value of false indicates that the bandwidth is not throttled. A value of true indicates that the bandwidth is throttled. The maximum transmission rate takes effect only if you set this parameter to true.
      "concurrent":1,// The maximum number of concurrent threads.
    }
  },
  "order":{
    "hops":[
      {
        "from":"Reader",
        "to":"Writer"
      }
    ]
  }
}
```

2.3.3.4.4. Configure DRDS Writer

This topic describes the data types and parameters supported by DRDS Writer and how to configure it by using the code editor.

DRDS Writer allows you to write data to tables stored in Distributed Relational Database Service (DRDS) databases. Specifically, DRDS Writer connects to the proxy of a remote DRDS database through Java Database Connectivity (JDBC), and runs an `REPLACE INTO` statement to write data to the DRDS database.

> **Note**
> - To run the `REPLACE INTO` statement, make sure that your table has the primary key or a unique index to avoid replicated data.
> - You must configure a connection before configuring DRDS Writer. For more information, see Add DRDS data sources.

DRDS Writer is designed for extract-transform-load (ETL) developers to import data from data warehouses to DRDS databases. DRDS Writer can also be used as a data migration tool by users such as database administrators (DBAs).

DRDS Writer obtains data from a Data Integration reader, and writes the data to the destination database by running the `REPLACE INTO` statement. If no primary key conflict or unique index conflict occurs, the action is the same as that of the `INSERT INTO` statement. If a conflict occurs, original rows are replaced by new rows. DRDS Writer sends data to the DRDS proxy when the amount of buffered data reaches a specific threshold. The proxy determines whether to write the data to one or more tables and how to route the data when it is written to multiple tables.

> **Note** A sync node that uses DRDS Writer must have at least the permission to run the REPLACE INTO statement. Whether other permissions are required depends on the SQL statements specified in the preSql and postSql parameters when you configure the node.

Similar to MySQL Writer, DRDS Writer supports most MySQL data types. Make sure that your data types are supported.

The following table lists the data types supported by DRDS Writer.

Category	MySQL data type
Integer	INT, TINYINT, SMALLINT, MEDIUMINT, BIGINT, and YEAR
Floating point	FLOAT, DOUBLE, and DECIMAL
String	VARCHAR, CHAR, TINYTEXT, TEXT, MEDIUMTEXT, and LONGTEXT
Date and time	DATE, DATETIME, TIMESTAMP, and TIME
Boolean	BIT and BOOLEAN

Category	MySQL data type
Binary	TINYBLOB, MEDIUMBLOB, BLOB, LONGBLOB, and VARBINARY

Parameters

Parameter	Description	Required	Default value
datasource	The connection name. It must be identical to the name of the added connection. You can add connections in the code editor.	Yes	None
table	The name of the destination table.	Yes	None
writeMode	The write mode. Valid values: *insert into*, *on duplicate key update*, and *replace into*. • *insert into*: If a primary key conflict or unique index conflict occurs, data cannot be written to the conflicting rows and is regarded as dirty data. • *on duplicate key update*: If no primary key conflict or unique index conflict occurs, the action is the same as that of `insert into`. If a conflict occurs, specified fields in original rows are updated. • *replace into*: If no primary key conflict or unique index conflict occurs, the action is the same as that of `insert into`. If a conflict occurs, original rows are deleted and new rows are inserted. That is, all fields of original rows are replaced.	No	*insert*
column	The columns in the destination table to which data is written. Separate the columns with a comma (,). Example: "column": ["id", "name", "age"]. Set the value to an asterisk (*) if data is written to all the columns in the destination table. That is, set the column parameter as follows: "column":["*"].	Yes	None
preSql	The SQL statement to run before the sync node is run. For example, you can clear outdated data before data synchronization. Currently, you can run only one SQL statement on the codeless user interface (UI), and multiple SQL statements in the code editor.	No	None
postSql	The SQL statement to run after the sync node is run. For example, you can add a timestamp after data synchronization. Currently, you can run only one SQL statement on the codeless UI, and multiple SQL statements in the code editor.	No	None
batchSize	The number of data records to write at a time. Setting this parameter can greatly reduce the interactions between Data Integration and the DRDS database over the network, and increase the throughput. However, an excessively large value may lead to the out of memory (OOM) error during the data synchronization process.	No	*1024*

Configure DRDS Writer by using the codeless UI

1. Configure the connections.

Configure the source and destination connections for the sync node.

Parameter	Description
Connection	The datasource parameter in the preceding parameter description. Select a connection type, and enter the name of a connection that has been configured in DataWorks.
Table	The table parameter in the preceding parameter description.
Statement Run Before Writing	The preSql parameter provided in the preceding parameter description. Enter an SQL statement to run before the sync node is run.
Statement Run After Writing	The postSql parameter provided in the preceding parameter description. Enter an SQL statement to run after the sync node is run.
Solution to Constraint Violation	The writeMode parameter in the preceding parameter description. Select the expected write mode.

2. Configure field mapping, that is, the column parameter in the preceding parameter description.

   Fields in the source table on the left have a one-to-one mapping with fields in the destination table on the right.

3. Configure channel control policies.

Configure DRDS Writer by using the code editor

In the following code, a node is configured to write data to a DRDS database.

```
{
  "type":"job",
  "version":"2.0",// The version number.
  "steps":[
    {
      "stepType":"stream",
      "parameter":{},
      "name":"Reader",
      "category":"reader"
        },
    {
      "stepType":"drds",// The writer type.
      "parameter":{
        "postSql":[],// The SQL statement to run after the sync node is run.
        "datasource":"",// The connection name.
        "column":[// The columns to which data is written.
        "id"
        ],
        "writeMode":"insert ignore",
```

```
            "batchSize":"1024",// The number of data records to write at a time.
            "table":"test",// The name of the destination table.
            "preSql":[]// The SQL statement to run before the sync node is run.
            },
          "name":"Writer",
          "category":"writer"
            }
            ],
    "setting":{
      "errorLimit":{
      "record":"0"// The maximum number of dirty data records allowed.
        },
      "speed":{
        "throttle":false,// Specifies whether to enable bandwidth throttling. A value of false indicates that the
bandwidth is not throttled. A value of true indicates that the bandwidth is throttled. The maximum transmi
ssion rate takes effect only if you set this parameter to true.
        "concurrent":1,// The maximum number of concurrent threads.
          }
        },
    "order":{
      "hops":[
        {
          "from":"Reader",
          "to":"Writer"
          }
        ]
      }
    }
```

2.3.3.4.5. Configure FTP Writer

This topic describes the data types and parameters supported by FTP Writer and how to configure it by using the codeless user interface (UI) and code editor.

FTP Writer allows you to write one or more comma-separated values (CSV) files to a remote FTP server. Specifically, FTP Writer converts the data obtained from a Data Integration reader to CSV files and writes these files to a remote FTP server by using FTP-related network protocols.

> **Note** You must configure a connection before configuring FTP Writer. For more information, see Add FTP data sources.

FTP Writer can write files that store logical two-dimensional tables, such as CSV files that store text data, to an FTP server.

FTP Writer allows you to convert data obtained from a Data Integration reader to files and write the files to an FTP server. The files on the FTP server store unstructured data only. Currently, FTP Writer supports the following features:

- Writes only files that store text data. The text data must be logical two-dimensional tables. FTP Writer cannot write files that store Binary Large Object (BLOB) data, such as video data.
- Writes CSV-like and text files with custom delimiters.
- Uses concurrent threads to write files. Each thread writes a file.

Currently, FTP Writer does not support the following features:

- Uses concurrent threads.to write a single file.
- Distinguishes between data types. FTP does not distinguish between data types. Therefore, FTP Writer writes all data as strings to files on an FTP server.
- Writes compressed files to an FTP server.

Parameters

Parameter	Description	Required	Default value
datasource	The connection name. It must be identical to the name of the added connection. You can add connections in the code editor.	Yes	None
timeout	The timeout period to connect to the FTP server. Unit: milliseconds.	No	60000
path	The directory on the FTP server to which the files are written. FTP Writer writes multiple files to the directory concurrently based on the concurrency setting.	Yes	None
fileName	The name prefix of the files to be written to the FTP server. A random suffix is appended to the specified prefix to form the actual file name used by each thread.	Yes	None
writeMode	The mode in which FTP Writer writes the files. Valid values: • truncate: deletes all existing files with the specified file name prefix in the destination directory before writing files to the directory. • append: writes the files based on the specified file name prefix and guarantees that the actual file names do not conflict with those of existing files. • nonConflict: returns an error if a file with the specified file name prefix exists in the destination directory.	Yes	None
fieldDelimiter	The column delimiter used in the files to be written to the FTP server. The delimiter must be a single character.	Yes	None

Parameter	Description	Required	Default value
compress	The compression format of the files to be written to the FTP server. The GZIP and BZIP2 compression format are supported.	No	None
encoding	The encoding format of the files to be written to the FTP server.	No	UTF-8
nullFormat	The string that represents null. No standard strings can represent null in text files. Therefore, Data Integration provides the nullFormat parameter to define which string represents a null pointer. For example, if you specify `nullFormat="null"`, Data Integration considers null as a null pointer.	No	None
dateFormat	The format in which the data of the Date type is serialized in a file, for example, "dateFormat":"yyyy-MM-dd".	No	None
fileFormat	The format in which the files are written to the FTP server. Valid values: csv and text. If a file is written as a CSV file, the file strictly follows CSV specifications. If the data in the file contains the column delimiter, the column delimiter is escaped by using double quotation marks ("). If a file is written as a text file, the data in the file is separated with the column delimiter. If the data in the file contains the column delimiter, the column delimiter is not escaped.	No	text
header	The table header if the files are written as text files, for example, ['id', 'name', 'age'].	No	None
markDoneFileName	The name of the file the existence of which indicates that the sync node succeeds. Data Integration checks whether the file exists after data synchronization.	No	None

Configure FTP Writer by using the codeless UI

1. Configure the connections.

   Configure the source and destination connections for the sync node.

Parameter	Description
Connection	The datasource parameter in the preceding parameter description. Select a connection type, and enter the name of a connection that has been configured in DataWorks.
File Path	The path parameter in the preceding parameter description.

Parameter	Description
Field Delimiter	The fieldDelimiter parameter in the preceding parameter description. The default delimiter is comma (,).
Encoding	The encoding parameter in the preceding parameter description. The default encoding format is UTF-8.
Null String	The nullFormat parameter in the preceding parameter description, which defines a string that represents the null value.
Compression Format	The compress parameter in the preceding parameter description. By default, files are not compressed.
Include Header	The skipHeader parameter in the preceding parameter description. The default value is No.
Solution to Duplicate Prefixes	The writeMode parameter in the preceding parameter description.

2. Configure field mapping, that is, the column parameter in the preceding parameter description.

   Fields in the source table on the left have a one-to-one mapping with fields in the destination table on the right.

Operation	Description
Map Fields with the Same Name	Click **Map Fields with the Same Name** to establish a mapping between fields with the same name. Note that the data types of the fields must match.
Map Fields in the Same Line	Click **Map Fields in the Same Line** to establish a mapping for fields in the same row. Note that the data types of the fields must match.
Delete All Mappings	Click **Delete All Mappings** to remove mappings that have been established.

3. Configure channel control policies.

Configure FTP Writer by using the code editor

In the following code, a node is configured to write files to an FTP server.

```
{
  "type":"job",
  "version":"2.0",// The version number.
  "steps":[
    {
      "stepType":"stream",
      "parameter":{},
      "name":"Reader",
      "category":"reader"
    },
```

```
    },
    {
      "stepType":"ftp",// The writer type.
      "parameter":{
        "path":"",// The directory on the FTP server to which the files are written.
        "fileName":"",// The name prefix of the files to be written to the FTP server.
        "nullFormat":"null",// The string that represents null.
        "dateFormat":"yyyy-MM-dd HH:mm:ss",// The format of the time.
        "datasource":"",// The connection name.
        "writeMode":"", // The write mode.
        "fieldDelimiter":",",// The column delimiter.
        "encoding":"",// The encoding format.
        "fileFormat":""// The format in which FTP Writer writes the files.
      },
      "name":"Writer",
      "category":"writer"
    }
  ],
  "setting":{
    "errorLimit":{
      "record":"0"// The maximum number of dirty data records allowed.
    },
    "speed":{
      "throttle":false,// Specifies whether to enable bandwidth throttling. A value of false indicates that the bandwidth is not throttled. A value of true indicates that the bandwidth is throttled. The maximum transmission rate takes effect only if you set this parameter to true.
      "concurrent":1,// The maximum number of concurrent threads.
    }
  },
  "order":{
    "hops":[
      {
        "from":"Reader",
        "to":"Writer"
      }
    ]
  }
}
```

2.3.3.4.6. Configure HBase Writer

This topic describes the features, data types, and parameters supported by HBase Writer and how to configure it by using the code editor.

HBase Writer allows you to write data to HBase data stores. Specifically, HBase Writer connects to a remote HBase data store through the Java client of HBase. Then, HBase Writer uses the PUT method to write data to the HBase data store.

Features

- HBase 0.94.x and 1.1.x are supported.
  - If you use HBase 0.94.x, set the hbaseVersion parameter to 094x for the writer.

    ```
    "writer": {
        "hbaseVersion": "094x"
      }
    ```

  - If you use HBase 1.1.x, set the hbaseVersion parameter to 11x for the writer.

    ```
    "writer": {
        "hbaseVersion": "11x"
      }
    ```

    Note Currently, HBase Writer for HBase 1.1.x is compatible with HBase 2.0. If you have any issues in using HBase Writer with HBase 2.0, submit a ticket.

- You can use concatenated fields as a rowkey.

  Currently, HBase Writer supports concatenating multiple fields to generate the rowkey of an HBase table.

- You can set the version of each HBase cell.

  The information that can be used as the version of an HBase cell includes:

  - Current time
  - Specified source column
  - Specified time

Data types

The following table lists the data types supported by HBase Writer.

Note
- The types of the specified columns must be the same as those in the HBase table.
- Data types that are not listed in the table are not supported.

Category	HBase data type
Integer	Int, Long, and Short
Floating point	Float and Double

Category	HBase data type
Boolean	Boolean
String	String

Parameters

Parameter	Description	Required	Default value
haveKerberos	Specifies whether Kerberos authentication is required. A value of true indicates that Kerberos authentication is required. **Note** • If the value is true, the following five Kerberos-related parameters must be specified: ◦ kerberosKeytabFilePath ◦ kerberosPrincipal ◦ hbaseMasterKerberosPrincipal ◦ hbaseRegionserverKerberosPrincipal ◦ hbaseRpcProtection • If the value is false, Kerberos authentication is not required and you do not need to specify the preceding parameters.	No	*false*
hbaseConfig	The properties of the HBase cluster, in JSON format. The hbase.zookeeper.quorum parameter is required. It specifies the ZooKeeper ensemble servers. You can also configure other properties, such as those related to the cache and batch for scan operations.	Yes	None
mode	The mode in which data is written to the HBase data store. Currently, only the normal mode is supported. The dynamic column selection mode is coming soon.	Yes	None
table	The name of the HBase table to which data is written. The name is case-sensitive.	Yes	None
encoding	The encoding format in which a string is converted through byte[]. Currently, UTF-8 and GBK are supported.	No	*utf-8*
column	The HBase columns to which data is written. • index: the ID of the column in the source table, starting from 0. • name: the name of the column in the HBase table, in the columnFamily:column format. • type: the type of the data written, which is used by the byte[] constructor.	Yes	None

Parameter	Description	Required	Default value
maxVersion	The number of versions read by HBase Reader when multiple versions are available. Valid values: -1 and integers greater than 1. A value of -1 indicates that all versions are read.	Required in multiVersionFixedColumn mode	None
range	The rowkey range that HBase Reader reads. • startRowkey: the start rowkey. • endRowkey: the end rowkey. • isBinaryRowkey: the operation called by byte[] to convert the specified start and end rowkeys. Default value: false. If the value is true, Bytes.toBytesBinary(rowkey) is called. If the value is false, Bytes.toBytes(rowkey) is called. Example: `"range": { "startRowkey": "aaa", "endRowkey": "ccc", "isBinaryRowkey":false }` Example: `"column": [ { "index":1, "name": "cf1:q1", "type": "string" }, { "index":2, "name": "cf1:q2", "type": "string" } ]`	No	None

Parameter	Description	Required	Default value
rowkeyColumn	The rowkey of each HBase cell. • index: the ID of the column in the source table, starting from 0. If the column is a constant, set the value to -1. • type: the type of the data written, which is used by the byte[] constructor. • value: a constant, which is usually used as the delimiter between fields. HBase Writer sequentially concatenates all columns specified in this parameter to a string, and uses the string as the rowkey. The specified columns cannot be all constants. Example: `"rowkeyColumn": [ { "index":0, "type":"string" }, { "index":-1, "type":"string", "value":"_" } ]`	Yes	None

Parameter	Description	Required	Default value
versionColumn	The version of each HBase cell. You can use the current time, a specified source column, or a specified time as the version. If you do not specify this parameter, the current time is used. • index: the ID of the column in the source table, starting from 0. Make sure that the value can be properly converted to the Long type. • type: the data type. If the type is Date, HBase Writer converts the date to yyyy-MM-dd HH:mm:ss or yyyy-MM-dd HH:mm:ss SSS. If you want to use a specified time as the version, set the value to -1. • value: the specified time of the Long type. Example: `"versionColumn":{` `"index":1` `}` `"versionColumn":{` `"index":-1,` `"value":123456789` `}`	No	None
nullMode	The method of processing null values. Valid values: • skip: HBase Writer does not write null values to the HBase data store. • empty: HBase Writer writes HConstants.EMPTY_BYTE_ARRAY (new byte [0]) to the HBase data store instead of null values.	No	skip
walFlag	Specifies whether to enable write ahead logging (WAL) for HBase. If the value is true, all edits requested by an HBase client for all Regions carried by the RegionServer are recorded first in the WAL (that is, the HLog). After the edits are successfully recorded in the WAL, they are implemented to the Memstore and a success indication is sent to the HBase client. If edits fail to be recorded in the WAL, a failure indication is sent to the HBase client without implementing the edits. If the value is false, WAL is disabled but writing efficiency is improved.	No	*false*

Parameter	Description	Required	Default value
writeBufferSize	The write buffer size, in bytes, of the HBase client. If you specify this parameter, you must also specify the autoflush parameter. autoflush: • If the value is true, the HBase client sends a PUT request each time it receives an edit. • If the value is false, the HBase client sends a PUT request only when its write buffer is full.	No	8 MB

Configure HBase Writer by using the codeless UI

Currently, the codeless user interface (UI) is not supported for HBase Writer.

Configure HBase Writer by using the code editor

In the following code, a node is configured to write data to an HBase 1.1.x data store.

```
{
  "type":"job",
  "version":"2.0",// The version number.
  "steps":[
    {
      "stepType":"stream",
      "parameter":{},
      "name":"Reader",
      "category":"reader"
    },
    {
      "stepType":"hbase",// The writer type.
      "parameter":{
        "mode":"normal",// The mode in which data is written to the HBase data store.
        "walFlag":"false",// WAL is disabled for HBase.
        "hbaseVersion":"094x",// The HBase version.
        "rowkeyColumn":[// The rowkey of each HBase cell.
          {
            "index":"0",// The ID of the column in the source table.
            "type":"string"// The data type.
          },
          {
            "index":"-1",
            "type":"string",
            "value":"_"
```

```
            }
          ],
          "nullMode":"skip",// The method of processing null values.
          "column":[// The HBase columns to which data is written.
            {
              "name":"columnFamilyName1:columnName1",// The name of the HBase column.
              "index":"0",// The ID of the column in the source table.
              "type":"string"// The data type.
            },
            {
              "name":"columnFamilyName2:columnName2",
              "index":"1",
              "type":"string"
            },
            {
              "name":"columnFamilyName3:columnName3",
              "index":"2",
              "type":"string"
            }
          ],
          "writeMode":"api",// The write mode.
          "encoding":"utf-8",// The encoding format.
          "table":"",// The name of the destination table.
          "hbaseConfig":{// The properties of the HBase cluster, in JSON format.
            "hbase.zookeeper.quorum":"hostname",
            "hbase.rootdir":"hdfs: //ip:port/database",
            "hbase.cluster.distributed":"true"
          }
        },
        "name":"Writer",
        "category":"writer"
      }
    ],
    "setting":{
      "errorLimit":{
        "record":"0"// The maximum number of dirty data records allowed.
      },
      "speed":{
        "throttle":false,// Specifies whether to enable bandwidth throttling. A value of false indicates that the
bandwidth is not throttled. A value of true indicates that the bandwidth is throttled. The maximum transmi
ssion rate takes effect only if you set this parameter to true.
```

```
        "concurrent":1,// The maximum number of concurrent threads.
      }
    },
    "order":{
      "hops":[
        {
          "from":"Reader",
          "to":"Writer"
        }
      ]
    }
}
```

2.3.3.4.7. Configure the HBase11xsql writer

The HBase11xsql writer allows you to batch import data into an SQL table (Phoenix) in HBase. Phoenix encodes the rowkey using a specific method. Therefore, you need to manually convert the data when you use HBase APIs to write data. The conversion process requires lots of efforts and makes it easy to make mistakes. This writer enables you to separately import data into SQL tables.

It runs the UPSERT statement at the underlying level to write data into HBase based on the JDBC drive of Phoenix.

Features

This writer supports importing tables with indexes and simultaneously updating all index tables.

Restrictions

The restrictions of the HBase11xsql writer are described as follows:

- Supports only 1.x versions of Hbase.
- Supports only HBase tables that are created using Phoenix.
- Does not support importing data that is assigned with timestamps.

Implementation

To batch import data into HBase, this writer runs the UPSERT statement through the JDBC drive of Phoenix. An upper-layer API enables the simultaneous update of indexed tables.

Parameters

Parameter	Description	Required	Default value
plugin	The name of this plug-in, which must be hbase11xsql.	Yes	None
table	The name of the table to be imported. The name is case sensitive, and the name for each Phoenix table contains only uppercase letters in most cases.	Yes	None

Parameter	Description	Required	Default value
column	The name of the column, which is case sensitive. The column names of Phoenix tables contain only uppercase letters in most cases. **Note** • The column sequence must be consistent with the sequence of output columns from the reader. • You do not need to specify the data type, and the column metadata is automatically retrieved from Phoenix.	Yes	None
hbaseConfig	The IP address of the HBase cluster, in the format of ip1,ip2,ip3. The zk parameter is required. **Note** • Separate multiple IP addresses with commas (,). • The znode parameter is optional, and its default value is /hbase.	Yes	None
batchSize	The number of rows to write per batch.	No	256
nullMode	The processing mode when the column value is null. The valid values for this parameter are as follows: • skip: Skip this column. In this mode, the column is not inserted. If the column of the row already exists, the column is deleted. • empty: Insert 0 or an empty string. In this mode, 0 is inserted for a numeric value, and an empty string is inserted for a varchar value.	No	skip

Configure the HBase11xsql writer in script mode

An example is described as follows:

```
{
 "type": "job",
 "version": "1.0",
 "configuration": {
  "setting": {
   "errorLimit": {
    "record": "0"
   },
   "speed": {
    "mbps": "1",
    "concurrent": "1"
   }
  },
  "reader": {
   "plugin": "odps",
   "parameter": {
    "datasource": "",
    "table": "",
    "column": [],
    "partition": ""
   }
  },
  "plugin": "hbase11xsql",
  "parameter": {
   "table": "The name of the target HBase table, which is case sensitive",
   "hbaseConfig": {
    "hbase.zookeeper.quorum": "The IP address of the ZooKeeper server for the target HBase cluster. Conta
ct the PE for more information.",
    "zookeeper.znode.parent": "The znode of the target HBase cluster. Contact the PE for more information.
"
   },
   "column": [
    "columnName"
   ],
   "batchSize": 256,
   "nullMode": "skip"
  }
 }
}
```

Restrictions

The sequence of columns in the reader determines how columns for each row are organized. The column sequence in the writer must be consistent with that in the reader. The sequence of columns in the writer describes how the writer expects the received data in columns for each row to be organized. For example:

If the column sequence in the reader is c1, c2, c3, c4, and the column sequence in the writer is x1, x2, x3, x4, column c1 from the reader corresponds to column x1 in the writer. If the column sequence in the writer is x1, x2, x4, x3, columns c3 and c4 from the reader correspond to columns x4 and x3, respectively.

FAQ

Q: What is the proper number of concurrent threads? Can I increase the number of concurrent threads to improve the efficiency of importing data?

A: The default JVM heap size is 2 GB during the data import process. Concurrent tasks are executed by multiple threads. An excessively large number of threads may not improve the import efficiency, and may compromise the performance due to frequent garbage collection (GC). We recommend that you set the number of concurrent threads to 5 to 10.

Q: What is the proper value for the batchSize parameter?

A: The default value is 256. Set the batchSize parameter based on the data volume in each row. Typically, the data volume for each operation is about 2 MB to 4 MB. Divide this value by the data volume in the row, and set the batchSize parameter accordingly.

2.3.3.4.8. Configure HDFS Writer

This topic describes the data types and parameters supported by HDFS Writer and how to configure it by using the code editor.

HDFS Writer allows you to write text, Optimized Row Columnar (ORC), or Parquet files to the specified directory in Hadoop Distributed File System (HDFS). In addition, you can associate the fields in the files with those in Hive tables. You must configure a connection before configuring HDFS Writer. For more information, see Add HDFS data sources.

Synchronization process

HDFS Writer writes files to HDFS in the following way:

1. Creates a temporary directory that does not exist in HDFS based on the path parameter you specified.

   The name of the temporary directory is in the format of path_random suffix.

2. Writes files that are read by a Data Integration reader to the temporary directory.
3. After all the files are written, moves the files in the temporary directory to the specified directory in HDFS. HDFS Writer guarantees that the file names do not conflict with existing files in HDFS when moving the files.
4. Deletes the temporary directory. If the deletion is interrupted because HDFS Writer fails to connect to HDFS, you must manually delete the temporary directory and files that are written to the directory.

> **Note** To synchronize data, use an admin account with the read and write permissions.

Limits

- Currently, HDFS Writer can write only text, ORC, and Parquet files that store logical two-dimensional tables to HDFS.
- HDFS is a distributed file system and does not have a schema. Therefore, you cannot write only some columns in a file to HDFS.
- Currently, HDFS Writer supports only the following Hive data types:
  - Numeric: TINYINT, SMALLINT, INT, BIGINT, FLOAT, and DOUBLE
  - String: STRING, VARCHAR, and CHAR
  - Boolean: BOOLEAN
  - Date and time: DATE and TIMESTAMP
- Currently, HDFS Writer does not support other Hive data types, such as DECIMAL, BINARY, ARRAY, MAP, STRUCT, or UNION.
- HDFS Writer can write data to only one partition in a partitioned Hive table at a time.
- To write a text file to HDFS, make sure that the delimiter in the file is the same as that in the Hive table to be associated with the file. Otherwise, you cannot associate the fields in the file stored in HDFS with those in the Hive table.
- Currently, HDFS Writer can be used in the environment where Hive 1.1.1 and Hadoop 2.7.1 (JDK version: 1.7) are installed. HDFS Writer can write files to HDFS properly in testing environments where Hadoop 2.5.0, Hadoop 2.6.0, or Hive 1.2.0 is installed.

Data types

HDFS Writer supports most Hive data types. Make sure that your data types are supported.

The following table lists the Hive data types supported by HDFS Writer.

> **Note** The types of the specified columns must be the same as those of columns in the Hive table.

Category	Hive data type
Integer	TINYINT, SMALLINT, INT, and BIGINT
Floating point	FLOAT and DOUBLE
String	CHAR, VARCHAR, and STRING
Boolean	BOOLEAN
Date and time	DATE and TIMESTAMP

Parameters

Parameter	Description	Required	Default value
defaultFS	The address of the HDFS Namenode, such as `hdfs://127.0.0.1:9000`. The default resource group does not support configuring advanced Hadoop parameters related to the high availability feature.	Yes	None
fileType	The format of the files to be written to HDFS. Valid values: • *text*: the text file format. • *orc*: the ORC file format. • *parquet*: the common Parquet file format.	Yes	None
path	The directory in HDFS to which the files are written. HDFS Writer writes multiple files to the directory concurrently based on the concurrency setting. To associate the fields in a file with those in a Hive table, set the path parameter to the storage path of the Hive table in HDFS. Assume that the storage path specified for the data warehouse of Hive is `/user/hive/warehouse/`. The storage path of the hello table created in the test database is `/user/hive/warehouse/test.db/hello`.	Yes	None
fileName	The name prefix of the files to be written to HDFS. A random suffix is appended to the specified prefix to form the actual file name used by each thread.	Yes	None

Parameter	Description	Required	Default value
column	The columns to be written to HDFS. You cannot write only some of the columns in a file to HDFS. To associate the fields in a file with those in a Hive table, specify the name and type parameters for each field. You can also specify the column parameter in the following way: `"column": [ { "name": "userName", "type": "string" }, { "name": "age", "type": "long" } ]`	Yes (Not required if the filetype parameter is set to parquet.)	None
writeMode	The mode in which HDFS Writer writes the files. Valid values: • *append*: writes the files based on the specified file name prefix and guarantees that the actual file names do not conflict with those of existing files. • *nonConflict*: returns an error if a file with the specified file name prefix exists in the destination directory. **Note** Parquet files do not support the append mode. They support only the nonConflict mode.	Yes	None
fieldDelimiter	The column delimiter used in the files to be written to HDFS. Make sure that you use the same delimiter as that in the Hive table. Otherwise, you cannot query data in the Hive table.	Yes (Not required if the filetype parameter is set to parquet.)	None

Parameter	Description	Required	Default value
compress	The compression format of the files to be written to HDFS. By default, this parameter is left empty, that is, files are not compressed. For a text file, the GZIP and BZIP2 compression formats are supported. For an ORC file, the SNAPPY compression format is supported. To compress an ORC file, you must install SnappyCodec.	No	None
encoding	The encoding format of the files to be written to HDFS.	No	None

Parameter	Description	Required	Default value
parquetSchema	The schema of the files to be written to HDFS. This parameter is required only when the fileType parameter is set to parquet. Format: `message messageTypeName {` `required, dataType, columnName;` `.....;` `}` The parameters are described as follows: • messageTypeName: the name of the MessageType object. • required: specifies whether the field is required or optional. We recommend that you set the parameter to optional for all fields. • dataType: the type of the field. valid values: BOOLEAN, INT32, INT64, INT96, FLOAT, DOUBLE, BINARY, and FIXED_LEN_BYTE_ARRAY. Set this parameter to BINARY if the field stores strings. **Note** Each line, including the last one, must end with a semicolon (;). Example: `message m {` `optional int64 id;` `optional int64 date_id;` `optional binary datetimestring;` `optional int32 dspId;` `optional int32 advertiserId;` `optional int32 status;` `optional int64 bidding_req_num;` `optional int64 imp;` `optional int64 click_num;` `}`	No	None

Parameter	Description	Required	Default value
hadoopConfig	The advanced parameter settings of Hadoop, such as those related to high availability. The default resource group does not support configuring advanced Hadoop parameters related to the high availability feature. "hadoopConfig":{ "dfs.nameservices": "testDfs", "dfs.ha.namenodes.testDfs": "namenode1,namenode2", "dfs.namenode.rpc-address.youkuDfs.namenode1": "", "dfs.namenode.rpc-address.youkuDfs.namenode2": "", "dfs.client.failover.proxy.provider.testDfs": "org.apache.hadoop.hdfs.server.namenode.ha.ConfiguredFailoverProxyProvider" }	No	None
	The synchronization mode for Parquet files. If the dataxParquetMode parameter is set to fields, you can write data of complex types, such as ARRAY, MAP, and STRUCT. Valid values: fields and columns. If the dataxParquetMode parameter is set to fields, HDFS Writer supports HDFS over Object Storage Service (OSS). That is, HDFS uses OSS as the storage service and HDFS Writer writes Parquet files to OSS. In this case, you can add the following OSS-related parameters in the hadoopConfig parameter: • fs.oss.accessKeyId: the AccessKey ID for accessing OSS. • fs.oss.accessKeySecret: the AccessKey secret for accessing OSS. • fs.oss.endpoint: the endpoint for accessing OSS. Example:		

Parameter	Description	Required	Default value
dataxParquetMode	```json "writer": { "name": "hdfswriter", "parameter": { "defaultFS": "oss://test-bucket", "fileType": "parquet", "path": "/datasets/oss_demo/kpt", "fileName": "test", "writeMode": "truncate", "compress": "SNAPPY", "encoding": "UTF-8", "hadoopConfig": { "fs.oss.accessKeyId": "the-access-id", "fs.oss.accessKeySecret": "the-access-key", "fs.oss.endpoint": "oss-cn-hangzhou.aliyuncs.com" }, "parquetSchema": "message test {\n required int64 id;\n optional binary name (UTF8);\n optional int64 gmt_create;\n required group map_col (MAP) {\n repeated group key_value {\n required binary key (UTF8);\n required binary value (UTF8);\n }\n }\n required group array_col (LIST) {\n repeated group list {\n required binary element (UTF8);\n }\n }\n required group struct_col {\n required int64 id;\n required binary name (UTF8);\n } \n}", "dataxParquetMode": "fields" } } ```	No	*columns*

Parameter	Description	Required	Default value
haveKerberos	Specifies whether Kerberos authentication is required. Default value: *false*.	If you set this parameter to *true*, you must also set the kerberosKeytabFilePath and kerberosPrincipal parameters.	*false*
kerberosKeytabFilePath	The absolute path of the keytab file for Kerberos authentication.	Required if the haveKerberos parameter is set to true	None
kerberosPrincipal	The Kerberos principal to which Kerberos can assign tickets. Example: ****/hadoopclient@**.***. **Note** The absolute path of the keytab file is required for Kerberos authentication. Therefore, you can configure Kerberos authentication only on a custom resource group. Example: `"haveKerberos":true, "kerberosKeytabFilePath":"/opt/datax/**.keytab", "kerberosPrincipal":"**/hadoopclient@**.**"`	Required if the haveKerberos parameter is set to true	None

Configure HDFS Writer by using the codeless UI

Currently, the codeless user interface (UI) is not supported for HDFS Writer.

Configure HDFS Writer by using the code editor

In the following code, a node is configured to write files to HDFS. For more information about the parameters, see the preceding parameter description.

```
{
  "type": "job",
  "version": "2.0",// The version number.
  "steps": [
    {
      "stepType": "stream",
      "parameter": {},
      "name": "Reader",
      "category": "reader"
    },
    {
      "stepType": "hdfs",// The writer type.
      "parameter": {
        "path": "",// The directory in HDFS to which the files are written.
        "fileName": "",// The name prefix of the files to be written to HDFS.
        "compress": "",// The compression format of the files.
        "datasource": "",// The connection name.
        "column": [
          {
            "name": "col1",// The name of the column.
            "type": "string"// The data type of the column.
          },
          {
            "name": "col2",
            "type": "int"
          },
          {
            "name": "col3",
            "type": "double"
          },
          {
            "name": "col4",
            "type": "boolean"
          },
          {
            "name": "col5",
            "type": "date"
          }
        ]
```

```
            ],
            "writeMode": "",// The write mode.
            "fieldDelimiter": ",",// The column delimiter.
            "encoding": "",// The encoding format.
            "fileType": "text"// The file format.
        },
        "name": "Writer",
        "category": "writer"
    }
  ],
  "setting": {
    "errorLimit": {
      "record": ""// The maximum number of dirty data records allowed.
    },
    "speed": {
      "concurrent": 3,// The maximum number of concurrent threads.
      "throttle": false,// Specifies whether to enable bandwidth throttling. A value of false indicates that the bandwidth is not throttled. A value of true indicates that the bandwidth is throttled. The maximum transmission rate takes effect only if you set this parameter to true.
    }
  },
  "order": {
    "hops": [
      {
        "from": "Reader",
        "to": "Writer"
      }
    ]
  }
}
```

2.3.3.4.9. Configure MaxCompute Writer

This topic describes the data types and parameters supported by MaxCompute Writer and how to configure it by using the codeless user interface (UI) and code editor.

MaxCompute Writer is designed for developers to insert data to or update data in MaxCompute. MaxCompute Writer is suitable for importing data of the GB or TB level to MaxCompute.

> **Note** You must configure a connection before configuring MaxCompute Writer. For more information, see Add MaxCompute data sources.

Based on the specified information such as the source project, table, partition, and field, MaxCompute Writer writes data to MaxCompute through a tunnel.

Data types

The following table lists the data types supported by MaxCompute Writer.

Category	MaxCompute data type
Integer	BIGINT
Floating point	DOUBLE and DECIMAL
String	STRING
Date and time	DATETIME
Boolean	BOOLEAN

Parameters

Parameter	Description	Required	Default value
datasource	The connection name. It must be identical to the name of the added connection. You can add connections in the code editor.	Yes	None
table	The name of the destination table. The name is case-insensitive. You can specify only one table as the destination table.	Yes	None
partition	The partition to which data is written. The last-level partition must be specified. For example, if you want to write data to a three-level partitioned table, set the partition parameter to a value that contains the last-level partition information, such as `pt=20150101, type=1, biz=2`. • To write data to a non-partitioned table, do not set this parameter. The data is directly written to the destination table. • MaxCompute Writer does not support writing data based on the partition route. To write data to a partitioned table, make sure that data is written to the last-level partition.	Required only for writing data to a partitioned table	None

Parameter	Description	Required	Default value
column	The columns in the destination table to which data is written. Set the value to an asterisk (*) if data is written to all the columns in the destination table. That is, set the column parameter as follows: `"column":["*"]`. Set the value to the specified columns if data is written to only some of the columns in the destination table. Separate the columns with a comma (,). Example: `"column": ["id","name"]`. • MaxCompute Writer supports filtering columns and changing the order of columns. For example, a MaxCompute table has three columns: a, b, and c. If you want to write data only to column c and column b, you can set the column parameter as follows: `"column": ["c","b"]`. During data synchronization, column a is automatically set to null. • The column parameter must explicitly specify a set of columns to which data is written. The parameter cannot be left empty.	Yes	None
truncate	To guarantee the idempotence of write operations, set the value to true. That is, set the truncate parameter as follows: `"truncate": "true"`. When a failed sync node is rerun due to a write failure, MaxCompute Writer deletes the data that has been written before importing the source data again. This guarantees that the same data is written for each rerun. MaxCompute Writer uses MaxCompute SQL to delete data. MaxCompute SQL cannot guarantee the atomicity. Therefore, the truncation operation is not an atomic operation. Conflicts may occur when concurrent nodes delete data from the same table or partition. To avoid this issue, we recommend that you do not run concurrent Data Definition Language (DDL) nodes to operate the same partition. You can create different partitions for nodes that need to run concurrently.	Yes	None

Configure MaxCompute Writer by using the codeless UI

1. Configure the connections.

   Configure the source and destination connections for the sync node.

Parameter	Description
Connection	The datasource parameter in the preceding parameter description. Select a connection type, and enter the name of a connection that has been configured in DataWorks.
Table	The table parameter in the preceding parameter description.

Parameter	Description
Partition Key Column	To write data to all the columns in the destination table, enter "column": ["*"]. The partition parameter supports wildcards and includes one or more partitions. ○ `"partition":"pt=20140501/ds=*"` specifies that data is written to all partitions in the ds partition. ○ `"partition":"pt=top?"` specifies that data is written to the partitions with pt=top and pt=to. You can specify the partition key columns to which data is written, such as a partition key column named pt. Assume that the partition key column of a MaxCompute table is pt=${bdp.system.bizdate}. You can configure the column to which data is written to pt. Ignore it if the column is marked as unidentified. To write data to all partitions, set pt=${*}. To write data to some of the partitions, specify the corresponding dates.
Writing Rule	○ Write with Original Data Deleted (Insert Overwrite): All data in the table or partition is deleted before data import. This rule is equivalent to the INSERT OVERWRITE statement. ○ Write with Original Data Retained (Insert Into): No data is deleted before data import. New data is always appended with each run. This rule is equivalent to the INSERT INTO statement.
Compression	Default value: Disable.
Convert Empty Strings to Null	Default value: Yes.

2. Configure field mapping, that is, the column parameter in the preceding parameter description.

   Fields in the source table on the left have a one-to-one mapping with fields in the destination table on the right.

Operation	Description
Map Fields with the Same Name	Click **Map Fields with the Same Name** to establish a mapping between fields with the same name. Note that the data types of the fields must match.
Map Fields in the Same Line	Click **Map Fields in the Same Line** to establish a mapping for fields in the same row. Note that the data types of the fields must match.
Delete All Mappings	Click **Delete All Mappings** to remove mappings that have been established.
Auto Layout	Click Auto Layout. The fields are automatically sorted based on specified rules.

3. Configure channel control policies.

Configure MaxCompute Writer by using the code editor

In the following code, a node is configured to write data to a MaxCompute table. For more information about the parameters, see the preceding parameter description.

```
{
  "type":"job",
  "version":"2.0",// The version number.
  "steps":[
    {
      "stepType":"stream",
      "parameter":{},
      "name":"Reader",
      "category":"reader"
    },
    {
      "stepType":"odps",// The writer type.
      "parameter":{
        "partition":"",// The partition information
        "truncate":true,// The writing rule.
        "compress":false,// Specifies whether to enable compression.
        "datasource":"odps_first",// The connection name.
      "column": [// The columns to which data is written.
        "id",
        "name",
        "age",
        "sex",
        "salary",
        "interest"
        ],
        "emptyAsNull":false,// Specifies whether to convert empty strings to null.
        "table":""// The name of the destination table.
      },
      "name":"Writer",
      "category":"writer"
    }
  ],
  "setting":{
    "errorLimit":{
      "record":"0"// The maximum number of dirty data records allowed.
    },
    "speed":{
```

```
        "throttle":false,// Specifies whether to enable bandwidth throttling. A value of false indicates that the bandwidth is not throttled. A value of true indicates that the bandwidth is throttled. The maximum transmission rate takes effect only if you set this parameter to true.
        "concurrent":1,// The maximum number of concurrent threads.
      }
    },
    "order":{
      "hops":[
        {
          "from":"Reader",
          "to":"Writer"
        }
      ]
    }
}
```

Additional instructions

- Column filter

  By configuring MaxCompute Writer, you can perform operations that MaxCompute does not support, such as filtering columns, reordering columns, and setting empty fields to null. To write data to all the columns in the destination table, set the column parameter as follows: `"column": ["*"]`.

  For example, a MaxCompute table has three columns: a, b, and c. If you want to write data only to column c and column b, you can set the column parameter as follows: `"column": ["c","b"]`. The first column and the second column of the source data are written to column c and column b in the MaxCompute table respectively. During data synchronization, column a is automatically set to null.

- Column configuration error handling

  To avoid losing the data of redundant columns and guarantee high data reliability, MaxCompute Writer returns an error message if more columns are to be written than expected. For example, a MaxCompute table has three columns: a, b, and c. MaxCompute Writer returns an error message if it is configured to write data to more than three columns.

- Partition configuration

  MaxCompute Writer can only write data to the last-level partition, and does not support writing data to the specified partition based on a field. To write data to a partitioned table, specify the last-level partition. For example, if you want to write data to a three-level partitioned table, set the partition parameter to a value that contains the last-level partition information, such as `pt=20150101, type=1, biz=2`. The data cannot be written if you set the partition parameter to `pt=20150101, type=1` or `pt=20150101`.

- Node rerunning

To guarantee the idempotence of write operations, set the `truncate` parameter to true. When a failed sync node is rerun due to a write failure, MaxCompute Writer deletes the data that has been written before importing the source data again. This guarantees that the same data is written for each rerun. If a sync node is interrupted due to other exceptions, the data cannot be rolled back and the node cannot be rerun automatically. By setting the truncate parameter to true, you can guarantee the idempotence of write operations and the data integrity.

> **Note** If the truncate parameter is set to true, all data of the specified partition or table is deleted before a rerun. Exercise caution when you set this parameter to true.

2.3.3.4.10. Configure Memcache Writer

This topic describes the data types and parameters supported by Memcache Writer and how to configure it by using the code editor.

ApsaraDB for Memcache is a distributed in-memory database service with high performance, reliability, and scalability. Based on the Apsara distributed operating system and high-performance storage technologies, ApsaraDB for Memcache provides a complete database solution with hot standby, fault recovery, business monitoring, and data migration features.

ApsaraDB for Memcache is immediately available after an instance is created. It relieves the load on databases from dynamic websites and applications by caching data in the memory and therefore improves the response speed of websites and applications.

Same as user-created Memcached databases, ApsaraDB for Memcache is compatible with the Memcached protocol. ApsaraDB for Memcache can be directly used in your environments. The difference is that the data, hardware infrastructure, network security, and system maintenance services used by ApsaraDB for Memcache are all deployed on the cloud.

Memcache Writer writes data to ApsaraDB for Memcache databases based on the Memcached protocol.

Currently, Memcache Writer writes data only in text format. The method of converting data types varies with the format of writing data.

- text: Memcache Writer uses the specified column delimiter to serialize source data to a string.
- binary: Currently, this format is not supported.

Parameters

Parameter	Description	Required	Default value
datasource	The connection name. It must be identical to the name of the added connection. You can add connections in the code editor.	Yes	None

Parameter	Description	Required	Default value
writeMode	The write mode. Valid values: • *set*: stores the source data. • *add*: stores the source data only when its key does not exist in the destination ApsaraDB for Memcache database. Currently, this mode is not supported. • *replace*: uses the source data to replace the data record with the same key in the destination ApsaraDB for Memcache database. Currently, this mode is not supported. • *append*: adds the value of the source data to the end of the value of an existing data record with the same key in the destination ApsaraDB for Memcache database, but does not update the expiration time of the existing data record. Currently, this mode is not supported. • *prepend*: adds the value of the source data to the beginning of the value of an existing data record with the same key in the destination ApsaraDB for Memcache database, but does not update the expiration time of the existing data record. Currently, this mode is not supported.	Yes	None
writeFormat	The format in which Memcache Writer writes the source data. Currently, only the text format is supported. text: serialize the source data to the text format. Memcache Writer uses the first column of the source data as the key and serializes the subsequent columns to the value by using the specified delimiter. Then, Memcache Writer writes the key-value pair to ApsaraDB for Memcache. For example, the source data is as follows: |ID |NAME |COUNT| |---- |:------|:-----| |23 |"CDP" |100 | If you set the column delimiter to a backslash and a caret (\^), data is written to ApsaraDB for Memcache in the following format: |KEY (OCS) |VALUE(OCS) | |--------- |:---------- | |23 |CDP\^100 |	No	None

Parameter	Description	Required	Default value
expireTime	The expiration time of the source data to be cached in ApsaraDB for Memcache. Currently, ApsaraDB for Memcache supports the following two types of expiration time: • unixtime: the UNIX timestamp, indicating that data is invalid at a certain time point in the future. The UNIX timestamp represents the number of seconds that have elapsed since 00:00:00 on January 1, 1970. • seconds: the relative time in seconds starting from the current time point. It specifies the time range during which data is valid. **Note** If the specified expiration time is larger than 30 days, the server identifies the time as the UNIX timestamp.	No	*0*, indicating that the data never expires
batchSize	The number of data records to write at a time. Setting this parameter can greatly reduce the interactions between Data Integration and the ApsaraDB for Memcache database over the network, and increase the throughput. However, an excessively large value may lead to the out of memory (OOM) error during the data synchronization process.	No	*1024*

Configure Memcache Writer by using the codeless UI

Currently, the codeless user interface (UI) is not supported for Memcache Writer.

Configure Memcache Writer by using the code editor

In the following code, a node is configured to write data to an ApsaraDB for Memcache database.

```
{
  "type":"job",
  "version":"2.0",// The version number.
  "steps":[
    {
      "stepType":"stream",
      "parameter":{},
      "name":"Reader",
      "category":"reader"
    },
    {
      "stepType":"ocs",// The writer type.
      "parameter":{
        "writeFormat":"text",// The format in which Memcache Writer writes the source data.
        "expireTime":1000,// The expiration time of the source data to be cached in ApsaraDB for Memcache.
        "indexes":0,
```

```
            "datasource":"",// The connection name.
            "writeMode":"set",// The write mode.
            "batchSize":"256"// The number of data records to write at a time.
        },
        "name":"Writer",
        "category":"writer"
      }
    ],
    "setting":{
      "errorLimit":{
        "record":"0"// The maximum number of dirty data records allowed.
      },
      "speed":{
        "throttle":false,// Specifies whether to enable bandwidth throttling. A value of false indicates that the
bandwidth is not throttled. A value of true indicates that the bandwidth is throttled. The maximum transmi
ssion rate takes effect only if you set this parameter to true.
        "concurrent":1,// The maximum number of concurrent threads.
      }
    },
    "order":{
      "hops":[
        {
          "from":"Reader",
          "to":"Writer"
        }
      ]
    }
}
```

2.3.3.4.11. Configure MongoDB Writer

This topic describes the data types and parameters supported by MongoDB Writer and how to configure it by using the code editor.

MongoDB Writer connects to a remote MongoDB database by using the Java client named MongoClient and writes data to the database. The latest version of MongoDB has improved the locking feature from database locks to document locks. With the powerful functionalities of indexes in MongoDB, MongoDB Writer can efficiently write data to MongoDB databases. If you want to update data, specify the primary key.

> **Note**
>
> - You must configure a connection before configuring MongoDB Writer. For more information, see Add a MongoDB connection.
> - If you use ApsaraDB for MongoDB, the MongoDB database has a root account by default.
> - For security concerns, Data Integration only supports access to a MongoDB database by using a MongoDB database account. When adding a MongoDB connection, do not use the root account for access.

MongoDB Writer obtains data from a Data Integration reader, and converts the data types to those supported by MongoDB. Data Integration does not support arrays. MongoDB supports arrays and the array index is useful.

To use MongoDB arrays, you can convert strings to MongoDB arrays by configuring a parameter and write the arrays to a MongoDB database.

Data types

MongoDB Writer supports most MongoDB data types. Make sure that your data types are supported.

The following table lists the data types supported by MongoDB Writer.

Category	MongoDB data type
Integer	Int and Long
Floating point	Double
String	String and Array
Date and time	Date
Boolean	Boolean
Binary	Bytes

> **Note** When data of the Date type is written to a MongoDB database, the type of the data is converted to Datetime.

Parameters

Parameter	Description	Required	Default value
datasource	The connection name. It must be identical to the name of the added connection. You can add connections in the code editor.	Yes	None
collectionName	The name of the MongoDB collection.	Yes	None

Parameter	Description	Required	Default value
column	The columns in MongoDB. • name: the name of the column. • type: the data type of the column. • splitter: the delimiter. Specify this field only when you want to convert the string to an array. The string is split based on the specified delimiter, and the split strings are saved in a MongoDB array.	Yes	None
writeMode	Specifies whether to overwrite data. • isReplace: If you set this parameter to true, MongoDB Writer overwrites the data in the destination table with the same primary key. If you set this parameter to false, the data is not overwritten. • replaceKey: the primary key for each record. Data is overwritten based on this primary key. The primary key must be unique.	No	None

Parameter	Description	Required	Default value
preSql	The action to perform before the sync node is run. For example, you can clear outdated data before data synchronization. If the preSql parameter is left empty, no action is performed before data synchronization. Make sure that the value of the preSql parameter complies with the JSON syntax. The format requirements for the preSql parameter are as follows: • Configure the type field to specify the action type. Valid values: drop and remove. Example: `"preSql":{"type":"remove"}`. ◦ *drop*: deletes the collection specified by the collectionName parameter and the data in the collection. ◦ *remove*: deletes data based on conditions. ◦ *json*: the conditions for deleting data. Example: `"preSql":{"type":"remove", "json":"{'operationTime':{'$gte':ISODate('${last_day}T00:00:00.424+0800')}}"}`. In the preceding JSON string, `${last_day}` is a scheduling parameter of DataWorks. The format is `$[yyyy-mm-dd]`. You can use comparison operators (such as $gt, $lt, $gte, and $lte), logical operators (such as $and and $or), and functions (such as max, min, sum, avg, and ISODate) supported by MongoDB as needed. For more information, see the MongoDB query syntax. Data Integration uses the following standard MongoDB API to query and delete the specified data: `query=(BasicDBObject) com.mongodb.util.JSON.parse(json);` `col.deleteMany(query);` Note If you want to delete data based on conditions, we recommend that you specify the conditions in JSON format preferentially. ◦ *item*: the name, condition, and value for filtering data. Example: `"preSql":{"type":"remove","item":[{"name":"pv","value":"100","condition":"$gt"},{"name":"pid","value":"10"}]}`. Data Integration sets query conditions based on the value of the item field and deletes data through the standard MongoDB API. Example: `col.deleteMany(query);`. • If the value of the preSql parameter cannot be recognized, no action is performed.	No	None

Configure MongoDB Writer by using the codeless UI

Currently, the codeless user interface (UI) is not supported for MongoDB Writer.

Configure MongoDB Writer by using the code editor

In the following code, a node is configured to write data to a MongoDB database. For more information about the parameters, see the preceding parameter description.

```
{
  "type": "job",
  "version": "2.0",// The version number.
  "steps": [
    {
      "stepType": "stream",
      "parameter": {},
      "name": "Reader",
      "category": "reader"
    },
    {
      "stepType": "mongodb",// The writer type.
      "parameter": {
        "datasource": "",// The connection name.
        "column": [
          {
            "name": "_id",// The name of the column to which data is written.
            "type": "ObjectId"// The data type of the column to which data is written. If the replacekey parameter is set to _id, set the type parameter to ObjectId. If you set the type parameter to String, the data cannot be overwritten.
          },
          {
            "name": "age",
            "type": "int"
          },
          {
            "name": "id",
            "type": "long"
          },
          {
            "name": "wealth",
            "type": "double"
          },
          {
            "name": "hobby",
            "type": "array",
```

```
            "splitter": " "
          },
          {
            "name": "valid",
            "type": "boolean"
          },
          {
            "name": "date_of_join",
            "format": "yyyy-MM-dd HH:mm:ss",
            "type": "date"
          }
        ],
        "writeMode": {// The write mode.
          "isReplace": "true",
          "replaceKey": "_id"
        },
        "collectionName": "datax_test"// The name of the MongoDB collection.
      },
      "name": "Writer",
      "category": "writer"
    }
  ],
  "setting": {
    "errorLimit": {// The maximum number of dirty data records allowed.
      "record": "0"
    },
    "speed": {
      "jvmOption": "-Xms1024m -Xmx1024m",
      "throttle": true,// Specifies whether to enable bandwidth throttling. A value of false indicates that the bandwidth is not throttled. A value of true indicates that the bandwidth is throttled. The maximum transmission rate takes effect only if you set this parameter to true.
      "concurrent": 1,// The maximum number of concurrent threads.
      "mbps": "1"// The maximum transmission rate.
    }
  },
  "order": {
    "hops": [
      {
        "from": "Reader",
        "to": "Writer"
```

```
      }
    ]
  }
}
```

2.3.3.4.12. Configure MySQL Writer

This topic describes the data types and parameters supported by MySQL Writer and how to configure it by using the codeless user interface (UI) and code editor.

MySQL Writer allows you to write data to tables stored in MySQL databases. Specifically, MySQL Writer connects to a remote MySQL database through Java Database Connectivity (JDBC), and runs an `INSERT INTO` or `REPLACE INTO` statement to write data to the MySQL database. MySQL uses the InnoDB engine so that data is written to the database in batches.

> **Note**
> - You must configure a connection before configuring MySQL Writer. For more information, see Add MySQL data sources.
> - Currently, MySQL Writer does not support MySQL 8.0 or later.

MySQL Writer can be used as a data migration tool by users such as database administrators (DBAs). MySQL Writer obtains data from a Data Integration reader, and writes the data to the destination database based on value of the writeMode parameter.

> **Note** A sync node that uses MySQL Writer must have at least the permission to run the `INSERT INTO or REPLACE INTO` statement. Whether other permissions are required depends on the SQL statements specified in the preSql and postSql parameters when you configure the node.

Data types

MySQL Writer supports most MySQL data types. Make sure that your data types are supported.

The following table lists the data types supported by MySQL Writer.

Category	MySQL data type
Integer	INT, TINYINT, SMALLINT, MEDIUMINT, BIGINT, and YEAR
Floating point	FLOAT, DOUBLE, and DECIMAL
String	VARCHAR, CHAR, TINYTEXT, TEXT, MEDIUMTEXT, and LONGTEXT
Date and time	DATE, DATETIME, TIMESTAMP, and TIME
Boolean	BOOLEAN
Binary	TINYBLOB, MEDIUMBLOB, BLOB, LONGBLOB, and VARBINARY

Parameters

Parameter	Description	Required	Default value
datasource	The connection name. It must be identical to the name of the added connection. You can add connections in the code editor.	Yes	None
table	The name of the destination table.	Yes	None
writeMode	The write mode. Valid values: *insert into*, *on duplicate key update*, and *replace into*. • *insert into*: If a primary key conflict or unique index conflict occurs, data cannot be written to the conflicting rows and is regarded as dirty data. • *on duplicate key update*: If no primary key conflict or unique index conflict occurs, the action is the same as that of `insert into`. If a conflict occurs, specified fields in original rows are updated. • *replace into*: If no primary key conflict or unique index conflict occurs, the action is the same as that of `insert into`. If a conflict occurs, original rows are deleted and new rows are inserted. That is, all fields of original rows are replaced.	No	*insert*
column	The columns in the destination table to which data is written. Separate the columns with a comma (,). Example: `"column": ["id", "name", "age"]`. Set the value to an asterisk (*) if data is written to all the columns in the destination table. That is, set the column parameter as follows: `"column":["*"]`.	Yes	None
preSql	The SQL statement to run before the sync node is run. For example, you can clear outdated data before data synchronization. Currently, you can run only one SQL statement on the codeless UI, and multiple SQL statements in the code editor. **Note** If you specify multiple SQL statements in the code editor, the system does not guarantee that they are run in the same transaction.	No	None
postSql	The SQL statement to run after the sync node is run. For example, you can add a timestamp after data synchronization. Currently, you can run only one SQL statement on the codeless UI, and multiple SQL statements in the code editor. **Note** If you specify multiple SQL statements in the code editor, the system does not guarantee that they are run in the same transaction.	No	None

Parameter	Description	Required	Default value
batchSize	The number of data records to write at a time. Setting this parameter can greatly reduce the interactions between Data Integration and the MySQL database over the network, and increase the throughput. However, an excessively large value may lead to the out of memory (OOM) error during the data synchronization process.	No	*1024*

Configure MySQL Writer by using the codeless UI

1. Configure the connections.

   Configure the source and destination connections for the sync node.

Parameter	Description
Connection	The datasource parameter in the preceding parameter description. Select a connection type, and enter the name of a connection that has been configured in DataWorks.
Table	The table parameter in the preceding parameter description.
Statement Run Before Writing	The preSql parameter in the preceding parameter description. Enter an SQL statement to run before the sync node is run.
Statement Run After Writing	The postSql parameter in the preceding parameter description. Enter an SQL statement to run after the sync node is run.
Solution to Primary Key Violation	The writeMode parameter in the preceding parameter description. Select the expected write mode.

2. Configure field mapping, that is, the column parameter in the preceding parameter description.

   Fields in the source table on the left have a one-to-one mapping with fields in the destination table on the right.

Operation	Description
Map Fields with the Same Name	Click **Map Fields with the Same Name** to establish a mapping between fields with the same name. Note that the data types of the fields must match.
Map Fields in the Same Line	Click **Map Fields in the Same Line** to establish a mapping for fields in the same row. Note that the data types of the fields must match.
Delete All Mappings	Click **Delete All Mappings** to remove mappings that have been established.
Auto Layout	Click Auto Layout. The fields are automatically sorted based on specified rules.

3. Configure channel control policies.

Configure MySQL Writer by using the code editor

In the following code, a node is configured to write data to a MySQL database. For more information about the parameters, see the preceding parameter description.

```
{
  "type":"job",
  "version":"2.0",// The version number.
  "steps":[
    {
      "stepType":"stream",
      "parameter":{},
      "name":"Reader",
      "category":"reader"
    },
    {
      "stepType":"mysql",// The writer type.
      "parameter":{
        "postSql":[],// The SQL statement to run after the sync node is run.
        "datasource":"",// The connection name.
        "column":[// The columns to which data is written.
          "id",
          "value"
        ],
        "writeMode":"insert",// The write mode.
        "batchSize":1024,// The number of data records to write at a time.
        "table":"",// The name of the destination table.
        "preSql":[]// The SQL statement to run before the sync node is run.
      },
      "name":"Writer",
      "category":"writer"
    }
  ],
  "setting":{
    "errorLimit":{// The maximum number of dirty data records allowed.
      "record":"0"
    },
    "speed":{
      "throttle":false,// Specifies whether to enable bandwidth throttling.
      "concurrent":1,// The maximum number of concurrent threads.
    }
  },
```

```
  "order":{
    "hops":[
      {
        "from":"Reader",
        "to":"Writer"
      }
    ]
  }
}
```

2.3.3.4.13. Configure Oracle Writer

This topic describes the data types and parameters supported by Oracle Writer and how to configure it by using the codeless user interface (UI) and code editor.

Oracle Writer allows you to write data to tables stored in primary Oracle databases. Specifically, Oracle Writer connects to a remote Oracle database through Java Database Connectivity (JDBC), and runs an `INSERT INTO` statement to write data to the Oracle database.

> **Note** You must configure a connection before configuring Oracle Writer. For more information, see Add Oracle data sources.

Oracle Writer is designed for extract-transform-load (ETL) developers to import data from data warehouses to Oracle databases. Oracle Writer can also be used as a data migration tool by users such as database administrators (DBAs).

Oracle Writer obtains data from a Data Integration reader, connects to a remote Oracle database through JDBC, and then runs an SQL statement to write data to the Oracle database.

Data types

Oracle Writer supports most Oracle data types. Make sure that your data types are supported.

The following table lists the data types supported by Oracle Writer.

Category	Oracle data type
Integer	NUMBER, ROWID, INTEGER, INT, and SMALLINT
Floating point	NUMERIC, DECIMAL, FLOAT, DOUBLE PRECISION, and REAL
String	LONG, CHAR, NCHAR, VARCHAR, VARCHAR2, NVARCHAR2, CLOB, NCLOB, CHARACTER, CHARACTER VARYING, CHAR VARYING, NATIONAL CHARACTER, NATIONAL CHAR, NATIONAL CHARACTER VARYING, NATIONAL CHAR VARYING, and NCHAR VARYING
Date and time	TIMESTAMP and DATE
Boolean	BIT and BOOLEAN

Category	Oracle data type
Binary	BLOB, BFILE, RAW, and LONG RAW

Parameters

Parameter	Description	Required	Default value
datasource	The connection name. It must be identical to the name of the added connection. You can add connections in the code editor.	Yes	None
table	The name of the destination table.	Yes	None
writeMode	The write mode. Valid values: *insert into*, *on duplicate key update*, and *replace into*. • *insert into*: If a primary key conflict or unique index conflict occurs, data cannot be written to the conflicting rows and is regarded as dirty data. • *on duplicate key update*: If no primary key conflict or unique index conflict occurs, the action is the same as that of `insert into`. If a conflict occurs, specified fields in original rows are updated. • *replace into*: If no primary key conflict or unique index conflict occurs, the action is the same as that of `insert into`. If a conflict occurs, original rows are deleted and new rows are inserted. That is, all fields of original rows are replaced.	No	*insert*
column	The columns in the destination table to which data is written. Separate the columns with a comma (,). Example: `"column": ["id","name","age"]`. Set the value to an asterisk (*) if data is written to all the columns in the destination table. That is, set the column parameter as follows: `"column":["*"]`.	Yes	None
preSql	The SQL statement to run before the sync node is run. For example, you can clear outdated data before data synchronization. Currently, you can run only one SQL statement on the codeless UI, and multiple SQL statements in the code editor.	No	None
postSql	The SQL statement to run after the sync node is run. For example, you can add a timestamp after data synchronization. Currently, you can run only one SQL statement on the codeless UI, and multiple SQL statements in the code editor.	No	None
batchSize	The number of data records to write at a time. Setting this parameter can greatly reduce the interactions between Data Integration and the Oracle database over the network, and increase the throughput. However, an excessively large value may lead to the out of memory (OOM) error during the data synchronization process.	No	*1024*

Configure Oracle Writer by using the codeless UI

1. Configure the connections.

   Configure the source and destination connections for the sync node.

Parameter	Description
Connection	The datasource parameter in the preceding parameter description. Select a connection type, and enter the name of a connection that has been configured in DataWorks.
Table	The table parameter in the preceding parameter description.
Statement Run Before Writing	The preSql parameter in the preceding parameter description. Enter an SQL statement to run before the sync node is run.
Statement Run After Writing	The postSql parameter in the preceding parameter description. Enter an SQL statement to run after the sync node is run.
Solution to Primary Key Violation	The writeMode parameter in the preceding parameter description. Select the expected write mode.

2. Configure field mapping, that is, the column parameter in the preceding parameter description.

   Fields in the source table on the left have a one-to-one mapping with fields in the destination table on the right.

Operation	Description
Map Fields with the Same Name	Click **Map Fields with the Same Name** to establish a mapping between fields with the same name. Note that the data types of the fields must match.
Map Fields in the Same Line	Click **Map Fields in the Same Line** to establish a mapping for fields in the same row. Note that the data types of the fields must match.
Delete All Mappings	Click **Delete All Mappings** to remove mappings that have been established.
Auto Layout	Click Auto Layout. The fields are automatically sorted based on specified rules.

3. Configure channel control policies.

Configure Oracle Writer by using the code editor

In the following code, a node is configured to write data to an Oracle database.

```
{
  "type":"job",
  "version":"2.0",// The version number.
  "steps":[
    {
      "stepType":"stream",
```

```
      "parameter":{},
      "name":"Reader",
      "category":"reader"
    },
    {
      "stepType":"oracle",// The writer type.
      "parameter":{
        "postSql":[],// The SQL statement to run after the sync node is run.
        "datasource":"",
        "session": [], // The settings of the session to the database.
        "column":[// The columns to which data is written.
          "id",
          "name"
        ],
        "encoding":"UTF-8",// The encoding format.
        "batchSize":1024,// The number of data records to write at a time.
        "table":"",// The name of the destination table.
        "preSql":[]// The SQL statement to run before the sync node is run.
      },
      "name":"Writer",
      "category":"writer"
    }
  ],
  "setting":{
    "errorLimit":{
      "record":"0"// The maximum number of dirty data records allowed.
    },
    "speed":{
      "throttle":false,// Specifies whether to enable bandwidth throttling. A value of false indicates that the bandwidth is not throttled. A value of true indicates that the bandwidth is throttled. The maximum transmission rate takes effect only if you set this parameter to true.
      "concurrent":1, // The maximum number of concurrent threads.
    }
  },
  "order":{
    "hops":[
      {
        "from":"Reader",
        "to":"Writer"
      }
    ]
```

```
  }
}
```

2.3.3.4.14. Configure OSS Writer

This topic describes the data types and parameters supported by OSS Writer and how to configure it by using the codeless user interface (UI) and code editor.

OSS Writer allows you to write one or more CSV-like files to Object Storage Service (OSS).

> **Note** You must configure a connection before configuring OSS Writer. For more information, see Add OSS data sources.

OSS Writer can write files that store logical two-dimensional tables, such as CSV files that store text data, to OSS.

OSS Writer allows you to convert data obtained from a Data Integration reader to files and write the files to OSS. The OSS files store unstructured data only. Currently, OSS Writer supports the following features:

- Writes only files that store text data. The text data must be logical two-dimensional tables.
- Writes CSV-like files with custom delimiters.
- Uses concurrent threads to write files. Each thread writes a file.
- Supports file rotation. OSS Writer can write data to another file when the size of the current file exceeds a specific value. OSS Writer can also write data to another object when the number of rows in the current file exceeds a specific value.

Currently, OSS Writer does not support the following features:

- Uses concurrent threads.to write a single file.
- Distinguishes between data types. OSS does not distinguish between data types. Therefore, FTP Writer writes all data as strings to files in OSS.

The following table lists the data types supported by OSS Writer.

Category	Data type
Integer	Long
Floating point	Double
String	String
Boolean	Boolean
Date and time	Date

Parameters

Parameter	Description	Required	Default value
datasource	The connection name. It must be identical to the name of the added connection. You can add connections in the code editor.	Yes	None
object	The name prefix of the files to be written to OSS as objects. OSS simulates the directory effect by adding separators to object names. You can set the object parameter as follows: • `"object": "datax"` : The names of the files start with datax, which is followed by a random string as the suffix. • `"object": "cdo/datax"` : The names of the files start with `/cdo/datax` , which is followed by a random string as the suffix. OSS uses backslashes (/) in objects to simulate the directory effect. If you do not want to add a random universally unique identifier (UUID) as the suffix, we recommend that you set the writeSingleObject parameter to `true` .	Yes	None
writeMode	The mode in which OSS Writer writes the files. Valid values: • *truncate*: deletes all existing objects with the specified object name prefix before writing files to OSS. For example, if you set the object parameter to `abc` , all objects whose names start with abc are deleted. • *append*: writes data to OSS objects based on the object names and guarantees that no duplicate object names exist by using a random UUID as the suffix. writes the files based on the specified object name prefix and guarantees that the actual file names do not conflict with those of existing objects by suffixing the file names with random UUIDs. For example, if you set the Object parameter to DI, the actual names of the files written to OSS are in the following format: DI_****_****_****. • *nonConflict*: returns an error message if an object with the specified object name exists. For example, if you set the `object` parameter to abc and the object named abc123 exists, an error message is returned.	Yes	None
fileFormat	The format in which the files are written to OSS. Valid values: csv and text. • If a file is written as a CSV file, the file strictly follows CSV specifications. If the data in the file contains the column delimiter, the column delimiter is escaped by using double quotation marks ("). • If a file is written as a text file, the data in the file is separated with the column delimiter. If the data in the file contains the column delimiter, the column delimiter is not escaped.	No	*text*

Parameter	Description	Required	Default value
fieldDelimiter	The column delimiter used in the files to be written to OSS.	No	,
encoding	The encoding format of the files to be written to OSS.	No	*UTF-8*
nullFormat	The string that represents null. No standard strings can represent null in text files. Therefore, Data Integration provides the nullFormat parameter to define which string represents a null pointer. For example, if you specify `nullFormat="null"`, Data Integration considers null as a null pointer.	No	None
header (advanced parameter, which is not supported on the codeless UI)	The table header in the files to be written to OSS, for example, ['id', 'name', 'age'].	No	None
maxFileSize (advanced parameter, which is not supported on the codeless UI)	The maximize size of a single file that can be written to OSS. Default value: 100000. Unit: MB. File rotation based on this maximum size is similar to log rotation of Log4j. When a file is uploaded to OSS in multiple parts, the minimum size of a part is 10 MB. This size is the minimum granularity for file rotation. That is, if you set the maxFileSize parameter to less than 10 MB, the minimum size of a file is still 10 MB. Each call of the InitiateMultipartUploadRequest operation supports writing up to 10,000 parts. If file rotation occurs, new files are named in the following rule: a suffix, such as _1, _2, and _3, is appended to the file name that consists of the file name prefix and random UUID.	No	100000
suffix (advanced parameter, which is not supported on the codeless UI)	The file name extension of the files to be written to OSS. For example, if you set the suffix parameter to .csv, the final name of a file written to OSS is in the following format: fileName****.csv.	No	None

Configure OSS Writer by using the codeless UI

1. Configure the connections.

   Configure the source and destination connections for the sync node.

Parameter	Description

Parameter	Description
Connection	The datasource parameter in the preceding parameter description. Select a connection type, and enter the name of a connection that has been configured in DataWorks.
Object Name Prefix	The object parameter in the preceding parameter description. Enter the path of the directory for storing the files. Do not include the name of the OSS bucket in the path.
File Type	The fileFormat parameter in the preceding parameter description. Valid values: *csv* and *text*.
Field Delimiter	The fieldDelimiter parameter in the preceding parameter description. The default delimiter is comma (,).
Encoding	The encoding parameter in the preceding parameter description. The default encoding format is *UTF-8*.
Null String	The nullFormat parameter in the preceding parameter description. Enter a string that represents null. If the source connection contains the string, the string is replaced with null.
Time Format	The format in which the data of the Date type is serialized in an object, for example, `"dateFormat": "yyyy-MM-dd"`.
Solution to Duplicate Prefixes	If an object with the specified name prefix exists, replace the object with the new object, insert the new object, or return an error message.

2. Configure field mappings.

   Fields in the source table on the left have a one-to-one mapping with fields in the destination table on the right.

Operation	Description
Map Fields with the Same Name	Click **Map Fields with the Same Name** to establish a mapping between fields with the same name. Note that the data types of the fields must match.
Map Fields in the Same Line	Click **Map Fields in the Same Line** to establish a mapping for fields in the same row. Note that the data types of the fields must match.
Delete All Mappings	Click **Delete All Mappings** to remove mappings that have been established.

3. Configure channel control policies.

Configure OSS Writer by using the code editor

In the following code, a node is configured to write files to OSS. For more information about the parameters, see the preceding parameter description.

```
{
  "type":"job",
  "version":"2.0",
  "steps":[
    {
      "stepType":"stream",
      "parameter":{},
      "name":"Reader",
      "category":"reader"
    },
    {
      "stepType":"oss",// The writer type.
      "parameter":{
        "nullFormat":"",//The string that represents null.
        "DateFormat": "", // The format in which the data of the Date type is serialized in an object.
        "datasource":"",// The connection name.
        "writeMode":"",// The write mode.
        "encoding":"",// The encoding format.
        "fieldDelimiter":",",// The column delimiter.
        "fileFormat": "",// The format in which the files are written to OSS.
        "Object":[]// The name prefix of the files to be written to OSS as objects.
      },
      "name":"Writer",
      "category":"writer"
    }
  ],
  "setting":{
    "errorLimit":{
      "record":"0"// The maximum number of dirty data records allowed.
    },
    "speed":{
      "throttle":false,// Specifies whether to enable bandwidth throttling. A value of false indicates that the bandwidth is not throttled. A value of true indicates that the bandwidth is throttled. The maximum transmission rate takes effect only if you set this parameter to true.
      "concurrent":1,// The maximum number of concurrent threads.
    }
  },
```

```
  "order":{
    "hops":[
      {
        "from":"Reader",
        "to":"Writer"
      }
    ]
  }
}
```

2.3.3.4.15. Configure PostgreSQL Writer

This topic describes the data types and parameters supported by PostgreSQL Writer and how to configure it by using the codeless user interface (UI) and code editor.

PostgreSQL Writer allows you to write data to a PostgreSQL database. Specially, PostgreSQL Writer connects to a remote PostgreSQL database through Java Database Connectivity (JDBC), and run an SQL statement to write data to the PostgreSQL database.

> **Note** You must configure a connection before configuring PostgreSQL Writer. For more information, see Add a PostgreSQL connection.

- PostgreSQL Writer generates the SQL statement based on the table, column, and where parameters that you specified, and sends the generated SQL statement to the PostgreSQL database.
- If you specify the querySql parameter, PostgreSQL Writer directly sends the value of this parameter to the PostgreSQL database.

Data types

PostgreSQL Writer supports most PostgreSQL data types. Make sure that your data types are supported.

The following table lists the data types supported by PostgreSQL Writer.

Data Integration data type	PostgreSQL data type
LONG	bigint, bigserial, integer, smallint, and serial
DOUBLE	double, precision, money, numeric, and real
STRING	varchar, char, text, bit, and inet
DATE	date, time, and timestamp
BOOLEAN	boolean
BYTES	bytea

> **Note**
> - Data types that are not listed in the table are not supported.
> - You can convert the money, inet, and bit types by using syntax such as `a_inet::varchar`.

Parameters

Parameter	Description	Required	Default value
datasource	The connection name. It must be identical to the name of the added connection. You can add connections in the code editor.	Yes	None
table	The name of the destination table.	Yes	None
writeMode	The write mode. Valid values: insert and copy. • *insert*: runs the `INSERT INTO` statement to write data to the PostgreSQL database. If a primary key conflict or unique index conflict occurs, data cannot be written to the conflicting rows and is regarded as dirty data. We recommend that you select the insert mode. • *copy*: copies data between tables and the standard input or standard output file. Data Integration supports the `COPY FRO M` command, which allows you to copy data from files to tables. We recommend that you try this mode when performance issues occur.	No	*insert*
column	The columns in the destination table to which data is written. Separate the columns with a comma (,). Example: `"column": ["id","name","age"]`. Set the value to an asterisk (*) if data is written to all the columns in the destination table. That is, set the column parameter as follows: `"column":["*"]`.	Yes	None
preSql	The SQL statement to run before the sync node is run. For example, you can clear outdated data before data synchronization. Currently, you can run only one SQL statement on the codeless UI, and multiple SQL statements in the code editor.	No	None
postSql	The SQL statement to run after the sync node is run. For example, you can add a timestamp after data synchronization. Currently, you can run only one SQL statement on the codeless UI, and multiple SQL statements in the code editor.	No	None
batchSize	The number of data records to write at a time. Setting this parameter can greatly reduce the interactions between Data Integration and the PostgreSQL database over the network, and increase the throughput. However, an excessively large value may lead to the out of memory (OOM) error during the data synchronization process.	No	*1024*

Parameter	Description	Required	Default value
pgType	The PostgreSQL configuration for converting data types. Valid values: bigint[], double[], text[], jsonb, and json. Example: { "job": { "content": [{ "reader": {...}, "writer": { "parameter": { "column": [// The columns in the destination table to which data is written. "bigint_arr", "double_arr", "text_arr", "jsonb_obj", "json_obj"], "pgType": { // The PostgreSQL configuration for converting data types. In each key-value pair, the key specifies the name of a field in the destination table, and the value specifies the data type of the field. "bigint_arr": "bigint[]", "double_arr": "double[]", "text_arr": "text[]", "jsonb_obj": "jsonb", "json_obj": "json" }}] } } }] } }	No	None

Parameter	Description	Required	Default value

Configure PostgreSQL Writer by using the codeless UI

1. Configure the connections.

   Configure the source and destination connections for the sync node.

Parameter	Description
Connection	The datasource parameter in the preceding parameter description. Select a connection type, and enter the name of a connection that has been configured in DataWorks.
Table	The table parameter in the preceding parameter description.
Statement Run Before Writing	The preSql parameter in the preceding parameter description. Enter an SQL statement to run before the sync node is run.
Statement Run After Writing	The postSql parameter in the preceding parameter description. Enter an SQL statement to run after the sync node is run.
WriteMode	The writeMode parameter in the preceding parameter description. You can select *insert* or *copy*.

2. Configure field mapping, that is, the column parameter in the preceding parameter description.

   Fields in the source table on the left have a one-to-one mapping with fields in the destination table on the right.

Operation	Description
Map Fields with the Same Name	Click **Map Fields with the Same Name** to establish a mapping between fields with the same name. Note that the data types of the fields must match.
Map Fields in the Same Line	Click **Map Fields in the Same Line** to establish a mapping for fields in the same row. Note that the data types of the fields must match.
Delete All Mappings	Click **Delete All Mappings** to remove mappings that have been established.
Auto Layout	Click Auto Layout. The fields are automatically sorted based on specified rules.

3. Configure channel control policies.

Configure PostgreSQL Writer by using the code editor

In the following code, a node is configured to write data to a PostgreSQL database. For more information about the parameters, see the preceding parameter description.

```
{
  "type":"job",
```

```
"version":"2.0",// The version number.
"steps":[
  {
    "stepType":"stream",
    "parameter":{},
    "name":"Reader",
    "category":"reader"
  },
  {
    "stepType":"postgresql",// The writer type.
    "parameter":{
      "postSql":[],// The SQL statement to run after the sync node is run.
      "datasource":"// The connection name.
        "col1",
        "col2"
      ],
      "table":"",// The name of the destination table.
      "preSql":[]// The SQL statement to run before the sync node is run.
    },
    "name":"Writer",
    "category":"writer"
  }
],
"setting":{
  "errorLimit":{
    "record":"0"// The maximum number of dirty data records allowed.
  },
  "speed":{
    "throttle":false,// Specifies whether to enable bandwidth throttling. A value of false indicates that the bandwidth is not throttled. A value of true indicates that the bandwidth is throttled. The maximum transmission rate takes effect only if you set this parameter to true.
    "concurrent":1,// The maximum number of concurrent threads.
  }
},
"order":{
  "hops":[
    {
      "from":"Reader",
      "to":"Writer"
    }
  ]
```

```
  }
}
```

2.3.3.4.16. Configure Redis Writer

Redis Writer is a writer plug-in developed based on the Data Integration framework. It can be used to import data from data stores such as data warehouses to Redis databases.

Redis is a network-enabled key-value storage system that is either in-memory or permanent. It supports logs and delivers high performance. It can be used as a database, cache, and message broker. Redis supports diverse data types for values, including String, List, Set, ZSet (sorted set), and Hash.

Redis Writer is a writer plug-in developed based on the Data Integration framework. It can be used to import data from data stores such as data warehouses to Redis databases. Redis Writer interacts with a Redis server through Jedis. As a preferred Java client development kit provided by Redis, Jedis supports almost all the features of Redis.

> **Note**
> - You must configure a connection before configuring Redis Writer. For more information, see Add Redis data sources.
> - If you write values of the List type to Redis by using Redis Writer, the result of rerunning a sync node is not idempotent. If the data type of the values is List, you must manually clear the corresponding data on Redis when you rerun a sync node.

Parameters

Parameter	Description	Required	Default value
datasource	The connection name. It must be identical to the name of the added connection. You can add connections in the code editor.	Yes	None
keyIndexes	The columns used as the key. The index of the first column is 0. For example, if you want to set the first and second columns of the source data as the key, set the keyIndexes parameter to [0,1]. **Note** After you specify the keyIndexes parameter, Redis Writer specifies the remaining columns as the value. If you do not want to synchronize all the columns, filter columns when you configure the reader.	Yes	None
keyFieldDelimiter	The delimiter used to separate keys when data is written to Redis. Example: key=key1\u0001id. If multiple keys need to be concatenated, this parameter is required. If only one key exists, this parameter is not required.	No	*\u0001*

Parameter	Description	Required	Default value
batchSize	The number of data records to write at a time. Setting this parameter can greatly reduce the interactions between Data Integration and the Redis database over the network, and increase the throughput. However, an excessively large value may lead to the out of memory (OOM) error during the data synchronization process.	No	*1000*
expireTime	The expiration time of the values to be cached in Redis. Unit: seconds. The data is valid permanently if you do not specify this parameter. • *seconds*: the relative time in seconds starting from the current time point. It specifies the time range during which data is valid. • *unixtime*: the UNIX timestamp, indicating that data is invalid at a certain time point in the future. The UNIX timestamp represents the number of seconds that have elapsed since 00:00:00 on January 1, 1970. **Note** If the specified expiration time is larger than 30 days, the server identifies the time as the UNIX timestamp.	No	*0*, indicating that the values never expire
timeout	The timeout period to connect to Redis when data is written to Redis. Unit: milliseconds.	No	*30000*
dateFormat	The format in which the data of the Date type is written to Redis. Set the value to yyyy-MM-dd HH:mm:ss.	No	None
writeMode	The write mode. Redis supports diverse data types for values, including String, List, Set, ZSet (sorted set), and Hash. Redis Writer allows you to write values of the preceding types to Redis. The value of the writeMode parameter varies with the specified data type of the values. **Note** When configuring Redis Writer, you can choose only one of the five data types described in the following table. If you do not specify a data type, the data type is String by default.	No	*string*

The following table lists the data types supported by Redis Writer.

Type	Parameter	Description	Required
String "writeMode":{ "type": "string", "mode": "set", "valueFieldDelimiter": "\u0001" }	type	The data type of the values is String.	Yes
	mode	The mode in which data of the String type is written to Redis.	Yes. Valid value: set (overwrites the existing data).
	valueFieldDelimiter	This parameter is required if two or more columns are specified as the values. This parameter is not required if only one column is specified as the values. The delimiter used to separate values if the data is of the String type. Example: value1\u0001value2\u0001value3.	No. Default value: \u0001.
List "writeMode":{ "type": "list", "mode": "lpush|rpush", "valueFieldDelimiter": "\u0001" }	type	The data type of the values is List.	Yes
	mode	The mode in which data of the List type is written to Redis.	Yes. Valid values: lpush (stores the data at the leftmost of the list) and rpush (stores the data at the rightmost of the list).
	valueFieldDelimiter	The delimiter used to separate values if the data is of the String type. Example: value1\u0001value2\u0001value3.	No. Default value: *\u0001*.
Set	type	The data type of the values is Set.	Yes
	mode	The mode in which data of the Set type is written to Redis.	Yes. Valid value: sadd (stores the data to a set, or overwrites the existing data).

Type	Parameter	Description	Required
"writeMode":{ "type": "set", "mode": "sadd", "valueFieldDeli miter": "\u0001" }	valueFieldDelimiter	The delimiter used to separate values if the data is of the String type. Example: value1\u0001value2\u0001value3.	No. Default value: *\u0001*.
Zset (sorted set) "writeMode":{ "type": "zset", "mode": "zadd" }	type	The data type of the values is Zset. **Note** If the data type of the values is Zset, each data record must follow the following standard: Except for the key, a data record can contain only one score and one value. The score must be placed before the value. In this way, Redis Writer can identify which column is the score and which column is the value.	Yes
	mode	The mode in which data of the Zset type is written to Redis.	Yes. Valid value: zadd (stores data to a sorted set, or overwrites the existing data).

Type	Parameter	Description	Required
Hash "writeMode":{ "type": "hash", "mode": "hset" }	type	The data type of the values is Hash. Note If the data type of the values is Hash, each data record must follow the following standards: Except for the key, a data record can contain only one attribute and one value. The attribute must be placed before the value. In this way, Redis Writer can identify which column is the attribute and which column is the value.	Yes
	mode	The mode in which data of the Hash type is written to Redis.	Yes. Valid value: hmset (stores data to a hash sorted set, or overwrites the existing data). If you do not specify a data type, the data type is String by default.

Configure Redis Writer by using the codeless UI

Currently, the codeless user interface (UI) is not supported for Redis Writer.

Configure Redis Writer by using the code editor

In the following code, a node is configured to write data to Redis. For more information about parameters, see the preceding parameter description.

```
{
  "type":"job",
  "version":"2.0",// The version number.
  "steps":[
    {
      "stepType":"stream",
      "parameter":{},
```

```
      "name":"Reader",
      "category":"reader"
    },
    {
      "stepType":"redis",// The writer type.
      "parameter":{
        "expireTime":{// The expiration time of the values to be cached in Redis.
          "seconds":"1000"
        },
        "keyFieldDelimiter":"u0001",// The delimiter used to separate keys when data is written to Redis.
        "dateFormat":"yyyy-MM-dd HH:mm:ss",// The format in which the data of the Date type is written to
Redis.
        "datasource":"",// The connection name.
        "writeMode":{// The write mode.
          "mode":"",// The write mode used to write data of a specified data type.
          "valueFieldDelimiter":"",// The delimiter used to separate values.
          "type": "// The data type of the values.
        },
        "keyIndexes": [// The columns used as the key.
          0,
          1
        ],
        "batchSize":"1000",// The number of data records to write at a time.
      },
      "name":"Writer",
      "category":"writer"
    }
  ],
  "setting":{
    "errorLimit":{
      "record":"0"// The maximum number of dirty data records allowed.
    },
    "speed":{
      "throttle":false,// Specifies whether to enable bandwidth throttling. A value of false indicates that the
bandwidth is not throttled. A value of true indicates that the bandwidth is throttled. The maximum transmi
ssion rate takes effect only if you set this parameter to true.
      "concurrent":1,// The maximum number of concurrent threads.
    }
  },
  "order":{
```

```
    "hops":[
      {
        "from":"Reader",
        "to":"Writer"
      }
    ]
  }
}Writer"
      }
    ]
  }
}
```

2.3.3.4.17. Configure SQL Server Writer

This topic describes the data types and parameters supported by SQL Server Writer and how to configure it by using the codeless user interface (UI) and code editor.

SQL Server Writer allows you to write data to tables stored in primary SQL Server databases. Specifically, SQL Server Writer connects to a remote SQL Server database through Java Database Connectivity (JDBC), and runs an `INSERT INTO` statement to write data to the SQL Server database. Internally, data is submitted to the database in batches.

SQL Server Writer is designed for extract-transform-load (ETL) developers to import data from data warehouses to SQL Server databases. SQL Server Writer can also be used as a data migration tool by users such as database administrators (DBAs).

SQL Server Writer obtains data from a Data Integration reader, and generates the `INSERT INTO` statement. If a primary key conflict or unique index conflict occurs, data cannot be written to the conflicting rows. To improve performance, SQL Server Writer makes `batch updates with the PreparedStatement method` and sets `rewriteBatchedStatements=true`. In this way, SQL Server Writer buffers data, and submits a write request when the amount of data in the buffer reaches a specific threshold.

> **Note**
>
> - Data can be written only to tables stored in the primary SQL Server database.
> - A sync node that uses SQL Server Writer must have at least the permission to run the INSERT INTO statement. Whether other permissions are required depends on the SQL statements specified in the preSql and postSql parameters when you configure the node.

Data types

SQL Server Writer supports most SQL Server data types. Make sure that your data types are supported.

The following table lists the data types supported by SQL Server Writer.

Category	SQL Server data type
Integer	bigint, int, smallint, and tinyint
Floating point	float, decimal, real, and numeric
String	char, nchar, ntext, nvarchar, text, varchar, nvarchar (max), and varchar (max)
Date and time	date, time, and datetime
Boolean	bit
Binary	binary, varbinary, varbinary (max), and timestamp

Parameters

Parameter	Description	Required	Default value
datasource	The connection name. It must be identical to the name of the added connection. You can add connections in the code editor.	Yes	None
table	The name of the destination table.	Yes	None
column	The columns in the destination table to which data is written. Separate the columns with a comma (,). Example: `"column": ["id","name","age"]`. Set the value to an asterisk (*) if data is written to all the columns in the destination table. That is, set the column parameter as follows: `"column":["*"]`.	Yes	None
preSql	The SQL statement to run before the sync node is run. For example, you can clear outdated data before data synchronization. Currently, you can run only one SQL statement on the codeless UI, and multiple SQL statements in the code editor.	No	None
postSql	The SQL statement to run after the sync node is run. For example, you can add a timestamp after data synchronization. Currently, you can run only one SQL statement on the codeless UI, and multiple SQL statements in the code editor.	No	None
writeMode	The write mode. Valid value: *insert*. When a data record violates the primary key constraint or unique index constraint, Data Integration considers it dirty and retains the original data.	No	*insert*
batchSize	The number of data records to write at a time. Setting this parameter can greatly reduce the interactions between Data Integration and the SQL Server database over the network, and increase the throughput. However, an excessively large value may lead to the out of memory (OOM) error during the data synchronization process.	No	*1024*

Configure SQL Server Writer by using the codeless UI

1. Configure the connections.

   Configure the source and destination connections for the sync node.

Parameter	Description
Connection	The datasource parameter in the preceding parameter description. Select a connection type, and enter the name of a connection that has been configured in DataWorks.
Table	The table parameter in the preceding parameter description.
Statement Run Before Writing	The preSql parameter in the preceding parameter description. Enter an SQL statement to run before the sync node is run.
Statement Run After Writing	The postSql parameter in the preceding parameter description. Enter an SQL statement to run after the sync node is run.
Solution to Primary Key Violation	The writeMode parameter in the preceding parameter description. Select the expected write mode.

2. Configure field mapping, that is, the column parameter in the preceding parameter description.

   Fields in the source table on the left have a one-to-one mapping with fields in the destination table on the right.

Operation	Description
Map Fields with the Same Name	Click **Map Fields with the Same Name** to establish a mapping between fields with the same name. Note that the data types of the fields must match.
Map Fields in the Same Line	Click **Map Fields in the Same Line** to establish a mapping for fields in the same row. Note that the data types of the fields must match.
Delete All Mappings	Click **Delete All Mappings** to remove mappings that have been established.
Auto Layout	Click Auto Layout. The fields are automatically sorted based on specified rules.

3. Configure channel control policies.

Configure SQL Server Writer by using the code editor

In the following code, a node is configured to write data to an SQL Server database. For more information about the parameters, see the preceding parameter description.

```
{
  "type":"job",
  "version":"2.0",// The version number.
  "steps":[
    {
```

```
      "stepType":"stream",
      "parameter":{},
      "name":"Reader",
      "category":"reader"
    },
    {
      "stepType":"sqlserver",// The writer type.
      "parameter":{
        "postSql":[],// The SQL statement to run after the sync node is run.
        "datasource":"",// The connection name.
        "column":[// The columns to which data is written.
          "id",
          "name"
        ],
        "table":"",// The name of the destination table.
        "preSql":[]// The SQL statement to run before the sync node is run.
      },
      "name":"Writer",
      "category":"writer"
    }
  ],
  "setting":{
    "errorLimit":{
      "record":"0"// The maximum number of dirty data records allowed.
    },
    "speed":{
      "throttle":false,// Specifies whether to enable bandwidth throttling. A value of false indicates that the bandwidth is not throttled. A value of true indicates that the bandwidth is throttled. The maximum transmission rate takes effect only if you set this parameter to true.
      "concurrent":1,// The maximum number of concurrent threads.
    }
  },
  "order":{
    "hops":[
      {
        "from":"Reader",
        "to":"Writer"
      }
    ]
  }
}
```

2.3.3.4.18. Configure Elasticsearch Writer

This topic describes the data types and parameters supported by Elasticsearch Writer and how to configure it by using the code editor.

Elasticsearch is an open-source product that complies with the Apache open standards. It is the mainstream search engine for enterprise data. Elasticsearch is a Lucene-based data search and analysis tool that provides distributed services. The mappings between Elasticsearch core concepts and database core concepts are as follows:

Relational database (instance) -> database -> table -> row -> column

Elasticsearch -> index -> type -> document -> field

Elasticsearch can contain multiple indexes (databases). Each index can contain multiple types (tables). Each type can contain multiple documents (rows). Each document can contain multiple fields (columns). Elasticsearch Writer uses the RESTful API of Elasticsearch to write multiple data records retrieved by a reader to Elasticsearch at a time.

Parameters

Parameter	Description	Required	Default value
endpoint	The endpoint for accessing Elasticsearch, in the format of `http://xxxx.com:9999`.	No	None
accessId	The AccessKey ID for accessing Elasticsearch, which is used for authorization when a connection with Elasticsearch is established. **Note** The accessId and accessKey parameters are required. If you do not set the parameters, an error is returned. If you use on-premises Elasticsearch for which basic authentication is not configured, the AccessKey ID and AccessKey secret are not required. In this case, you can set the accessId and accessKey parameters to random values.	No	None
accessKey	The AccessKey secret for accessing Elasticsearch.	No	None
index	The index name in Elasticsearch.	No	None
indexType	The type name in the index of Elasticsearch.	No	*Elasticsearch*

Parameter	Description	Required	Default value
cleanup	Specifies whether to clear existing data in the index. The method used to clear the data is to delete and rebuild the corresponding index. The default value false indicates that the existing data in the index is retained.	No	*false*
batchSize	The number of data records to write at a time.	No	*1000*
trySize	The number of retries after a failure.	No	*30*
timeout	The connection timeout of the client. Unit: milliseconds.	No	*600000*
discovery	Specifies whether to enable Node Discovery. When Node Discovery is enabled, the server list in the client is polled and regularly updated.	No	*false*
compression	Specifies whether to enable compression for an HTTP request.	No	*true*
multiThread	Specifies whether to use multiple threads for an HTTP request.	No	*true*
ignoreWriteError	Specifies whether to ignore write errors and proceed with writing without retries.	No	*false*
ignoreParseError	Specifies whether to ignore format parsing errors and proceed with writing.	No	*true*
alias	The alias of the index. The alias feature of Elasticsearch is similar to the view feature of a traditional database. For example, if you create an alias named my_index_alias for the index my_index, the operations on my_index_alias also take effect on my_index. Configuring alias means that after the data import is completed, an alias is created for the specified index.	No	None
aliasMode	The mode in which an alias is added after the data is imported. Valid values: *append* and *exclusive*.	No	append

Parameter	Description	Required	Default value
settings	The delimiter (-,-) for splitting the source data if you are inserting an array to Elasticsearch. Example: The source column stores data `a-,-b-,-c-,-d` of the String type. Elasticsearch Writer uses the delimiter (-,-) to split the source data and obtains the array `["a", "b", "c", "d"]`. Then, Elasticsearch Writer writes the array to the corresponding field in Elasticsearch.	No	-,-
	The fields of the document. The parameters for each field include basic parameters such as name and type and advanced parameters such as analyzer, format, and array. The field types supported by Elasticsearch are as follows:		

Parameter	Description	Required	Default value
column	- id // The id type corresponds to the _id type in Elasticsearch, and can be considered as the unique primary key. Data with the same ID will be overwritten and not indexed. - string - text - keyword - long - integer - short - byte - double - float - date - boolean - binary - integer_range - float_range - long_range - double_range - date_range - geo_point - geo_shape - ip - token_count - array - object - nested • When the field type is Text, you can specify the analyzer, norms, and index_options parameters. Example: `{ "name": "col_text", "type": "text", "analyzer": "ik_max_word" }` • When the field type is date, you can specify the format and timezone parameters, indicating the date serialization format and the time zone, respectively. Example:	Yes	None

Parameter	Description	Required	Default value
	{ "name": "col_date", "type": "date", "format": "yyyy-MM-dd HH:mm:ss", "timezone": "UTC" } • When the field type is ge_shape, you can specify the tree (geohash or quadtree) and precision parameters. Example: { "name": "col_geo_shape", "type": "geo_shape", "tree": "quadtree", "precision": "10m" } If you specify the array parameter for a field and set the array parameter to *true*, the field is an array column. Elasticsearch Writer uses the delimiter specified by the splitter to split the source data, converts the data to an array of strings, and writes the array to the destination. Only one delimiter is supported for one node. Example: { "name": "col_integer_array", "type": "integer", "array": true }		
dynamic	Specifies whether to use the mapping configuration of Elasticsearch. A value of *true* indicates that the mapping configuration of Elasticsearch, instead of the mapping configuration of Data Integration, is used.	No	*false*
actionType	The type of the action for writing data to Elasticsearch. Currently, Data Integration supports only the following action types: *index* and *update*. Default value: *index*. • *index*: Data Integration uses Index.Builder of the Elasticsearch SDK to construct a request for writing multiple data records at a time. In *index* mode, Elasticsearch first checks whether an ID is specified for the document to be inserted. ◦ If the ID is not specified, Elasticsearch generates a unique ID by default. In this case, the document is directly inserted to Elasticsearch. ◦ If the ID is specified, Elasticsearch replaces the existing document with the document to be inserted. Note In this case, you cannot modify specific fields in the document. • *update*: Data Integration uses Update.Builder of the Elasticsearch SDK to construct a request for writing multiple data records at a time. In *update* mode, Elasticsearch calls the get method of InternalEngine to obtain the information of the original document for each update. In this way, you can modify specific fields. In update mode, you must obtain the information of the original document for each update, which greatly affects the performance. However, you can modify specific fields in this mode. If the original document does not exist, the new document is directly inserted.	No	*index*

Configure Elasticsearch Writer by using the code editor

In the following code, a node is configured to write data to Elasticsearch. For more information about the parameters, see the preceding parameter description.

```
{
  "order": {
    "hops": [
      {
        "from": "Reader",
        "to": "Writer"
      }
    ]
  },
  "setting": {
    "errorLimit": {
      "record": "0"
    },
    "speed": {
      "concurrent": 1,
      "throttle": false
    }
  },
  "steps": [
    {
      "category": "reader",
      "name": "Reader",
      "parameter": {
      },
      "stepType": "stream"
    },
    {
      "category": "writer",
      "name": "Writer",
      "parameter": {
        "endpoint": "http://xxxx.com:9999",
        "accessId": "xxxx",
        "accessKey": "yyyy",
        "index": "test-1",
        "type": "default",
        "cleanup": true,
        "settings": {
          "index": {
            "number_of_shards": 1,
            "number_of_replicas": 0
```

```
        }
      },
      "discovery": false,
      "batchSize": 1000,
      "splitter": ",",
      "column": [
        {
          "name": "pk",
          "type": "id"
        },
        {
          "name": "col_ip",
          "type": "ip"
        },
        {
          "name": "col_double",
          "type": "double"
        },
        {
          "name": "col_long",
          "type": "long"
        },
        {
          "name": "col_integer",
          "type": "integer"
        },
        {
          "name": "col_keyword",
          "type": "keyword"
        },
        {
          "name": "col_text",
          "type": "text",
          "analyzer": "ik_max_word"
        },
        {
          "name": "col_geo_point",
          "type": "geo_point"
        },
        {
          "name": "col_date",
```

```
            "type": "date",
            "format": "yyyy-MM-dd HH:mm:ss"
          },
          {
            "name": "col_nested1",
            "type": "nested"
          },
          {
            "name": "col_nested2",
            "type": "nested"
          },
          {
            "name": "col_object1",
            "type": "object"
          },
          {
            "name": "col_object2",
            "type": "object"
          },
          {
            "name": "col_integer_array",
            "type": "integer",
            "array": true
          },
          {
            "name": "col_geo_shape",
            "type": "geo_shape",
            "tree": "quadtree",
            "precision": "10m"
          }
        ]
      },
      "stepType": "elasticsearch"
    }
  ],
  "type": "job",
  "version": "2.0"
}
```

> **Note** Currently, Elasticsearch that is deployed in a Virtual Private Cloud (VPC) supports only custom resource groups. A sync node that is run on the default resource group may fail to connect to Elasticsearch.

2.3.3.4.19. Configure LogHub Writer

This topic describes the data types and parameters supported by LogHub Writer and how to configure it by using the code editor.

LogHub Writer allows you to transfer data from a Data Integration reader to LogHub through Log Service Java SDK.

> **Note** LogHub does not guarantee idempotence. Rerunning a node after the node fails may result in redundant data.

LogHub Writer obtains data from a Data Integration reader and converts the data types supported by Data Integration to String. When the number of the data records reaches the value specified for the batchSize parameter, LogHub Writer sends the data records to LogHub at a time through Log Service Java SDK. LogHub Writer sends 1,024 data records at a time by default. The batchSize parameter can be set to 4096 at most.

Data types

The following table lists the data types supported by LogHub Writer.

Data Integration data type	LogHub data type
LONG	STRING
DOUBLE	STRING
STRING	STRING
DATE	STRING
BOOLEAN	STRING
BYTES	STRING

Parameters

Parameter	Description	Required	Default value
endpoint	The endpoint for accessing Log Service.	Yes	None
accessKeyId	The AccessKey ID for accessing Log Service.	Yes	None
accessKeySecret	The AccessKey secret for accessing Log Service.	Yes	None

Parameter	Description	Required	Default value
project	The name of the destination Log Service project.	Yes	None
logstore	The name of the destination Logstore.	Yes	None
topic	The name of the destination topic.	No	Empty string
batchSize	The number of data records to write at a time.	No	*1024*
column	The columns in each data record.	Yes	None

Configure LogHub Writer by using the codeless UI

Currently, the codeless user interface (UI) is not supported for LogHub Writer.

Configure LogHub Writer by using the code editor

In the following code, a node is configured to write data to LogHub. For more information about the parameters, see the preceding parameter description.

```
{
  "type": "job",
  "version": "2.0",// The version number.
  "steps": [
    { //
      "stepType": "stream",
      "parameter": {},
      "name": "Reader",
      "category": "reader"
    },
    {
      "stepType": "loghub",// The writer type.
      "parameter": {
        "datasource": "",// The connection name.
        "column": [// The columns in each data record.
          "col0",
          "col1",
          "col2",
          "col3",
          "col4",
          "col5"
        ],
        "topic": "",// The name of the destination topic.
        "batchSize": "1024",// The number of data records to write at a time
```

```
            "batchSize": "1024",// The number of data records to write at a time.
            "logstore": ""// The name of the destination Logstore.
        },
        "name": "Writer",
        "category": "writer"
      }
    ],
    "setting": {
      "errorLimit": {
        "record": ""// The maximum number of dirty data records allowed.
      },
      "speed": {
        "concurrent": 3,// The maximum number of concurrent threads.
        "throttle": false,// Specifies whether to enable bandwidth throttling. A value of false indicates that the bandwidth is not throttled. A value of true indicates that the bandwidth is throttled. The maximum transmission rate takes effect only if you set this parameter to true.
      }
    },
    "order": {
      "hops": [
        {
          "from": "Reader",
          "to": "Writer"
        }
      ]
    }
}
```

2.3.3.4.20. Configure Open Search Writer

Open Search Writer allows you to insert data to or update data in Open Search. Open Search Writer is designed for developers to import data to Open Search so that the data can be searched.

Implementation

At the underlying layer, Open Search Writer uses the search API provided by Open Search to import data.

> **Note**
>
> - To use Open Search Writer, you must install JDK 1.6-32 or later. You can run the java-version command to view the JDK version.
> - Currently, a sync node that is run on the default resource group may fail to connect to Open Search that is deployed in a Virtual Private Cloud (VPC).

Features

Column order

The columns in Open Search are unordered. Therefore, Open Search Writer writes data strictly in accordance with the order of the specified columns. If the number of specified columns is less than that in Open Search, redundant columns are set to the default value or null.

For example, an Open Search table contains column a, column b, and column c, and you only need to write data to column b and column c. You can set the column parameter to ["c","b"]. In this case, the first and second columns of the source data obtained from a reader are imported to column c and column b in Open Search respectively. The column a in the Open Search table is set to the default value or null.

- Column configuration error handling

  To avoid losing the data of redundant columns and guarantee high data reliability, Open Search Writer returns an error message if more columns are written than expected. For example, if an Open Search table contains column a, column b, and column c, Open Search Writer reports an error if more than three columns are to be written to the table.

- Table configuration

  Open Search Writer can write data to only one table at a time.

- Node rerunning

  After a node is rerun, data is automatically overwritten based on IDs. Therefore, the data written to Open Search must contain one ID column. An ID is a unique identifier of a row in Open Search. The existing data with the same ID as the new data will be overwritten.

- Node rerunning

  After a node is rerun, data is automatically overwritten based on IDs.

Open Search Writer supports most Open Search data types. Make sure that your data types are supported.

The following table lists the data types supported by Open Search Writer.

Category	Open Search data type
Integer	INT
Floating point	DOUBLE and FLOAT
String	TEXT, LITERAL, and SHORT_TEXT
Date and time	INT

Category	Open Search data type
Boolean	LITERAL

Parameters

Parameter	Description	Required	Default value
host	The endpoint for accessing Open Search. You can view the endpoint in the Alibaba Cloud console.	Yes	None
indexName	The name of the Open Search project.	Yes	None
table	The table to which data is written. You can specify only one table because Data Integration does not support importing data to multiple tables at a time.	Yes	None
column	The columns in the destination table to which data is written. Set the value to an asterisk (*) if data is written to all the columns in the destination table. That is, set the column parameter as follows: `"column":["*"]`. Separate the columns with a comma (,) if data is written to some of the columns in the destination table. Example: `"column": ["id","name"]`. Open Search Writer supports filtering columns and changing the order of columns. For example, an Open Search table has three columns: a, b, and c. If you want to write data only to column c and column b, you can set the column parameter as follows: `"column": ["c","b"]`. During data synchronization, column a is automatically set to null.	Yes	None
batchSize	The number of data records to write at a time. Data is written to Open Search in batches. The advantage of Open Search is data query. The transactions per second (TPS) of Open Search is generally not high. Set this parameter based on the resources applied for the account used to access Open Search. Generally, the size of a data record must be less than 1 MB, and the size of the data records to write at a time must be less than 2 MB.	Required only for writing data to a partitioned table	*300*

Parameter	Description	Required	Default value
writeMode	The write mode. To guarantee the idempotence of write operations, set the writeMode parameter to add/update when you configure Open Search Writer. • add: deletes the existing data record and insert the new data record to Open Search, which is an atomic operation. • update: updates the existing data record based on the new data record, which is an atomic operation. **Note** Writing data to Open Search in batches is not an atomic operation. Part of the data may fail to be written. Exercise caution when you set the writeMode parameter. Currently, Open Search V3 does not support the update mode.	Yes	None
ignoreWriteError	Specifies whether to ignore failed write operations. Example: `"ignoreWriteError":true`. If data is written to Open Search in batches, this parameter specifies whether to ignore failed write operations in the current batch. If you set the parameter to true, Open Search Writer continues to perform other write operations. If you set the parameter to false, the sync node ends and an error message is returned. We recommend that you use the default value.	No	*false*
version	The version of Open Search, for example, `"version":"v3"`. We recommend that you use Open Search V3 because the push operation faces many constraints in Open Search V2.	No	*v2*

Configure Open Search Writer by using the code editor

In the following code, a node is configured to write data to Open Search.

```
{
  "type": "job",
  "version": "1.0",
  "configuration": {
    "reader": {},
    "writer": {
      "plugin": "opensearch",
      "parameter": {
        "accessId": "*********",
        "accessKey": "********",
        "host": "http://yyyy.aliyuncs.com",
        "indexName": "datax_xxx",
        "table": "datax_yyy",
        "column": [
        "appkey",
        "id",
        "title",
        "gmt_create",
        "pic_default"
        ],
        "batchSize": 500,
        "writeMode": add,
        "version":"v2",
        "ignoreWriteError": false
      }
    }
  }
}
```

2.3.3.4.21. Configure Table Store Writer

This topic describes the data types and parameters supported by Table Store Writer and how to configure it by using the code editor.

Table Store is a NoSQL database service built on the Apsara distributed operating system that allows you to store and access large amounts of structured data in real time. Table Store organizes data into instances and tables. Using data sharding and load balancing technologies, Table Store seamlessly expands the data scale.

Table Store Writer connects to a Table Store server by using the official Java SDK and writes data to the Table Store server by using the SDK. Table Store Writer has greatly optimized the write process, including retry upon write timeout, retry upon exceptions, and batch submission.

Currently, Table Store Writer supports all Table Store data types and supports the following two write modes:

- PutRow: the PutRow API operation for Table Store, which is used to insert data to a specified row. If this row does not exist, a new row is added. Otherwise, the original row is overwritten.
- UpdateRow: the UpdateRow API operation for Table Store, which is used to update the data of a specified row. If this row does not exist, a new row is added. Otherwise, the values of the specified columns are added, modified, or deleted as requested.

Currently, Table Store Writer supports all Table Store data types. The following table lists the data types supported by Table Store Writer.

Category	Table Store data type
Integer	INTEGER
Floating point	DOUBLE
String	STRING
Boolean	BOOLEAN
Binary	BINARY

Note To write data of the INTEGER type, set the data type to INT in the code editor. Then, DataWorks converts the INT type to the Integer type. If you set the data type to INTEGER for the data to be written to Table Store, an error is reported in the log and the sync node fails.

Parameters

Parameter	Description	Required	Default value
datasource	The connection name. It must be identical to the name of the added connection. You can add connections in the code editor.	Yes	None
endPoint	The endpoint of the Table Store server.	Yes	None
accessId	The AccessKey ID for accessing Table Store.	Yes	None
accessKey	The AccessKey secret for accessing Table Store.	Yes	None
instanceName	The name of the Table Store instance to access. You access and manage the Table Store service through an instance. After activating Table Store, you can create an instance in the Table Store console and then create and manage tables in the instance. Instances are the basic unit for managing Table Store resources. All access control and resource measurement for applications are completed at the instance level.	Yes	None

Parameter	Description	Required	Default value
table	The name of the destination table. You can specify only one table as the destination table. Multi-table synchronization is not required for Table Store.	Yes	None
primaryKey	The primary keys of the destination table in Table Store. The primary keys are described in a JSON array. Table Store is a NoSQL database service. The field names must be specified for Table Store Writer to import data. **Note** The primary keys in Table Store only support the STRING and INT types. Therefore, you must set the data type of a primary key to either of the two types in the code editor. Data Integration supports converting data types. Table Store Writer can convert data that is not of the STRING or INT type to the STRING or INT type. Example: `"primaryKey" : [` `{"name":"pk1", "type":"string"},` `{"name":"pk2", "type":"int"}` `],`	Yes	None
column	The columns in the destination table to which data is written. The columns are described in a JSON array. Format: `{"name":"col2", "type":"INT"},` The name parameter specifies the name of the column to which data is written. The type parameter specifies the data type of the column. Data types supported by Table Store include String, Int, Double, Boolean, and Binary.	Yes	None

Parameter	Description	Required	Default value
writeMode	The write mode. Constants, functions, or custom statements are not supported during the write process. The following three modes are supported: • Single-row operations ○ GetRow: reads data from a single row. ○ PutRow: the PutRow API operation for Table Store, which is used to insert data to a specified row. If this row does not exist, a new row is added. Otherwise, the original row is overwritten. ○ UpdateRow: the UpdateRow API operation for Table Store, which is used to update the data of a specified row. If this row does not exist, a new row is added. Otherwise, the values of the specified columns are added, modified, or deleted as requested. ○ DeleteRow: deletes a row. • Multi-row operation BatchGetRow: reads data from multiple rows. • Range-based operation GetRange: reads data from a table within a range.	Yes	None

Configure Table Store Writer by using the codeless UI

Currently, the codeless user interface (UI) is not supported for Table Store Writer.

Configure Table Store Writer by using the code editor

In the following code, a node is configured to write data to Table Store.

```
{
  "type":"job",
  "version":"2.0",// The version number.
  "steps":[
    {
      "stepType":"stream",
      "parameter":{},
      "name":"Reader",
      "category":"reader"
    },
    {
      "stepType":"ots",// The writer type.
      "parameter":{
        "datasource":"",// The connection name.
```

```
        "column":[// The columns to which data is written.
          {
            "name":"columnName1",// The name of the column.
            "type": "INT" // The data type of the column.
          },
          {
            "name":"columnName2",
            "type":"STRING"
          },
          {
            "name":"columnName3",
            "type":"DOUBLE"
          },
          {
            "name":"columnName4",
            "type":"BOOLEAN"
          },
          {
            "name":"columnName5",
            "type":"BINARY"
          }
        ],
        "writeMode":"",// The write mode.
        "table":"",// The name of the destination table.
        "primaryKey":[// The primary keys of the destination table in Table Store.
          {
            "name":"pk1",
            "type":"STRING"
          },
          {
            "name":"pk2",
            "type":"INT"
          }
        ]
      },
      "name":"Writer",
      "category":"writer"
    }
  ],
  "setting":{
    "errorLimit":{
```

```
      "record":"0"// The maximum number of dirty data records allowed.
    },
    "speed":{
      "throttle":false,// Specifies whether to enable bandwidth throttling. A value of false indicates that the bandwidth is not throttled. A value of true indicates that the bandwidth is throttled. The maximum transmission rate takes effect only if you set this parameter to true.
      "concurrent":1,// The maximum number of concurrent threads.
    }
  },
  "order":{
    "hops":[
      {
        "from":"Reader",
        "to":"Writer"
      }
    ]
  }
}
```

2.3.3.4.22. Configure RDBMS Writer

This topic describes the data types and parameters supported by RDBMS Writer and how to configure it by using the code editor.

RDBMS Writer allows you to write data to tables stored in primary relational database management system (RDBMS) databases. Specifically, RDBMS Writer obtains data from a Data Integration reader, connects to a remote RDBMS database through Java Database Connectivity (JDBC), and then runs an `INSERT INTO` statement to write data to the RDBMS database. RDBMS Writer is a common writer for relational databases. To enable RDBMS Writer to support a new relational database, register the driver for the relational database.

RDBMS Writer is designed for extract-transform-load (ETL) developers to import data from data warehouses to RDBMS databases. RDBMS Writer can also be used as a data migration tool by users such as database administrators (DBAs).

Data types

RDBMS Writer supports most data types in relational databases, such as numbers and characters. Make sure that your data types are supported.

Parameters

Parameter	Description	Required	Default value

Parameter	Description	Required	Default value
jdbcUrl	The JDBC URL for connecting to the database. The format must be in accordance with official specifications. You can also specify the information of the attachment facility. The format varies with the database type. Data Integration selects an appropriate driver for data reading based on the format. • Format for DM databases: `jdbc:dm://ip:port/database` • Format for Db2 databases: `jdbc:db2://ip:port/database` • Format for PPAS databases: `jdbc:edb://ip:port/database`	Yes	None
username	The username for connecting to the database.	Yes	None
password	The password for connecting to the database.	Yes	None
table	The name of the destination table.	Yes	None
column	The columns in the destination table to which data is written. Separate the columns with a comma (,). **Note** We recommend that you do not use the default setting.	Yes	None
preSql	The SQL statement to run before the sync node is run. For example, you can clear outdated data before data synchronization. Currently, you can run only one SQL statement. **Note** If you specify multiple SQL statements in the code editor, the system does not guarantee that they are run in the same transaction.	No	None

Parameter	Description	Required	Default value
postSql	The SQL statement to run after the sync node is run. For example, you can add a timestamp after data synchronization. Currently, you can run only one SQL statement. Note If you specify multiple SQL statements in the code editor, the system does not guarantee that they are run in the same transaction.	No	None
batchSize	The number of data records to write at a time. Setting this parameter can greatly reduce the interactions between Data Integration and the RDBMS database over the network, and increase the throughput. However, an excessively large value may lead to the out of memory (OOM) error during the data synchronization process.	No	1024

Configure RDBMS Writer by using the code editor

In the following code, a node is configured to write data to an RDBMS database.

```
{
  "job": {
    "setting": {
      "speed": {
        "channel": 1
      }
    },
    "content": [
      {
        "reader": {
          "name": "streamreader",
          "parameter": {
            "column": [
              {
                "value": "DataX",
                "type": "string"
              },
              {
                "value": 19880808,
                "type": "long"
              },
              {
```

```
            {
              "value": "1988-08-08 08:08:08",
              "type": "date"
            },
            {
              "value": true,
              "type": "bool"
            },
            {
              "value": "test",
              "type": "bytes"
            }
          ],
          "sliceRecordCount": 1000
        }
      },
      "writer": {
        "name": "RDBMS Writer",
        "parameter": {
          "connection": [
            {
              "jdbcUrl": "jdbc:dm://ip:port/database",
              "table": [
                "table"
              ]
            }
          ],
          "username": "username",
          "password": "password",
          "table": "table",
          "column": [
            "*"
          ],
          "preSql": [
            "delete from XXX;"
          ]
        }
      }
    }
  ]
}
```

```
}
```

You can enable RDBMS Writer to support a new database as follows:

1. Go to the directory of RDBMS Writer, *${DATAX_HOME}/plugin/writer/RDBMS Writer*. In the preceding directory, ${DATAX_HOME} indicates the main directory of Data Integration.
2. Add the driver of your database to the drivers array in the *plugin.json* file in the RDBMS Writer directory. RDBMS Writer automatically selects an appropriate driver for connecting to a database.

```
{
  "name": "RDBMS Writer",
  "class": "com.alibaba.datax.plugin.reader.RDBMS Writer.RDBMS Writer",
  "description": "useScene: prod. mechanism: Jdbc connection using the database, execute select sql, r
etrieve data from the ResultSet. warn: The more you know about the database, the less problems you e
ncounter.",
  "developer": "alibaba",
  "drivers": [
    "dm.jdbc.driver.DmDriver",
    "com.ibm.db2.jcc.DB2Driver",
    "com.sybase.jdbc3.jdbc.SybDriver",
    "com.edb.Driver"
  ]
}
```

3. Add the package of the driver to the libs directory in the RDBMS Writer directory.

```
$tree
.
|-- libs
|  |-- Dm7JdbcDriver16.jar
|  |-- commons-collections-3.0.jar
|  |-- commons-io-2.4.jar
|  |-- commons-lang3-3.3.2.jar
|  |-- commons-math3-3.1.1.jar
|  |-- datax-common-0.0.1-SNAPSHOT.jar
|  |-- datax-service-face-1.0.23-20160120.024328-1.jar
|  |-- db2jcc4.jar
|  |-- druid-1.0.15.jar
|  |-- edb-jdbc16.jar
|  |-- fastjson-1.1.46.sec01.jar
|  |-- guava-r05.jar
|  |-- hamcrest-core-1.3.jar
|  |-- jconn3-1.0.0-SNAPSHOT.jar
|  |-- logback-classic-1.0.13.jar
|  |-- logback-core-1.0.13.jar
|  |-- plugin-rdbms-util-0.0.1-SNAPSHOT.jar
|  `-- slf4j-api-1.7.10.jar
|-- plugin.json
|-- plugin_job_template.json
`-- RDBMS Writer-0.0.1-SNAPSHOT.jar
```

2.3.3.4.23. Configure Stream Writer

This topic describes the data types and parameters supported by Stream Writer and how to configure it by using the code editor.

Stream Writer allows you to display the data obtained from a Data Integration reader on the screen or discard the data. Stream Writer is mainly applicable to performance testing for data synchronization and basic functional testing.

Parameters

print

- Description: specifies whether to display the data obtained from the reader on the screen.
- Required: No
- Default value: true

Configure Stream Writer by using the codeless UI

Currently, the codeless user interface (UI) is not supported for Stream Writer.

Configure Stream Writer by using the code editor

In the following code, a node is configured to display the data obtained from a Data Integration reader on the screen.

```
{
  "type":"job",
  "version":"2.0",// The version number.
  "steps":[
    {
      "stepType":"stream",
      "parameter":{},
      "name":"Reader",
      "category":"reader"
    },
    {
      "stepType":"stream",// The writer type.
      "parameter":{
        "print": false, // Specifies whether to display data on the screen.
        "fieldDelimiter":","// The column delimiter.
      },
      "name":"Writer",
      "category":"writer"
    }
  ],
  "setting":{
    "errorLimit":{
      "record":"0"// The maximum number of dirty data records allowed.
    },
    "speed":{
      "throttle":false,// Specifies whether to enable bandwidth throttling. A value of false indicates that the bandwidth is not throttled. A value of true indicates that the bandwidth is throttled. The maximum transmission rate takes effect only if you set this parameter to true.
      "concurrent":1,// The maximum number of concurrent threads.
    }
  },
  "order":{
    "hops":[
      {
        "from":"Reader",
        "to":"Writer"
      }
    ]
  }
}
```

2.3.3.4.24. Configure Hive Writer

Parameters

Parameter	Description	Required	Default value
column	The fields to which data is written. Example: "column": ["id", "name"].	Yes	None
table	The name of the Hive table to which data is written. The name is case sensitive.	Yes	None
partition	The partition information of the table to which data is written. The last-level partition must be specified. For example, if you want to write data to a three-level partition table, set this parameter to a value that contains the last-level partition information, such as pt=20150101/type=1/biz=2.	Yes	None

Parameter	Description	Required	Default value
writeMode	The mode in which Hive Writer writes data to the Hive table. Valid values: • append: Hive Writer directly writes data to data files based on the file names and ensures that no duplicate file names exist. • nonConflict: If a data file exists in the directory, Hive Writer returns an error. • truncate: Hive Writer deletes conflicting data files before synchronization. Note Parquet files do not support the append mode. They support only the nonConflict mode.	Yes	None

Parameter	Description	Required	Default value
hiveConfig	Hive-related extension parameters. You can use this parameter to specify the location of Hive Command or the Hive Java Database Connectivity (JDBC) connectivity URL. If the data written to Hadoop Distributed File System (HDFS) needs to be visible to the Hive table, specify this parameter. If you do not specify this parameter, the data written to HDFS is invisible to the Hive table. • Specify the location of Hive Command. `"hiveConfig":{ "hiveCommand":"/usr/lib/hive-current/bin/hive" }` • Specify the Hive JDBC connectivity URL. `"hiveConfig":{ "jdbcUrl":"jdbc:hive2://47.98.51.107:10000/default", "username":"root", "password":"" }`	No	None

Configure Hive Writer by using the code editor

In the following code, a node is configured to write data to a Hive data store.

```
{
  "type":"job",
  "version":"2.0",// The version number.
  "steps":[
    {
      "stepType":"stream",
      "parameter":{},
      "name":"Reader",
      "category":"reader"
    },
    {
      "stepType":"hive",// The writer type. The name is the same as that in MaxCompute.
      "parameter":{
        "parameter":{
          "column": [// The columns to be synchronized.
            "id",
            "name"
          ],
          "table": "student_tmp_2", // The name of the table to be synchronized.
          "writeMode": "append", // The write mode.
          "partition": "academy=yx/class=001", // The partition settings.
          "datasource": "hive_demo"
        }
      },
      "name":"Writer",
      "category":"writer"
    }
  ],
  "setting":{
  },
  "order":{
    "hops":[// Synchronize data from the reader to the writer.
      {
        "from":"Reader",
        "to":"Writer"
      }
    ]
  }
}
```

2.3.3.4.25. Configure Gbase8a Writer

This topic describes the implementation principle and parameter configurations of Gbase8a Writer.

Gbase8a Writer allows you to write data to tables stored in Gbase8a databases. At the underlying implementation level, Gbase8a Writer connects to a remote Gbase8a database through the JDBC Driver and runs the relevant SQL statements to write data to the Gbase8a database.

> **Note** You must configure a connection before configuring Gbase8a Writer.

Parameters

Parameter	Description	Required	Default value
datasource	The connection name. It must be identical to the name of the added connection. You can add connections in the code editor.	Yes	None
table	The name of the table to be synchronized.	Yes	None
writeMode	The write mode. Valid values: *insert into*, *on duplicate key update*, and *replace into*. • *insert into*: If a primary key conflict or unique index conflict occurs, data cannot be written to the conflicting rows and is regarded as dirty data. • *on duplicate key update*: If no primary key conflict or unique index conflict occurs, the action is the same as that of `insert into`. If a conflict occurs, specified fields in original rows are updated. • *replace into*: If no primary key conflict or unique index conflict occurs, the action is the same as that of `insert into`. If a conflict occurs, original rows are deleted and new rows are inserted. That is, all fields of original rows are replaced.	No	*insert*
column	The columns in the destination table to which data is written. Separate the columns with a comma (,). Example: `"column": ["id", "name", "age"]`. Set the value to an asterisk (*) if data is written to all the columns in the destination table. That is, set the column parameter as follows: `"column":["*"]`.	Yes	None

Parameter	Description	Required	Default value
preSql	The SQL statement to run before the sync node is run. For example, you can clear outdated data before data synchronization. Currently, you can run only one SQL statement on the codeless user interface (UI), and multiple SQL statements in the code editor. **Note** If you specify multiple SQL statements in the code editor, the system does not guarantee that they are run in the same transaction.	No	None
postSql	The SQL statement to run after the sync node is run. For example, you can add a timestamp after data synchronization. Currently, you can run only one SQL statement on the codeless UI, and multiple SQL statements in the code editor. **Note** If you specify multiple SQL statements in the code editor, the system does not guarantee that they are run in the same transaction.	No	None
batchSize	The number of data records to write at a time. Setting this parameter can greatly reduce the interactions between Data Integration and the Gbase8a database over the network, and increase the throughput. However, an excessively large value may lead to the out of memory (OOM) error during the data synchronization process.	No	*1024*

Configure Gbase8a Writer by using the codeless UI

Currently, the codeless UI is not supported for Gbase8a Writer.

Configure Gbase8a Writer by using the code editor

In the following code, a node is configured to write data to the Gbase8a database. For more information about the parameters, see the preceding parameter description.

```
{
  "type":"job",
  "version":"2.0",// The version number.
  "steps":[
    {
      "stepType":"stream",
      "parameter":{},
      "name":"Reader",
      "category":"reader"
    },
```

```
    {
      "stepType":"gbase8a",// The writer type.
      "parameter":{
        "postSql":[],// The SQL statement to run after the sync node is run.
        "datasource":"",// The connection name.
        "column":[// The columns to be synchronized.
          "id",
          "value"
        ],
        "writeMode":"insert",// The write mode.
        "batchSize":1024,// The number of data records to write at a time.
        "table":"",// The name of the table to be synchronized.
        "preSql":[]// The SQL statement to run before the sync node is run.
      },
      "name":"Writer",
      "category":"writer"
    }
  ],
  "setting":{
    "errorLimit":{// The maximum number of dirty data records allowed.
      "record":"0"
    },
    "speed":{
      "throttle":false,// Specifies whether to enable bandwidth throttling.
      "concurrent":1,// The maximum number of concurrent threads.
    }
  },
  "order":{
    "hops":[
      {
        "from":"Reader",
        "to":"Writer"
      }
    ]
  }
}
```

2.3.3.5. Optimize synchronization performance

This topic describes how to maximize the synchronization speed by adjusting the concurrency configuration, the difference between nodes that are configured with bandwidth throttling and those that are not, and precautions for custom resource groups.

Data Integration is a one-stop platform that supports real-time and offline data synchronization between any connections in any location and in any network environment. You can synchronize 10 TB of data between various types of cloud storage and local storage each day.

DataWorks provides excellent data transmission performance and supports data exchanges between more than 400 pairs of disparate connections. These features allow you to focus on the key issues on constructing big data solutions.

Factors affecting the speed of data synchronization

The factors that affect the speed of data synchronization are listed as follows:

- Source
  - Database performance: the performance of the CPU, memory module, SSD, network, and hard disk.
  - Concurrency: A high concurrency results in a heavy database workload.
  - Network: the bandwidth (throughput) and speed of the network. Generally, a database with better performance can support more concurrent nodes and a larger concurrency value can be set for sync nodes.
- Sync node
  - Synchronization speed: whether an upper limit is set for the synchronization speed.
  - Concurrency: a maximum number of concurrent threads to read data from the source and write data to destination data storage within a single sync node.
  - Nodes that are waiting for resources.
  - Bandwidth throttling: The bandwidth of a single thread is 1,048,576 bit/s. Timeout occurs when the business is sensitive to the network speed. We recommend that you set a smaller value.
  - Whether to create an index for query statements.
- Destination
  - Performance: the performance of the CPU, memory module, SSD, network, and hard disk.
  - Load: Excessive load in the destination database affects the write efficiency within the sync nodes.
  - Network: the bandwidth (throughput) and speed of the network.

You need to monitor and optimize the performance, load, and network of the source and destination databases. The following describes the optimal settings of a sync node.

Concurrency

You can configure the concurrency for a node on the codeless user interface (UI). The following is an example of how to configure the concurrency in the code editor:

```
"setting":{
    "speed":{
     "concurrent":10
    }
  } }
```

Bandwidth throttling

By default, bandwidth throttling is disabled. In a sync node, data is synchronized at the maximum speed given the concurrency configured for the node. Considering that excessively fast synchronization may overstress the database and thus affect the production, Data Integration allows you to limit the synchronization speed and optimize the configuration as required. If bandwidth throttling is enabled, we recommend that you limit the maximum speed to 30 Mbit/s. The following is an example for configuring an upper limit for synchronization speed in the code editor, in which the transmission bandwidth is 1 Mbit/s:

```
"setting":{
    "speed":{
      "throttle": true // The bandwidth throttling is enabled.
     "mbps": 1, // The synchronization speed.
    }
  }
```

Note

- When the throttle parameter is set to false, throttling is disabled, and you do not need to configure the mbps parameter.
- The bandwidth value is a Data Integration metric and does not represent the actual network interface card (NIC) traffic. Generally, the NIC traffic is two to three times of the channel traffic, which depends on the serialization of the data storage system.
- A semi-structured file does not have shard keys. If multiple files exist, you can set the maximum job speed to increase the synchronization speed. However, the maximum job speed is limited by the number of files. For example, the maximum job speed limit is set to n Mbit/s for n files. If you set the limit to n+1 Mbit/s, the synchronization speed remains at n Mbit/s. If you set the limit to n-1 Mbit/s, the synchronization is performed at n-1 Mbit/s.
- A table can be partitioned according to the preset maximum job speed only when a maximum job speed and a shard key are configured for a relational database. Relational databases only support numeric shard keys, while Oracle databases support both numeric and string shard keys.

Scenarios of slow data synchronization

- Scenario 1: Resolve the issue that sync nodes to be run on the default resource group remain waiting for resources.

- Example

  When you test a sync node in DataWorks, the node remains waiting for resources and an internal system error occurs.

  For example, a sync node is configured to synchronize data from RDS to MaxCompute. The node has waited for about 800 seconds before it is run successfully. However, the log shows that the node runs for only 18 seconds and then stops. The sync node uses the default resource group. When you run other sync nodes, they also remain in the waiting state.

  The log is displayed as follows:

  ```
  2017-01-03 07:16:54 : State: 2(WAIT) | Total: 0R 0B | Speed: 0R/s 0B/s | Error: 0R 0B | Stage: 0.0%
  ```

- Solution

  The default resource group is not exclusively used by a single user. It is used by many projects concurrently, not just two or three nodes for a single user. If such resources are insufficient after you start to run a node, the node needs to wait for resources. In this case, the node is completed 800 seconds after you start running the node, but it only takes 10 seconds for the node to be executed.

  To improve the synchronization speed and reduce the waiting time, we recommend that you run sync nodes during off-peak hours. Typically, most sync nodes are run between 00:00 and 03:00.

- Scenario 2:

  Accelerate nodes that synchronize data from multiple source tables to the same destination table.

  - Example

    To synchronize data from tables of multiple data stores to a table, you configure multiple sync nodes to run in sequence. However, the synchronization takes a long time.

  - Solution

    To launch multiple concurrent nodes that write data to the same destination database, pay attention to the following points:

    - Ensure that the destination database can support the execution of all the concurrent nodes.
    - You can configure a sync node that synchronizes multiple source tables to the same destination table. Alternatively, you can configure multiple nodes to run concurrently in the same workflow.
    - If resources are insufficient, you can configure sync nodes to run during off-peak hours.

- Scenario 3:

  If no index is added when the WHERE clause is used, a full table scan slows down the data synchronization.

  - Example

    SQL statement:

    ```
    select bid,inviter,uid,createTime from `relatives` where createTime>='2016-10-23 00:00:00'and reateTi
    me<'2016-10-24 00:00:00';
    ```

    Assume that the sync node started to run the preceding statement at 2016-10-25 11:01:24 and started to return results from 2016-10-25 11:11:05. It took a long time to finish the sync node.

- Cause

  When the WHERE clause is used for a query, the createTime column is not indexed, resulting in a full table scan.

- Solution

  We recommend that you use an indexed column or add an index to the column that you want to scan if you use the WHERE clause.

2.3.4. Real-time synchronization

2.3.4.1. Configure the DataHub reader, writer, and filter

This topic describes how to configure the DataHub reader, writer, and filter on the Data Integration page.

You need to configure the reader, filter, and writer in sequence.

Prepare DataHub

In the DataHub console, create a DataHub project. For example, create a project named streamx_datahub and create two topics under the project: datahub_test_topic1 and datahub_test_topic2.

Add a DataHub connection

1. Log on to the DataWorks console.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > Data Integration** to go to the **Data Integration** page.
3. In the left-side navigation pane, choose **Sync Resources > Connections**. On the page that appears, click **Add Connection** in the upper-right corner.
4. In the **Add Connection** dialog box that appears, select **DataHub**.
5. Set the parameters for the DataHub connection.
6. Click **Test Connection**.
7. After the connectivity test is passed, click **Complete**.

Configure a node

1. Go to the **Data Integration** page. In the left-side navigation pane, choose **Nodes > Real-Time Sync**.
2. Drag **DataHub** under **Reader** to the development section. Configure the reader in the right-side pane.
3. Filter

   Drag **Filter** under **Transform** to the development section. Filter data based on the columns you selected for the DataHub reader.

4. Configure the DataHub writer.

   To configure the DataHub writer, follow these steps:

   i. Specify the connection and topic.

ii. Set the number of data records to be synchronized each time. This parameter is usually set to 512 or 1024.

iii. Map the fields in the source and destination.

2.3.4.2. Reader

2.3.4.2.1. MySQL binlogs

The MySQL binlog reader reads data from the tables of MySQL databases in real time.

The MySQL binlog reader reads data from the MySQL database in real time by using Canal, which parses incremental MySQL binlogs and subscribes to data changes.

Parameters

Parameter	Description	Required	Default value
dbHost	The endpoint of the database. You can set this parameter to the domain name or the IP address.	Yes	None
dbName	The name of the database.	Yes	None
port	The port number of the database.	Yes	None
table	The name of the table to be synchronized.	Yes	None
username	The username used to access the database.	Yes	None
password	The password used to access the database.	Yes	None

Parameter	Description	Required	Default value
startTimestampMills	The start time of data synchronization. The value of this parameter is a 13-bit timestamp. **Note** If the start time you specify is later than the last data change time of MySQL binlogs, data synchronization starts from the last data change time of MySQL binlogs. If the start time you specify is earlier than the earliest data change time of MySQL binlogs, no data is synchronized.	No	None

Example

In the following code, a node is configured to read data from a MySQL database and write data to DataHub in real time:

```
{
 "order":{
  "hops":[
   {
    "from":"mysqlbinlog_01"
```

```
    "from": "mysqlbinlog_01",
    "to": "datahub_01"
   }
  ]
 },
 "setting": {
  "errorLimit": {
   "record": 0
  },
 },
 "steps": [
  {
   "category": "reader",
   "name": "mysqlbinlog_01",
   "parameter": {
    "password": "xxx",
    "column": [
     "_log_file_name_offset_",
     "_operation_type_",
     "_execute_time_",
     "_before_image_",
     "_after_image_",
     "id",
     "pipeline_name",
     "execute_name",
     "context"
    ],
    "dbHost": "127.0.0.1",
    "dbName": "xxx",
    "port": 3306,
    "startTimestampMills": 1555689600000,
    "table": "xxx",
    "username": "xxx"
   },
   "stepType": "mysqlbinlog"
  },
  {
   "category": "writer",
   "name": "datahub_O1",
   "parameter": {
    "accessKey": "xxx",
```

```
"accessId": "xxx",
"batchSize": 1000,
"column": [
 "_log_file_name_offset_",
 "_execute_time_",
 "_before_image_",
 "_after_image_",
 "id",
 "pipeline_name",
 "execute_name",
 "context"
],
"columnMapping": [
 {
  "dstColName": "_log_file_name_offset_",
  "sourceColName": "_log_file_name_offset_"
 },
 {
  "dstColName": "_execute_time_",
  "sourceColName": "_execute_time_"
 },
 {
  "dstColName": "_before_image_",
  "sourceColName": "_before_image_"
 },
 {
  "dstColName": "_after_image_",
  "sourceColName": "_after_image_"
 },
 {
  "dstColName": "id",
  "sourceColName": "id"
 },
 {
  "dstColName": "pipeline_name",
  "sourceColName": "pipeline_name"
 },
 {
  "dstColName": "execute_name",
  "sourceColName": "execute_name"
 },
```

```
      {
        "dstColName": "context",
        "sourceColName": "context"
      }
     ],
     "endpoint": "xxx",
     "project": "xxx",
     "topic": "xxx"
    },
    "stepType": "datahub"
   }
 ]
}
```

2.3.4.2.2. Oracle CDC

StreamX uses Change Data Capture (CDC) to synchronize data of Oracle databases in real time. This synchronization mode uses triggers on the source database to capture change data. When the CDC synchronization mode is enabled, the performance of the database may be deteriorated.

Before synchronizing data from an Oracle database, you need to perform a series of operations in the database. Take data synchronization between two Oracle tables as an example.

Synchronize data from the source table named synctest.trade to the destination table named cdcuser.trade_target.

The source and destination tables are created by using the CREATE TABLE statement. StreamX obtains changes of the incremental data and synchronizes the changed data to the destination table. The changed incremental data that StreamX reads includes the specific information about the action types. The UPDATE statements are divided into the before image and after image. The before image contains the data before the update. The after image contains the updated data.

Procedure

1. Create a table. You can also select an existing table.

   ```
   create tablespace ts_cdcpub
   logging datafile '/u01/app/oracle/oradata/mydb/cdcpub01.dbf'
   size 5000M autoextend off;
   ```

2. Create a user named cdcuser to store incremental data and grant permissions to the user.

```
CREATE USER cdcuser IDENTIFIED BY cdcuser DEFAULT TABLESPACE ts_cdcpub QUOTA UNLIMITED ON ts
_cdcpub;
GRANT CREATE SESSION TO cdcuser;
GRANT CREATE TABLE TO cdcuser;
GRANT SELECT_CATALOG_ROLE TO cdcuser;
GRANT EXECUTE_CATALOG_ROLE TO cdcuser;
GRANT CONNECT, RESOURCE TO cdcuser;
```

3. Grant the SELECT permission on the table to be synchronized to the cdcuser user.

```
grant select on syntest.trade to cdcuser;
```

4. Create a change set and a change table.
   - Create a change set

```
DBMS_CDC_PUBLISH.CREATE_CHANGE_SET(
change_set_name => 'tradetest',
description => 'Change set for synctest.trade info',
change_source_name => 'SYNC_SOURCE');
```

   - Create a change table

```
DBMS_CDC_PUBLISH.CREATE_CHANGE_TABLE(
owner => 'cdcuser',
change_table_name => 'trade_ct',
change_set_name => 'tradetest',
source_schema => 'synctest',
source_table => 'trade',
column_type_list => 'id number,money number,op_user varchar(100)',
capture_values => 'both',
rs_id => 'y',
row_id => 'n',
user_id => 'n',
timestamp => 'n',
object_id => 'n',
source_colmap => 'y',
target_colmap => 'y',
DDL_MARKERS => 'N',
options_string => 'TABLESPACE ts_cdcpub');
```

5. After the change set and change table are created, add an Oracle CDC connection and an Oracle connection.
6. Go to the **Data Integration** page. In the left-side navigation pane, choose **Nodes > Real-Time Sync**.

- Configure the reader. The reader currently supports four connection types including MySQL Binlog, Oracle CDC, DataHub, and LogHub. Configure the corresponding connection before configuring the reader.

Parameter	Description
Connection	The name of the connection.
Table	By default, four data records in the selected table are available for preview.
Start Offset	The time when the data synchronization node runs.
Time Zone	The time zone of the data synchronization node. The time zone can be determined based on the time zone of the connection.

- Configure the writer. The writer currently supports three connection types including MySQL, Oracle, and DataHub. Configure the corresponding connection before configuring the writer.

  Specify and map the fields in the source and destination.

2.3.4.2.3. DataHub

The DataHub stream reader reads data from DataHub in real time by using the DataHub SDK.

The reader keeps running after it is started and reads data from DataHub when DataHub stores new data. The DataHub stream reader has the following two features:

- Reads data in real time.
- Reads data concurrently based on the number of shards in DataHub.

Parameters

Parameter	Description	Required
endpoint	The endpoint used to access DataHub.	Yes
accessId	The AccessKey ID used to access DataHub.	Yes
project	The destination project of DataHub. A project is the resource management unit in DataHub for resource isolation and control.	Yes
topic	The destination topic of DataHub.	Yes
batchSize	The size of data read at a time.	No. Default value: 1024.

Parameter	Description	Required
startTimestampMills	The start time of data consumption. The time is an integer accurate to milliseconds. Example: 1554739200000.	No. You must specify either the startTimestampMills parameter or the position parameter.
position	The start time of data consumption for each shard. You can specify this parameter for each shard. Example: `{"allShardTimestampMillis":{"0":1549098048000,"1":1549098048000,"2":1549098048000,"3":1549098048000,"4":1549098048000}}` .	No. You must specify either the startTimestampMills parameter or the position parameter.

Example

In the following code, a node is configured to read data from DataHub and write data to a MySQL database in real time:

```
{
 "connections": [],
 "name": "yj_datahub2datahub4",
 "order": {
  "hops": [
   {
    "from": "datahubstreamreader",
    "to": "mysqloutput001"
   }
  ]
 },
 "params": [],
 "setting": {
  "performance": {}
 },
 "steps": [
  {
   "name": "datahubstreamreader",
   "category": "reader",
   "parameter": {
    "endpoint": "http://dh-cn-hangzhou.aliyuncs.com",
    "accessId": "********",
    "accessKey": "********",
```

```
    "project": "streamx_datahub",
    "topic": "mysqlbinlog_to_datahub_topic2",
    "batchSize": 512,
    "startTimestampMills": 1554739200000,
    "position": "{\"allShardTimestampMillis\": {\"0\":1549098048000,\"1\":1549098048000,\"2\":15490980480
00,\"3\":1549098048000,\"4\":1549098048000}}",
    "column": [
     "cdc_record_id",
     "cdc_operation",
     "cdc_timestamp",
     "cdc_before_image",
     "cdc_after_image",
     "id",
     "name",
     "age"
    ]
   },
   "stepType": "datahubstream"
  },
  {
   "name": "mysqloutput001",
   "category": "writer",
   "parameter": {
    "batchSize": 100,
    "writeMode": "insert",
    "username": "********",
    "password": "********",
    "column": [
     "cdc_record_id",
     "cdc_operation",
     "cdc_timestamp",
     "cdc_before_image",
     "cdc_after_image",
     "id",
     "name",
     "age"
    ],
    "connection": [
     {
      "jdbcUrl": "jdbc:mysql://10.101.83.3:3306/test",
```

```
        "table": [
          "streamx_test_real_time_inc_datahub"
        ]
       }
      ]
     },
     "stepType": "mysql"
    }
  ],
  "type": "job",
  "version": "2.0"
}
```

2.3.4.2.4. LogHub

The LogHub stream reader reads data from LogHub in real time by using the LogHub SDK.

The reader reads data from LogHub topics you specified in real time and supports shard merge and split.

> **Note** When shard merge or split is enabled, duplicate data records may exist. However, data missing is avoided.

Parameters

Parameter	Description	Required	Default value
endpoint	The endpoint used to access LogHub.	Yes	None
project	The name of the LogHub project.	Yes	None
logstore	The Logstore of LogHub.	Yes	None
table	The name of the table to be synchronized.	Yes	None
accessId	The AccessKey ID used to access LogHub.	Yes	None
accessKey	The AccessKey secret used to access LogHub.	Yes	None

Parameter	Description	Required	Default value
startTimestampMills	The start time of data synchronization. The value of this parameter is a 13-bit timestamp. **Note** If the start time you specify is later than the last data change time of MySQL binlogs, data synchronization starts from the last data change time of MySQL binlogs. If the start time you specify is earlier than the earliest data change time of MySQL binlogs, no data is synchronized.	No	None

Example

In the following code, a node is configured to read data from LogHub and write data to DataHub in real time:

```
{
 "order":{
  "hops":[
   {
    "from":"loghubstream_01",
    "to":"datahub_01"
   }
  ]
 },
 "steps":[
  {
   "category":"reader",
   "name":"loghubstream_01",
   "parameter":{
    "accessKey":"<yourAccessKey>",
    "accessId":"<yourAccessId>",
    "column":[
```

```
      "col1",
      "col2",
      "col3"
    ],
    "endpoint": "<yourEndpoint>",
    "logstore": "<yourLogstore>",
    "project": "<yourProject>",
    "startTimestampMills": 1555050358000,
   },
   "stepType": "loghubstream"
  },
  {
   "category": "writer",
   "name": "datahub_01",
   "parameter": {
    "accessKey": "<yourAccessKey>",
    "batchSize": 1000,
    "column": [
     "col1",
     "col2",
     "col3"
    ],
    "columnMapping": [
     {
      "dstColName": "col1",
      "sourceColName": "col1"
     },
     {
      "dstColName": "col2",
      "sourceColName": "col2"
     },
     {
      "dstColName": "col3",
      "sourceColName": "col3"
     }
    ],
    "endpoint": "<yourEndpoint>",
    "project": "<yourProject>",
    "topic": "<yourTopic>"
   },
```

```
    "stepType": "datahub"
  }
 ]
}
```

2.3.4.2.5. Kafka

Create a real-time sync node

1. Log on to the DataWorks console.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > Data Integration** to go to the **Data Integration** page.
3. In the left-side navigation pane, choose **Nodes > Real-Time Sync**. Click **Create Node** in the upper-right corner.
4. In the **Create Node** dialog box that appears, set **Node Name** and **Description**.
5. Click **OK**.

Configure an input node of the Kafka type

Drag **Kafka** under **Reader** to the canvas. Click the node and then configure the node in the **Node Settings** dialog box that appears.

Parameter	Description
server	The broker server address of Kafka in the format of `ip:port`.
topic	The name of the Kafka topic.
keyType	The type of the Kafka key.
valueType	The type of the Kafka value.
Consumer Offset	The consumer offset from which Kafka starts to consume data.
Parameters	The JSON-formatted parameters for specifying additional Kafka configurations. Example: group_id.
Start Offset	The date and time of the start offset.
Time Zone	The time zone.
Output Fields	The output fields of the node. You can customize the output fields.

Take the following Kafka configuration script as an example.

```
"parameter": {
    "server": "100.81.127.26:9092",
    "topic": "xin_001",
    "keyType": "long",
    "valueType": "string",
    "startupMode": "earliestOffset", -- Consume data from the earliest consumer offset.
    "discoveryIntervalMillis": 10000, -- The interval between partitions. The value is automatically discovere
d by the system.
    "kafkaConfig": {
     "group.id":"xin_group_001"
    }
   }
```

2.3.4.3. Writer

2.3.4.3.1. MySQL

Currently, the writer supports the MySQL connection. You need to configure the corresponding connection before configuring the writer.

On the Data Integration page, choose **Nodes > Real-Time Sync** and configure the MySQL writer.

Configure mappings after selecting destination connection and table.

2.3.4.3.2. Oracle

Currently, the writer supports the Oracle connection. You need to configure the corresponding connection before configuring the writer.

On the Data Integration page, choose **Nodes > Real-Time Sync** and configure the Oracle writer.

Configure mappings after selecting destination connection and table.

2.3.4.3.3. DataHub

Currently, the writer supports the DataHub connection. You need to configure the corresponding connection before configuring the writer.

DataHub is a platform designed to process streaming data. You can publish and subscribe applications to streaming data in DataHub and distribute the data to other platforms. This allows you to easily analyze streaming data and build applications based on the streaming data.

DataHub Writer writes data to DataHub by using the DataHub SDK for Java. The SDK version is as follows:

```
<dependency>
  <groupId>com.aliyun.datahub</groupId>
  <artifactId>aliyun-sdk-datahub</artifactId>
  <version>2.5.1</version>
</dependency>
```

Parameters

Parameter	Description	Required
endpoint	The endpoint used to access DataHub.	Yes
accessId	The AccessKey ID used to access DataHub.	Yes
accessKey	The AccessKey secret used to access DataHub.	Yes
project	The destination project of DataHub. A project is the resource management unit in DataHub for resource isolation and control.	Yes
topic	The destination topic of DataHub.	Yes
maxCommitSize	The size of the data written into DataHub at one time. Unit: Bytes.	No. Default value: 1,048,576 Bytes (1 MB).
maxRetryCount	The maximum number of operation retries in DataHub.	No. Default value: 500.
column	The output columns. Currently, you need to specify all columns in the destination DataHub data store as the output columns.	Yes
columnMapping	The mapping between the columns in the source and destination.	No

Example

```
{
 "connections": [],
 "name": "yj_datah***hub4",
 "order": {
  "hops": [
```

```
    {
     "from": "datahub***r86m8vT24",
     "to": "datahub_cM***aNAHUly"
    }
   ]
  },
  "params": [],
  "setting": {
   "performance": {}
  },
  "steps": [
   {
    "category": "reader",
    "name": "datahu***6m8vT24",
    "parameter": {
     "accessKey": "<yourAccessKey>",
     "accessId": "<yourAccessId",
     "column": [
      "string_col",
      "bigint_col",
      "double_col",
      "timestamp_col",
      "bool_col"
     ],
     "endpoint": "http://dh-cn-hangzhou.aliyuncs.com",
     "name": "<yourDatahubName>",
     "project": "streamx_datahub",
     "startTimestampMills": 1554739200000,
     "topic": "datahub_test_topic1"
    },
    "stepType": "datahubstream"
   },
   {
    "category": "writer",
    "name": "datahub_cM5XnifsIaNAHUly",
    "parameter": {
     "accessKey": "********",
     "accessId": "********",
     "batchSize": 512,
     "column": [
      "string_col",
```

```
      "bigint_col",
      "double_col",
      "timestamp_col",
      "bool_col"
     ],
     "columnMapping": [
      {
       "dstColName": "string_col",
       "sourceColName": "string_col"
      },
      {
       "dstColName": "bigint_col",
       "sourceColName": "bigint_col"
      },
      {
       "dstColName": "double_col",
       "sourceColName": "double_col"
      },
      {
       "dstColName": "timestamp_col",
       "sourceColName": "timestamp_col"
      },
      {
       "dstColName": "bool_col",
       "sourceColName": "bool_col"
      }
     ],
     "endpoint": "http://dh-cn-hangzhou.aliyuncs.com",
     "name": "yj_datahub_datasource",
     "project": "streamx_datahub",
     "topic": "datahub_test_topic2"
    },
    "stepType": "datahub"
   }
  ]
}
```

2.3.4.3.4. Kafka

Create a real-time sync node

1. Log on to the DataWorks console.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > Data Integration** to go to the **Data Integration** page.
3. In the left-side navigation pane, choose **Nodes > Real-Time Sync**. Click **Create Node** in the upper-right corner.
4. In the **Create Node** dialog box that appears, set **Node Name** and **Description**.
5. Click **OK**.

Configure an output node of the Kafka type

Drag **Kafka** under **Writer** to the canvas. Click the node and then configure the node in the **Node Settings** dialog box that appears.

Configuration item	Description
server	The broker server address of Kafka in the format of `ip:port`.
topic	The name of the Kafka topic.
keyColumn	The column for storing the key.
keyType	The type of the Kafka key.
valueColumn	The column for storing the value. If this parameter is not specified, all columns are concatenated by using the delimiter specified by fieldDelimiter to form the value.
valueType	The type of the Kafka value.
batchSize	The amount of data written at a time. Default value: 1024.
Set parameters	The extended parameters specified when KafkaConsumer is created, such as bootstrap.servers, auto.commit.interval.ms, and session.timeout.ms. By setting parameters in kafkaConfig, you can control the data consumption behaviors of KafkaConsumer.

Take the following Kafka configuration script as an example:

```
"parameter": {
    "server": "100.81.127.26:9092",
    "keyIndex": 0,
    "valueIndex": 1,
    "keyType": "long",
    "valueType": "string",
    "topic": "xin_002",
    "batchSize": 1,
  }
```

2.3.4.4. Transform

2.3.4.4.1. Data filter

The data filter plug-in is used to filter data.

Parameters

Parameter	Description	Required
category	The category of the plug-in. Set this parameter to filter for the data filter plug-in.	Yes
stepType	The type of the step. Set this parameter to filterrows for the data filter plug-in.	Yes
name	The name of the step.	Yes
condition	The filter condition in the expression format. The expression can contain the columns of the reader. In this example, the id and age columns in the filter condition are two columns specified in the reader. An expression that does not contain any column names can also be valid, such as 1==1.	Yes

Example

```
{
 "connections": [],
 "name": "yj_mysql_2_mysql",
 "order": {
  "hops": [
   {
    "from": "J3Bji***NPLn",
    "to": "rYCN***VxmlK0"
   },
   {
    "from": "rYCNF***mlK0",
    "to": "nD***JWPh0YJl0X"
   }
  ]
```

```
},
"params": [],
"setting": {
 "keyVersion": "201412091312",
 "metric": {
  "transMetric": {
   ...
  }
 },
},
"steps": [
 {
  "category": "reader",
  "name": "J3BjiG***QNPLn",
  "parameter": {
   "password": "<yourPassWord>",
   "access": "Native",
   "column": [
    "id",
    "name",
    "age"
   ],
   "dbHost": "10.101.83.3",
   "dbName": "test",
   "port": 3306,
   "startTimestampMills": 1551801600000,
   "table": "streamx_test_real_time",
   "type": "MYSQLBINLOG",
   "username": "<yourUserName>"
  },
  "stepType": "mysqlbinlog"
 },
 {
  "category": "filter",
  "name": "rYCNFINr38VxmlK0",
  "parameter": {
   "condition": " (id > 10) &&(age > 30)",
  },
  "stepType": "filterrows"
 },
 ... // The writer configuration is omitted here.
```

```
 ]
}
```

2.3.4.4.2. String replacement

The string replacement plug-in is used to replace the field values of the String type.

Parameter	Description
Field	The input fields read in the previous step.
Regular Expression Match	Specifies whether to perform regular expression match on the fields. For more information about regular expressions, see the relevant Java documentation.
Original String	The string to be replaced.
New String	The string used to replace the original string.
Case Sensitive	Specifies whether the query of the original string is case-sensitive.

2.3.4.4.3. Groovy

The Groovytrans transformer allows you to customize the Groovy code so that you can transform each record to be synchronized to meet different requirements.

You can use Groovytrans transformer to transform a column from uppercase to lowercase, add a prefix or a suffix to all columns, or add properties parsed from JSON columns to other columns.

How Groovytrans transformer works

The Groovytrans transformer compiles and runs the custom Groovy code through the Groovy compiler. The code needs to inherit the com.alibaba.di.plugin.center.transformer.Transformer class and implement the Record evaluate(Record record) method.

Example

In the following code, a node is configured to read data from MySQL, add the Groovy suffix to the first column in the data, and write the data to DataHub:

```
{
 "order":{
  "hops":[
   {
    "from":"Reader",
    "to":"Writer"
   }
  ]
```

```
},
"setting": {
 "errorLimit": {
  "record": "1"
 },
 "jvmOption": "",
 "speed": {
  "concurrent": 1,
  "throttle": false
 }
},
"steps": [
 {
  "stepType": "mysqlbinLog",
  "parameter": {
   "password": "xxx",
   "port": 3306,
   "dbName": "test",
   "column": [
    "col1",
    "col2",
    "col3"
   ],
   "dbHost": "127.0.0.1",
   "batchSize": 1024,
   "table": "t_table1",
   "username": "<yourUserName>"
  },
  "name": "mysqlbinlog001",
  "category": "reader"
 },
 {
  "stepType": "groovy",
  "parameter": {
   "groovyScript": "import com.alibaba.di.plugin.center.element.Column;
            import com.alibaba.di.plugin.center.element.StringColumn;
            import com.alibaba.di.plugin.center.record.Record;
            import com.alibaba.di.plugin.center.transformer.Transformer;
            class MyTransformer extends Transformer {
              @Override
              public Record evaluate(Record record) {
```

```
                public Record evaluate(Record record) {
                  Column column = record.getColumn(0);
                  String newValue = column.asString() + "GROOVY";
                  record.setColumn(0, new StringColumn(newValue));
                  return record;
                }
              }"
    },
    "transformType": "customize",
    "name": "groovytrans01",
    "category": "transformer"
  },
  {
    "stepType": "datahub",
    "parameter": {
      "endpoint": "http://dh-et2.aliyun-inc.com",
      "accessId": "<yourAccessId>",
      "accessKey": "<yourAccessKey>",
      "project": "<yourProject>",
      "topic": "table01",
      "maxCommitSize": 524288,
      "maxRetryCount": 30
    },
    "name": "datahubwriter01",
    "category": "writer"
  }
 ],
 "type": "job",
 "version": "2.0"
}
```

Parameters

GroovyScript

- Description: The Groovy code needs to inherit the com.alibaba.di.plugin.center.transformer.Transformer class and implement the Record evaluate(Record record) method.
- Required: yes.
- Default value: none.

2.3.5. Full-database migration

2.3.5.1. Overview

This section describes the full-database migration feature in terms of its functions and limits.

Full-database migration is an easy-to-use tool that helps you to improve cost-efficiency. It can quickly upload all the tables in a MySQL database to MaxCompute at a time, saving time that is spent on creating batch tasks for initial data migration to the cloud.

For example, if a database contains 100 tables, you must configure 100 data synchronization tasks in a traditional way. With the full-database migration, you can upload all the tables at a time. However, an upload failure might occur due to the issues that involve the principles of designing database tables.

Task generation rules

After the configuration is completed, MaxCompute tables are created and data synchronization tasks are generated based on the selected tables to be synchronized.

The table names, field names, and field types of the MaxCompute tables are generated according to the advanced settings. If no advanced settings are configured, the structure of MaxCompute tables is identical to that of MySQL tables. The partition of these tables is pt, and its format is yyyymmdd.

The generated data synchronization tasks are daily scheduled tasks and run automatically on the early morning of the next day. The typical transmission rate is 1 Mbit/s, but it varies depending on the synchronization method and concurrency configurations. **To customize a data synchronization task, locate the task by choosing clone_database > Data Source Name > mysql2odps_table name,** and then specify its settings.

> **Note** We recommend that you perform smoke testing on a data synchronization task on the day when it is generated.**To perform smoke testing, choose Administration Center > Task Management > project_etl_start > Upload Database > Data Source Name**, find the synchronization task, right-click the task, and then test the task.

Limits

Full-database migration has the following limits due to the issues that involve the principles of designing database tables.

- Currently, only the full-database migration from a MySQL data source to MaxCompute is supported. We are working on support for full-database migration from a Hadoop or Hive data source to Oracle.
- Only the daily incremental and daily full upload modes are available.

  If you want to synchronize historical data at a time, this feature cannot meet your needs. We recommend that:

  - You configure daily tasks instead of synchronizing historical data at a time. You trace the historical data with the provided retrospective data import feature. This eliminates the need to run temporary SQL tasks to split data after all the historical data is synchronized.
  - To synchronize historical data at a time, configure a task on the task development page and click **Run**. Then, data is converted by using SQL statements. They are both one-time operations.

  If your daily incremental upload task uses a special business logic and cannot be identified by a date field, this feature cannot meet your needs. We provide the following suggestions:

- The incremental data upload can be achieved by using two methods: binlog provided by the DTS product and the date field for data changes provided by databases.

  Currently, Data Integration supports the second method. Therefore, your database must contain the date field for data changes. The system determines whether your data is changed on the same day as the business date by using this field. If yes, all the changed data is synchronized.

- To facilitate the incremental data uploading, we recommend that you include the gmt_create and gmt_modify fields when creating any database tables. Additionally, you can set the id field as the primary key to improve efficiency.

- Full-database migration supports batch upload and full upload modes.

  Batch upload is configured with time intervals. Currently, the connection pool protection feature for data sources is not supported, but will be available later.

  - To prevent overloads on the database, the full-database migration feature provides the batch upload mode. This mode enables you to upload tables in batches at a specified time interval and prevents compromised service functionality. We provide the following suggestions:
    - If you have master and slave databases, we recommend that you synchronize the data of the slave database.
    - In a batch upload task, each table has a database connection with a maximum transmission rate of 1 Mbit/s. For example, if you run a synchronization task for 100 tables at a time, 100 database connections are established. We recommend that you specify proper concurrency settings based on your business needs.
  - If you have special requirements for transmission efficiency, this feature cannot meet your needs. The maximum transmission of each generated tasks is 1 Mbit/s.

- Only the mapping of all table names, field names, and field types are supported.

  During the full-database migration process, MaxCompute tables are created automatically, where the partition field is pt, the field type is string, and the format is yyyymmdd.

  > **Note** When you select tables for synchronization, all fields must be synchronized and none of these fields can be edited.

2.3.5.2. Migrate a MySQL database

This topic describes how to migrate a MySQL database to MaxCompute.

The database migration feature improves efficiency and reduces costs. It can quickly upload all tables in a MySQL database to MaxCompute. For more information, see Overview.

Procedure

1. Log on to the DataWorks console.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > Data Integration** to go to the **Data Integration** page.
3. In the left-side navigation pane, choose **Sync Resources > Connections**. On the page that appears, click **Add Connection**.
4. In the **Add Connection** dialog box that appears, select **MySQL**.
5. Add a MySQL connection named clone_database for database migration.

6. Click **Test Connection** and verify that the database can be accessed. Click **Complete**.
7. The added MySQL connection named clone_database appears in the connection list. Find the added connection and click **Migrate Database** in the Actions column.

   The database migration settings page consists of three functional modules.

Functional module	Description
Tables to migrate	This module lists all the tables in the MySQL connection named clone_database. Selected tables will be migrated.
Advanced Settings	You can configure the rules for converting the table name, column names, and data types.
Basic settings	You can select whether to synchronize full or incremental data, whether to upload data in one or more batches, and the synchronization efficiency. You can also view the migration progress and results.

8. Click **Advanced Settings** and configure conversion rules based on your needs. For example, you can add an ods_ prefix to the name of each MaxCompute table.
9. Specify basic settings. Set Sync Method to Synchronize Incremental Data Daily, and configure the incremental data to be determined based on the gmt_modified column. Data Integration will generate WHERE clauses based on the specified column and DataWorks scheduling parameters such as ${bdp.system.bizdate}.

   Data Integration reads data from MySQL tables by connecting to a remote MySQL database over JDBC and running SELECT statements. Data Integration uses standard SQL statements, and therefore you can configure WHERE clauses to filter data. The WHERE clause used in this example is provided as follows:

   ```
   STR_TO_DATE('${bdp.system.bizdate}', '%Y%m%d') <= gmt_modified AND gmt_modified < DATE_ADD(
   STR_TO_DATE('${bdp.system.bizdate}', '%Y%m%d'), interval 1 day)
   ```

   Select data upload in batches to protect the MySQL database from being overloaded. Let Data Integration start data synchronization for three tables every one hour from 00:00 each day.

   Click **Commit**. Then, you can view the migration progress and results of each table.
10. Find table a1 and click View Node to view the migration results.

You have configured a node for migrating a MySQL connection named clone_database to MaxCompute. This node is run based on the specified schedule, daily by default. You can also create retroactive node instances to transmit historical data. The database migration feature of **Data Integration** significantly simplifies the initial configurations for migrating your data to the cloud and reduces data migration costs.

You can view the migration success logs of table a1.

2.3.5.3. Migrate Oracle databases

This topic describes how to migrate an Oracle database to MaxCompute.

The database migration feature improves efficiency and reduces costs. It can quickly upload all tables in an Oracle database to MaxCompute. For more information, see Overview.

Procedure

1. Log on to the DataWorks console.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > Data Integration** to go to the **Data Integration** page.
3. In the left-side navigation pane, choose **Sync Resources > Connections**. On the page that appears, click **Add Connection** in the upper-right corner.
4. In the **Add Connection** dialog box that appears, select **Oracle**.
5. Add an Oracle connection named clone_databae for database migration.
6. Click **Test Connection** and verify that the database can be accessed. Click **Complete**.
7. The added Oracle connection named clone_databae appears in the connection list. Find the added connection and click **Migrate Database** in the Actions column.

   The database migration settings page consists of three functional modules.

Functional module	Description
Tables to migrate	This module lists all the tables in the Oracle connection named clone_databae. Selected tables will be migrated.
Advanced Settings	You can configure the rules for converting the table name, column names, and data types.
Basic settings	You can select whether to synchronize full or incremental data, whether to upload data in one or more batches, and the synchronization efficiency. You can also view the migration progress and results.

8. Click **Advanced Settings** and configure conversion rules based on your needs.
9. Set Sync Method to Synchronize All Data Daily.

   > **Note** If a date column exists in your table, you can select incremental migration and configure the incremental data to be determined based on the date column. Data Integration will generate WHERE clauses based on the specified column and DataWorks scheduling parameters such as ${bdp.system.bizdate}.

   Select data upload in batches to protect the Oracle database from being overloaded. Let Data Integration start data synchronization for three tables every one hour from 00:00 each day.

   Click **Commit**. Then, you can view the migration progress and results of each table.
10. Find a related table and click **View Node** to view the node details.

    You have configured a node for migrating an Oracle connection named clone_databae to MaxCompute. This node is run based on the specified schedule, daily by default. You can also create retroactive node instances to transmit historical data. The database migration feature of **Data Integration** significantly simplifies the initial configurations for migrating your data to the cloud and reduces data migration costs.

2.3.6. FAQs

2.3.6.1. What can I do if the status of the node is Pending (Resources)?

Symptom

The node is not functioning properly, and the current instance has no log information recorded. The status of the node is Pending (Resources).

Cause

The node is configured to use a custom resource group but no custom resource group is available.

Resolution

1. Move the pointer over the DataWorks icon and select Operation Center. In the left-side navigation pane, choose **Nodes > Recurring**. In the DAG, right-click the node that is not scheduled as expected and select **View Node Details** to check the resource group used by the node.
2. Move the pointer over the DataWorks icon and select **Project Management**. In the left-side navigation pane, click **Schedule Resources**. On the Schedule Resources page, click **Manage Servers**. Check whether the server is stopped or occupied by other nodes.
3. If the issue persists, restart the service by running the following command:

```
su - admin
/home/admin/alisatasknode/target/alisatasknode/bin/serverctl restart
```

2.3.6.2. RDS data synchronization fails

Description

When data is synchronized from ApsaraDB RDS for MySQL/PostgreSQL to user-created MySQL/SQL Server/PostgreSQL databases, the error message "DataX cannot connect to the corresponding database" appears.

Solution

Take data synchronization from ApsaraDB RDS for MySQL to user-created SQL Server as an example. You must complete the following operations:

1. Add a MySQL connection that supports Java Database Connectivity (JDBC).
2. Use the new connection to configure and run a sync node.

2.3.6.3. How do I troubleshoot data integration issues?

If an error occurs with operations performed in Data Integration, locate the fault first. You can check the information related to the error, such as the running resources, connections, and the region where node instances reside.

Check running resources

- If nodes are run on the default resource group, the following information appears in logs:

```
running in Pipeline[basecommon_ group_xxxxxxxxx]
```

- If nodes are run on a custom resource group of Data Integration, the following information appears in logs:

```
running in Pipeline[basecommon_xxxxxxxxx]
```

- If nodes are run on a dedicated resource group of Data Integration, the following information appears in logs:

```
running in Pipeline[basecommon_S_res_group_xxx]
```

Check connection information

You need to check the following configurations of connections:

- Check the names and types of the source and destination connections.
- Check the network environment.

  Example: ApsaraDB, connections in connection string mode where Data Integration networks can be directly connected, connections in connection string mode where Data Integration networks cannot be directly connected, RDS or other connections in Virtual Private Cloud (VPC), and connections in Finance Cloud (VPC and the classic network).
- Check whether each data source has passed the connectivity test.

  For more information about how to check whether the configurations of connections are correct, see Data sources. Some examples of invalid configurations are as follows:

  - Multiple database names are incorrect.
  - The entered information contains spaces or special characters.
  - Connectivity testing is not supported for the connections, such as the connections in connection string mode where Data Integration networks cannot be directly connected and non-RDS connections in VPCs.

Check the region where node instances reside

Go to DataWorks console, and view the corresponding region, such as China (Shanghai), China (Shenzhen), China (Hong Kong), Singapore, Germany (Frankfurt), and Australia (Sydney). By default, the China (Shanghai) region is selected.

> **Note** You can view the region only after you have purchased the MaxCompute service.

Copy the error message that appears on the page

If an error occurs, copy the error message and send it to engineers.

Analyze errors in logs

- The data store has failed the connectivity test.

  An error message returned because the database cannot be accessed. Database URL: `jdbc:mysql://xx.xx.xx.x:3306/t_demo`. Username: fn_test. Error message: `Access denied for user 'fn_test'@'%' to database 't_demo'`. Check whether the RDS whitelist is properly configured.

Troubleshooting method:

- An error message starting with "Access denied for" returned because the information you specified is incorrect. Check the configurations you specified.
- For example, check whether the RDS whitelist is properly configured and whether the specified account has required database permissions. You can configure the whitelist and permissions in the RDS console.

- The routing policy is incorrect. The node is run on an OXS cluster and an ECS cluster.

  ```
  2017-08-08 15:58:55 : Start Job[xxxxxxx], traceId **running in Pipeline[basecommon_group_xxx_cdp_oxs]
  **ErrorMessage:Code:[DBUtilErrorCode-10]
  ```

  Analysis:

  The database connection failed. Check the account, password, database name, IP address, port, and the network environment or ask the database administrator for help. The database connection failed because no available JDBC URL can be found in the jdbc:oracle:thin:@xxx.xxxxx.x.xx:xxxx:prod configuration you have made.

- java.lang.Exception: DataX cannot connect to the database.

  Analysis:

  Possible reasons are described as follows:

  - The ip, port, database, or jdbc parameter setting is incorrect.
  - The authorization failed because the username or password parameter setting is incorrect. Confirm with the database administrator that the configurations of the database are correct.

  Troubleshooting method:

  Scenario 1:

  - If you need to synchronize data from an Oracle database to an ApsaraDB for PostgreSQL instance, you can only click the **Run** icon. Recurring tasks are not supported for such synchronization because different resource pools are required.
  - When adding an RDS connection, use a normal JDBC URL. Then, Oracle data can be successfully synchronized to ApsaraDB for PostgreSQL.

  Scenario 2:

  - You cannot run nodes related to an ApsaraDB for PostgreSQL instance located in a VPC on custom resource groups. This is because RDS instances use the reverse proxy feature, which can lead to network issues between the RDS instance and your custom resource group. We recommend that you run such nodes on the default resource group. If you need to run such nodes on your custom resource group, configure the RDS instance as a JDBC data store and create an ECS instance in the same Classless Inter-Domain Routing (CIDR) block.
  - The URL of an RDS instance located in a VPC contains an IP address. For example, `jdbc:mysql://100.100.70.1:4309/xxx` where 100.100.70.1 is an IP address. In contrast, the URL of an RDS instance that is not located in a VPC contains a domain name.

- The HBase writer is configured to write data of the Date type.

Synchronize data from an HBase database to another HBase database: 2017-08-15 11:19:29 : State: 4(FAIL) | Total: 0R 0B | Speed: 0R/s 0B/s | Error: 0R 0B | Stage: 0.0% ErrorMessage:Code: [Hbasewriter-01]

Analysis:

The error message returned because you specified an invalid data type.

The HBase writer does not support writing data of the Date type. Currently, it only supports the following data types: String, Boolean, Short, Int, Long, Float, and Double.

Troubleshooting method:

- Change the data type. Do not configure the HBase writer to write data of the Date type.
- Change the data type to String. This is because HBase does not support typed values and stores all data as Byte arrays.

- The configurations you specified are not in the correct JSON format.

  The column configurations are incorrect.

  The intelligent analysis results of DataX show that the most possible cause is as follows:

  ```
  com.alibaba.datax.common.exception.DataXException: Code:[Framework-02]
  ```

  Analysis:

  The DataX engine encountered an error when running. For more information, see the diagnostic information prompted when DataX stops running.

  java.lang.ClassCastException:com.alibaba.fastjson. JSONObject cannot be cast to java.lang.String

  Troubleshooting method:

  The configurations you specified are not in the correct JSON format.

  ```
  For the writer:
  "column":[
  {
  "name":"busino",
  "type":"string"
  }
  ]
  The correct format is provided as follows:
  "column":[
  {
  "busino"
  }
  ]
  ```

- Square brackets ([]) are missing in the JSON list.

  The intelligent analysis results of DataX show that the most possible cause is as follows:

```
com.alibaba.datax.common.exception.DataXException: Code:[Framework-02]
```

Analysis:

The DataX engine encountered an error when running. For more information, see the diagnostic information prompted when DataX stops running.

```
java.lang.String cannot be cast to java.util.List - java.lang.String cannot be cast to java.util.List
at com.alibaba.datax.common.exception.DataXException.asDataXException(DataXException.java:41)
```

Troubleshooting method:

If square brackets ([]) are missing, a list will be recognized as another data type. Add square brackets ([]) if necessary.

- You are not authorized to perform related operations.
  - You do not have the permission to delete tables.

    An error message returned when data is synchronized from MaxCompute to ApsaraDB for MySQL. The error message is as follows:

    ```
    ErrorMessage:Code:[DBUtilErrorCode-07]
    ```

    Analysis:

    The error message returned because the data cannot be read from the database. Check the column, table, where, and querySql parameters you have configured or ask the database administrator for help.

    SQL statement:

    ```
    delete from fact_xxx_d where sy_date=20170903
    ```

    Error message:

    ```
    **DELETE command denied** to user 'xxx_odps'@'[xx.xxx.xxx.xxx](http://xx.xxx.xxx.xxx)' for table 'fact_xxx_d' - com.mysql.jdbc.exceptions.jdbc4.MySQLSyntaxErrorException: DELETE command denied to user 'xxx_odps'@'[xx.xxx.xxx.xxx](http://xx.xxx.xxx.xxx)' for table 'fact_xxx_d'
    ```

    Troubleshooting method:

    The error message starting with "DELETE command denied to" indicates that you are not authorized to delete the table. You must be granted the required permission in the database console.

- You do not have the permission to drop tables.

  ```
  Code:[DBUtilErrorCode-07]
  ```

  Analysis:

  The error message returned because the data cannot be read from the database. Check the column, table, where, and querySql parameters you have configured or ask the database administrator for help.

  SQL statement: `truncate table be_xx_ch`

  Error message:

  ```
  **DROP command denied to user** 'xxx'@'[xxx.xx.xxx.xxx](http://xxx.xx.xxx.xxx)' for table 'be_xx_ch' - com.mysql.jdbc.exceptions.jdbc4.MySQLSyntaxErrorException: DROP command denied to user 'xxx'@'[xxx.xx.xxx.xxx](http://xxx.xx.xxx.xxx)' for table 'be_xx_ch'
  ```

  Troubleshooting method:

  The error message returned because the TRUNCATE statement is specified in the preSql parameter and you are not authorized to drop the table.

- The whitelist is not properly configured.
  - The data store has failed the connectivity test because its whitelist is not properly configured.

    An error occurs because the data store has failed the connectivity test.

    ```
    error message: **Timed out after 5000** ms while waiting for a server that matches ReadPreferenceServerSelector{readPreference=primary}. Client view of cluster state is {type=UNKNOWN, servers=[{[address:3717=dds-bp1afbf47fc7e8e41.mongodb.rds.aliyuncs.com](http://address:3717=dds-bp1afbf47fc7e8e41.mongodb.rds.aliyuncs.com), type=UNKNOWN, state=CONNECTING, exception={com.mongodb.MongoSocketReadException: Prematurely reached end of stream}}, {[address:3717=dds-bp1afbf47fc7e8e42.mongodb.rds.aliyuncs.com](http://address:3717=dds-bp1afbf47fc7e8e42.mongodb.rds.aliyuncs.com), type=UNKNOWN, state=CONNECTING,** exception={com.mongodb.MongoSocketReadException: Prematurely reached end of stream**}}]
    ```

    Troubleshooting method:

    The error message starting with "Timed out after 5000" returned when you add MongoDB connections that are not in the VPC because the whitelist is not properly configured.

    > **Note** If you use ApsaraDB for MongoDB, the MongoDB database has a root account by default. For security concerns, Data Integration only supports access to a MongoDB database by using a MongoDB database account. When adding a MongoDB connection, do not use the root account for access.

- The whitelist is incomplete.

  ```
  for Code:[DBUtilErrorCode-10]
  ```

  Analysis:

  The database connection failed. Check the account, password, database name, IP address, port, and the network environment or ask the database administrator for help.

  Error message:

  ```
  java.sql.SQLException: Invalid authorization specification, message from server: "#**28000ip not in whitelist, client ip is xx.xx.xx.xx". **
  2017-10-17 11:03:00.673 [job-xxxx] ERROR RetryUtil - Exception when calling callable
  ```

  Troubleshooting method:

  The whitelist is incomplete. You have not added your server IP address to the whitelist.

- The connection configurations are incorrect.
  - The connection name is not specified in the code editor.

    ```
    2017-09-06 12:47:05 [INFO] Success to fetch meta data for table with **projectId [43501]** **project ID **and instanceId **[mongodb]connection name. **
    2017-09-06 12:47:05 [INFO] Data transport tunnel is CDP.
    2017-09-06 12:47:05 [INFO] Begin to fetch alisa account info for 3DES encrypt with parameter account: [zz_683cdbcefba143b7b709067b362d4385].
    2017-09-06 12:47:05 [INFO] Begin to fetch alisa account info for 3DES encrypt with parameter account: [zz_683cdbcefba143b7b709067b362d4385].
    [Error] Exception when running task, message:** Configuration property [accessId]Parameter could not be blank! **
    ```

    Troubleshooting method:

    If the error message does not contain any AccessKey, the data synchronization node is usually configured in the code editor. View the JSON code to check whether you have configured the connection information.

- The connection configurations are incorrect.

  ```
  2017-10-10 10:30:08 INFO ==========================================================
  File "/home/admin/synccenter/src/Validate.py", line 16, in notNone
  raise Exception("Configuration property [%s] could not be blank!" % (context))
  **Exception: Configuration property [username] could not be blank! **
  ```

  Troubleshooting method:

  - Check with normal logs:

    ```
    [56810] and instanceId(instanceName) [spfee_test_mysql]...
    2017-10-09 21:09:44 [INFO] Success to fetch meta data for table with projectId [56810] and instanceId
    [spfee_test_mysql].
    ```

  - The logs of ApsaraDB for MySQL show that an error occurs while loading data from data stores and the username parameter returns an empty value. The connection configurations are incorrect.

- The connection to a Distributed Relational Database Service data store times out.

  When you synchronize data from MaxCompute to other database, the following error may occur:

  ```
  [2017-09-11 16:17:01.729 [49892464-0-0-writer] WARN CommonRdbmsWriter$Task
  ```

  Roll back the synchronization, and enable the writer to write only one row at each time.

  ```
  com.mysql.jdbc.exceptions.jdbc4.CommunicationsException: **Communications link failure **
  The last packet successfully received from the server was 529 milliseconds ago. The last packet sent su
  ccessfully to the server was** 528 milliseconds ago**.
  ```

  Troubleshooting method:

  The error occurs because the connection to the DataX client times out. When you add connections, add the `? useUnicode=true&characterEncoding=utf-8&socketTimeout=3600000` parameter.

  Example:

  ```
  jdbc:mysql://10.183.80.46:3307/ae_coupon? useUnicode=true&characterEncoding=utf-8&socketTimeo
  ut=3600000
  ```

- An internal system error occurs.

  Troubleshooting method:

  An internal system error occurs usually because the configurations are not in the correct JSON format in the development environment. If the interface is displayed as blank, you can directly provide the workspace name and the node name to the technical support engineers to fix this problem.

- Dirty data occurs.

- Empty strings (String[""]) cannot be converted into the Long data type.

  ```
  2017-09-21 16:25:46.125 [51659198-0-26-writer] ERROR WriterRunner - Writer Runner Received Exceptio
  ns:
  com.alibaba.datax.common.exception.DataXException: Code:[Common-01]
  ```

  Analysis:

  Dirty data occurs during data synchronization because of infeasible data type conversion. Empty strings (String[""]) cannot be converted into the Long data type.

  Troubleshooting method:

  Empty strings (String[""]) cannot be converted into the Long data type. The two tables use the same CREATE TABLE statement. The error is reported because the empty strings cannot be converted into the Long data type. Configure the data type as String.

- Data is out of valid value range.

  ```
  2017-11-07 13:58:33.897 [503-0-0-writer] ERROR StdoutPluginCollector
  Dirty data:
  {"exception":"Data truncation: Out of range value for column 'id' at row 1","record":[{"byteSize":2,"ind
  ex":0,"rawData":-3,"type":"LONG"},{"byteSize":2,"index":1,"rawData":-2,"type":"LONG"},{"byteSize":2
  ,"index":2,"rawData":"other","type":"STRING"},{"byteSize":2,"index":3,"rawData":"other","type":"ST
  RING"}],"type":"writer"}
  ```

  Troubleshooting method:

  The SMALLINT(5) data type allows negative values while the unsigned INT(11) data type does not. For data synchronization between MySQL data stores, dirty data occurs if the source table has a field of the SMALLINT(5) type and the destination table has a field of the unsigned INT(11) data type.

- Emoji characters are synchronized.

  Dirty data occurs during data synchronization that involves a table with emoji characters.

  Troubleshooting method:

  Dirty data occurs during data synchronization that involves a table with emoji characters. Change the encoding mode.

  - Add connections through JDBC URL.

    ```
    jdbc:mysql://xxx.x.x.x:3306/database? characterEncoding=utf8&com.mysql.jdbc.faultInjection.server
    CharsetIndex=45
    ```

  - Add connections through the ID of the instance.

    Add `? characterEncoding=utf8&com.mysql.jdbc.faultInjection.serverCharsetIndex=45` after the database name you specified.

- Dirty data occurs because of empty columns.

  ```
  {"exception":"Column 'xxx_id' cannot be null","record":[{"byteSize":0,"index":0,"type":"LONG"},{"byteSize":8,"index":1,"rawData":-1,"type":"LONG"},{"byteSize":8,"index":2,"rawData":641,"type":"LONG"}
  ```

  The intelligent analysis results of DataX show that the most possible cause is as follows:

  ```
  com.alibaba.datax.common.exception.DataXException: Code:[Framework-14]
  ```

  Analysis:

  DataX reports more dirty data than expected. For example, you limit the number of dirty data records to one but seven dirty data records are found. In this case, check the dirty data log information or increase the limit.

  DataX reports more dirty data than expected. For example, you limit the number of dirty data records to one but seven dirty data records are found.

  Troubleshooting method:

  According to the code Column 'xxx_id' cannot be null, the xxx_id field cannot be left blank. Dirty data occurs if an xxx_id field value is unspecified. Modify the value or the code.

- The data length exceeds the limit imposed by the field.

  ```
  2017-01-02 17:01:19.308 [16963484-0-0-writer] ERROR StdoutPluginCollector
  Dirty data:
  {"exception":"Data truncation: Data too long for column 'flash' at row 1","record":[{"byteSize":8,"index":0,"rawData":1,"type":"LONG"},{"byteSize":8,"index":3,"rawData":2,"type":"LONG"},{"byteSize":8,"index":4,"rawData":1,"type":"LONG"},{"byteSize":8,"index":5,"rawData":1,"type":"LONG"},{"byteSize":8,"index":6,"rawData":1,"type":"LONG"}
  ```

  Troubleshooting method:

  According to the code Data too long for column 'flash', the flash field imposes a limit on the data length and a field value exceeds the limit. Modify the data or the field.

- The data store is read-only.

  ```
  2016-11-02 17:27:38.288 [12354052-0-8-writer] ERROR StdoutPluginCollector
  Dirty data:
  {"exception":"The MySQL server is running with the --read-only option so it cannot execute this statement","record":[{"byteSize":3,"index":0,"rawData":201,"type":"LONG"},{"byteSize":8,"index":1,"rawData":1474603200000,"type":"DATE"},{"byteSize":8,"index":2,"rawData":"12:00 on September 23","type":"STRING"},{"byteSize":5,"index":3,"rawData":"12:00","type":"STRING"}
  ```

  Troubleshooting method:

  When the data store is read-only, all the data to be synchronized is dirty data. Change the read-only mode of the data store to read/write.

- An error occurs with the partition.

  The setting of the $[yyyymm] parameter is invalid. The log is provided as follows:

  ```
  [2016-09-13 17:00:43]2016-09-13 16:21:35.689 [job-10055875] ERROR Engine
  ```

  The intelligent analysis results of DataX show that the most possible cause is as follows:

  ```
  com.alibaba.datax.common.exception.DataXException: Code:[OdpsWriter-13]
  ```

  Analysis:

  If an error occurs while running a MaxCompute SQL statement, you can try again. If an error occurs while running SQL statements in the destination MaxCompute table, contact the MaxCompute administrator. The SQL statement is provided as follows:

  ```
  alter table db_rich_gift_record add IF NOT EXISTS
     partition(pt='${thismonth}');
  ```

  Troubleshooting method:

  The relative time parameter ${thismonth} becomes invalid because it is included in a pair of single quotation marks ('). Remove the single quotation marks (').

- The column parameter is not organized in a JSON array.

  ```
  Run command failed.
  com.alibaba.cdp.sdk.exception.CDPException: com.alibaba.fastjson.JSONException: syntax error, **ex
  pect {,** actual error, pos 0
  at com.alibaba.cdp.sdk.exception.CDPException.asCDPException(CDPException.java:23)
  ```

  Troubleshooting method:

  The configurations are not specified in the correct format. Example:

  ```
  "plugin": "mysql",**
  "parameter": {
  "datasource": "xxxxx",
  ** "column": "uid",**
  "where": "",
  "splitPk": "",
  "table": "xxx"
  }
  **"column": "uid",-----Not organized in an array**
  ```

- The JDBC URL is not in the correct format.

  Troubleshooting method:

  The JDBC URL is not in the correct format. The correct format is `jdbc:mysql://ServerIP:Port/Database`.

- A data store fails the connectivity test.

  Troubleshooting method:

  - Check whether the firewall limits the IP address and port in use.
  - Check the security group of the port.

- An issue related to uid[xxxxxxxx] is logged.

  ```
  Run command failed.
  com.alibaba.cdp.sdk.exception.CDPException: RequestId[F9FD049B-xxxx-xxxx-xxx-xxxx] Error: CDP server encounter problems, please contact us, reason: An error occurs while retrieving the network information of an instance. Check the account which purchases the RDS instance and the RDS instance name., uid[xxxxxxxx],instance[rm-bp1cwz5886rmzio92]ServiceUnavailable : The request has failed due to a temporary failure of the server.
  RequestId : F9FD049B-xxxx-xxxx-xxx-xxxx
  ```

  Troubleshooting method:

  If the preceding error occurs when you synchronize data from ApsaraDB for RDS to MaxCompute, you can copy RequestId: F9FD049B-xxxx-xxxx-xxx-xxxx to the ApsaraDB for RDS engineers.

- The query parameter is invalid for MongoDB.

  The following error message returned when you synchronize data from a MongoDB database to a MySQL database. The reason is that the query parameter is not in the correct JSON format.

  ```
  Exception in thread "taskGroup-0" com.alibaba.datax.common.exception.DataXException: Code:[Framework-13]
  ```

  Analysis:

  The DataX engine encountered an error when running. For more information, see the diagnostic information prompted when DataX stops running.

  ```
  org.bson.json.JsonParseException: Invalid JSON input. Position: 34. Character: '.'.
  ```

  Troubleshooting method:

  - Invalid example: `"query":"{'update_date':{'$gte':new Date().valueOf()/1000}}"`. Parameters such as new Date() are not supported.
  - Valid example: `"query":"{'operationTime'{'$gte':ISODate('${last_day}T00:00:00.424+0800')}}"`.

- The memory is insufficient.

  ```
  2017-10-11 20:45:46.544 [taskGroup-0] INFO  TaskGroupContainer - taskGroup[0] taskId[358] attemptC
  ount[1] is started
  Java HotSpot™ 64-Bit Server VM warning: INFO: os::commit_memory(0x00007f15ceaeb000, 12288, 0) fai
  led; error='**Cannot allocate memory'** (errno=12)
  ```

  Troubleshooting method:

  The memory is insufficient. If you run a node on custom resources, you need to add memory. If you run a node on the resources provided by Alibaba Cloud, open a ticket.

- The max_allowed_packet parameter is set to an improper value.

  Error message:

  ```
  Packet for query is too large (70 > -1). You can change this value on the server by setting the max_allow
  ed_packet' variable. - **com.mysql.jdbc.PacketTooBigException: Packet for query is too large (70 > -1).
  You can change this value on the server by setting the max_allowed_packet' variable. **
  ```

  Troubleshooting method:

  - The max_allowed_packet parameter defines the maximum length of the communication buffer. A MySQL data store drops packets whose size is larger than the value of this parameter. Therefore, large inserts and updates will fail.
  - If the value of the max_allowed_packet parameter is excessively large, change it to a smaller value. Usually, set it to 10 MB (10 × 1024 × 1024 Bytes).

- HTTP status code 500 is logged because logs cannot be retrieved.

  ```
  Unexpected Error:
  Response is com.alibaba.cdp.sdk.util.http.Response@382db087[proxy=HTTP/1.1 500 Internal Server Er
  ror [Server: Tengine, Date: Fri, 27 Oct 2017 16:43:34 GMT, Content-Type: text/html;charset=utf-8, Transf
  er-Encoding: chunked, Connection: close,
  **HTTP Status 500** - Read timed out**type** Exception report**message**++Read timed out++**desc
  ription**++The server encountered an internal error that prevented it from fulfilling this request.++**e
  xception**
  java.net.SocketTimeoutException: Read timed out
  ```

  Troubleshooting method:

  HTTP status code 500 is logged while your nodes are running on resources provided by Alibaba Cloud. Data Integration fails to retrieve logs. In this case, contact Alibaba Cloud technical support. If the nodes are running on custom resources provided by other vendors, rerun the alisa command.

  > **Note** If you refresh the page and the node is still stopped, you can switch to the admin account and rerun the following alisa command: `/home/admin/alisatatasknode/target/alisatatasknode/bin/serverct1 restart`.

- The hbase.zookeeper.quorum parameter setting for the HBase writer is invalid.

  ```
  2017-11-08 09:29:28.173 [61401062-0-0-writer] INFO  ZooKeeper - Initiating client connection, connectString=xxx-2:2181,xxx-4:2181,xxx-5:2181,xxxx-3:2181,xxx-6:2181 sessionTimeout=90000 watcher=hconnection-0x528825f50x0, quorum=node-2:2181,node-4:2181,node-5:2181,node-3:2181,node-6:2181, baseZNode=/hbase
  Nov 08, 2017 9:29:28 AM org.apache.hadoop.hbase.zookeeper.RecoverableZooKeeper checkZk
  WARNING: **Unable to create ZooKeeper Connection**
  ```

  Troubleshooting method:

  - Invalid example: "hbase.zookeeper.quorum":"xxx-2,xxx-4,xxx-5,xxxx-3,xxx-6"
  - Valid example: "hbase.zookeeper.quorum":"Your ZooKeeper IP address"

- The specified directory is empty.

  The intelligent analysis results of DataX show that the most possible cause is as follows:

  ```
  com.alibaba.datax.common.exception.DataXException: Code:[HdfsReader-08]
  ```

  Analysis:

  The specified directory is empty. The files to be read cannot be found. Check your configurations.

  ```
  path:/user/hive/warehouse/tmp_test_map/*
  at com.alibaba.datax.common.exception.DataXException.asDataXException(DataXException.java:26)
  ```

  Troubleshooting method:

  Check the files based on the directory provided. If files still cannot be found, configure the files.

- The table does not exist.

  The intelligent analysis results of DataX show that the most possible cause is as follows:

  ```
  com.alibaba.datax.common.exception.DataXException: Code:[MYSQLErrCode-04]
  ```

  Analysis:

  The table does not exist. Check the table name or contact the database administrator to check whether the table exists.

  Table name: xxxx.

  Run the following SQL statement: `select * from xxxx where 1=2;` .

  Error message:

  ```
  Table 'darkseer-test.xxxx' doesn't exist - com.mysql.jdbc.exceptions.jdbc4.MySQLSyntaxErrorException: Table 'darkseer-test.xxxx' doesn't exist
  ```

  Troubleshooting method:

  Run the `select * from xxxx where 1=2` SQL statement to check whether the table has any errors. Do appropriate operations on the table if any errors exist.

2.3.6.4. Data synchronization task failure when the column name of the synchronized table is a keyword

Problem

When you perform a synchronization task, the task fails because the column name of the synchronized table is a keyword.

Solution

Take MySQL data source as an example:

1. Create a new table with the name of aliyun, and the statement is as follows:

   ```
   create table aliyun (`table` int ,msg varchar(10));
   ```

2. Create a view and assign an alias to the table column.

   ```
   create view v_aliyun as  select `table` as col1,msg as col2 from aliyun;
   ```

   > **Note**
   > - The word table is a MySQL keyword. In this case, a code error is reported when data is synchronized. To prevent such errors, create a view and assign an alias to the table column.
   > - We do not recommend that you use a keyword as a column name for a table.

3. The preceding statement assigns an alias to a column that has a keyword. Therefore, when configuring a data synchronization task, you can replace the aliyun table with the v_aliyun view.

> **Note**
> - The escape character for MySQL is 'key'.
> - The escape characters for Oracle and PostgreSQL are "keywords".

2.3.6.5. How do I customize table names in a sync node?

Data background

One table with the same schema is created each day. The table names are distinguished by day, such as orders_20170310, orders_20170311, and orders_20170312.

Requirement

You want to create a single sync node to import tables with custom names into MaxCompute. The sync node automatically collects the table data of the previous day from the source database every early morning. For example, the sync node automatically collects the table data of orders_20170314 from the source database on March 15, 2017.

Implementation

1. Log on to the DataWorks console.
2. On the **Data Analytics** page, create a sync node.

   > **Note** When configuring the sync node, select a table name for the source table, for example, orders_20170310.

3. Click **Switch to Code Editor** to switch the codeless user interface (UI) to the code editor.
4. In the code editor, use a variable as the name of the source table, for example, orders_${tablename}.

   In the parameter settings for the sync node, assign a value to the ${tablename} variable. According to the data background, table names are distinguished by day. To enable the sync node to collect the table data of the previous day every day, assign the value $[yyyymmdd-1] to the ${tablename} variable.

   > **Note** You can also directly use the orders_${bdp.system.bizdate} variable as the name of the source table.

After completing the preceding configurations, save and commit the sync node.

2.3.6.6. The specified encoding is incorrect

A data synchronization task may fail with dirty data generated, or it succeed with data garbled. This can be caused by an incorrect encoding setting.

A data synchronization task fails with dirty data generated

Symptom

A data synchronization task fails and dirty data is generated because the specified encoding is incorrect. The error log is shown as follows:

```
016-11-18 14:50:50.766 13350975-0-0-writer ERROR StdoutPluginCollector - Dirty data:<br>
{"exception":"Incorrect string value: '\\xF0\\x9F\\x98\\x82\\xE8\\xA2...' for column 'introduction' at row 1","re
cord":[{"byteSize":8,"index":0,"rawData":9642,"type":"LONG"},
{"byteSize":33,"index":1,"rawData":" Hello world! (http://docs-aliyun.cn-hangzhou.oss.aliyun-inc.com/asse
ts/pic/56134/cn_zh/1498728641169/%E5%9B%BE%E7%89%877.png)
","type":"STRING"},
{"byteSize":8,"index":4,"rawData":0,"type":"LONG"}],"type":"writer"}
2016-11-18 14:50:51. 265 [13350975-0-0-writer] warn maid $ task-roll back this write, commit by writing one r
ow at a time. Because: Java. SQL. batchupdateexception: incorrect string value: '\ xq0 \ x9f \ x88 \ xB6 \ XeF \ x
b8... 'For column' introduction 'at Row 1
```

Cause

The encoding specified for the data source is not utf8mb4. Only the utf8mb4 encoding supports emoji characters.

Solution

- When you add a data source over a JDBC connection, you need to select utf8mb4 as the encoding. An example setting is jdbc:mysql://xxx.x.x.x:3306/database?com.mysql.jdbc.faultInjection.serverCharsetIndex=45. Then, emoji characters can be properly synchronized.
- Change the data source encoding to utf8mb4. For example, modify the encoding of an RDS instance in the RDS console.

A data synchronization task succeed with data garbled

Symptom

A data synchronization task succeeds but data is garbled.

Cause

Three possible causes are listed as follows:

- The source data is garbled.
- The specified encoding is different between the reader and the writer.
- The browser encoding is different from the data source encoding, and therefore the preview fails or the preview is garbled.

Solution

The solution varies with the cause.

- If the source data is garbled, re-process the source data and then start a data synchronization task.
- If the data source encoding is different from the client encoding, correct the settings so that the data source encoding is the same as the client encoding.
- If the browse encoding is different from the data source encoding, correct the settings so that the browser encoding is the same as the data source encoding.

2.4. Data Analytics

2.4.1. Solution

The data analytics mode of DataWorks is upgraded so that you can group multiple workflows in a solution of a workspace.

Overview

DataWorks upgrades the data analytics mode to organize various types of nodes based on the business category, enabling you to better analyze multiple workflows by business. With the data analytics mode that involves the workspace, solution, and workflow, DataWorks defines a new development process and improves user experience.

- A workspace is the basic organizational unit that manages the development and O&M permissions of users. The code of all nodes in a workspace can be collaboratively developed and managed by workspace members.
- A solution contains one or more workflows. It has the following advantages:
  - A solution can contain multiple workflows.
  - A workflow can be added to multiple solutions.

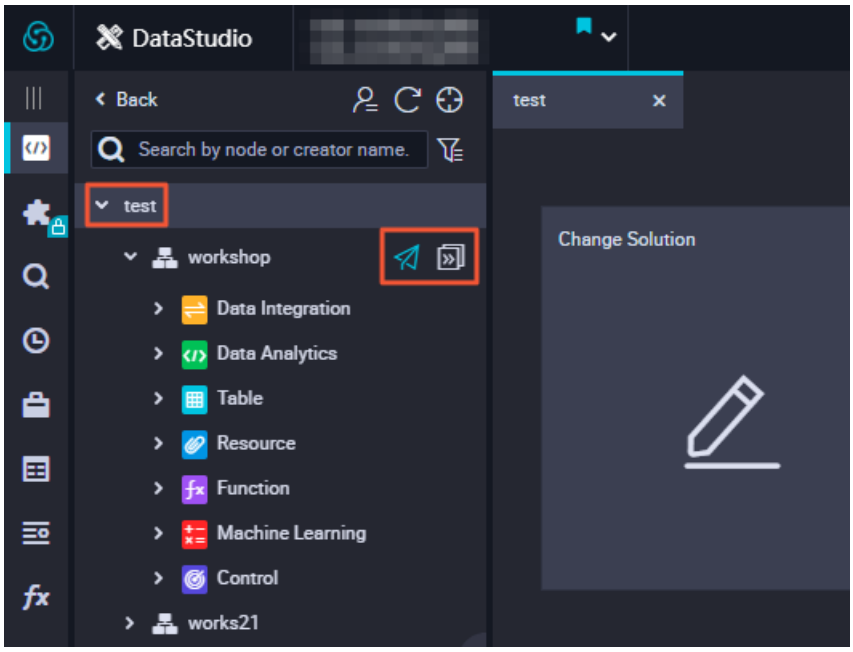
  - All solutions in a workspace can be collaboratively developed and managed by workspace members.

- A workflow is an abstract entity of business that enables you to develop data code from a business perspective. A workflow can be reused by multiple solutions. It has the following advantages:
  - Workflows facilitate business-oriented code development. Nodes in a workflow are organized by type. The hierarchical directory structure is supported. We recommend that you create a maximum of four levels of subfolders. To create a subfolder, right-click the node type and select **Create Folder**.
  - You can view and optimize each workflow from a business perspective.
  - You can view each workflow on a dashboard to efficiently develop code.
  - You can deploy and manage each workflow as a whole.

Develop a solution

If you double-click a solution in the left-side navigation pane, the left-side navigation pane only displays workflows in the solution. This prevents the development process from being affected by the code that is not related to the current solution in the workspace.

1. Go to the **DataStudio** page, move the pointer over the icon, and click **Solution**.
2. In the **Create Solution** dialog box that appears, set **Solution Name**, **Description**, and **Workflows**, and click **Create**.
3. Right-click the created solution and select **Solution Kanban**. On the solution dashboard that appears, you can view the selected workflows or modify the solution.
4. In the left-side navigation pane, double-click the created solution. All workflows in the solution appear in the left-side navigation pane. You can edit the workflows.



Move the pointer over the solution name. The and icons appear.

  - Click the icon. The **Deploy** page appears. You can view the nodes to be deployed in the current solution.

- Click the icon. The **Dashboard** page of **Operation Center** appears. You can view recurring instances of all nodes in the current solution.

A workflow can be reused by multiple solutions. After you develop a solution and add a workflow to the solution, other users can edit the workflow you referenced in their solutions for collaborative development.

Node status model

The node status model defines six states of a node throughout the lifecycle.

2.4.2. SQL coding guidelines and specifications

This topic describes the basic guidelines and detailed specifications of SQL coding.

SQL coding guidelines

The SQL coding guidelines are as follows:

- Make sure that the code is comprehensive.
- Make sure that code lines are clear, neat, well-organized, and structured.
- Consider the optimal execution speed during SQL coding.
- Provide comments whenever necessary to enhance the readability of your code.
- The guidelines impose non-mandatory constraints on the coding behavior of developers. In practice, understandable deviations are allowed when developers obey general rules.
- Use lowercase letters for all keywords and reserved words. Keywords and reserved words include select, from, where, and, or, union, insert, delete, group, having, and count.
- In addition to keywords and reserved words, other code such as field names and table alias must be in lowercase.
- A unit of indentation contains four spaces. All indentations must be the integral multiple of an indentation unit. The code is aligned according to its hierarchy.
- The `select *` operation is prohibited. The column name must be specified for all operations.
- Matching opening and closing parentheses must be placed in the same column.

SQL coding specifications

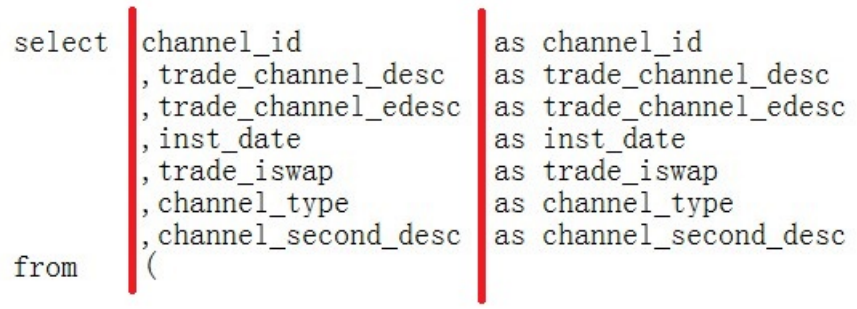
The SQL coding specifications are as follows:

- Code header

  The code header contains information such as the subject, description, author, and date. Reserve a line for change log and a title line so that later users can add change records. Each line can contain a maximum of 80 characters. The template is as follows:

```
-- MaxCompute(ODPS) SQL
--********************************************************************
-- ** Subject: Transaction
-- ** Description: Transaction refund analysis
-- ** Author: Youma
-- ** Created on: 20170616
-- ** Change log:
-- ** Modified on Modified by Content
-- yyyymmdd name comment
-- 20170831 Wuma Add a comment on the biz_type=1234 transaction
--********************************************************************
```

- Field arrangement
  - Use a line for each field that is selected for the SELECT statement.
  - Separate the first field from SELECT by one indentation unit.
  - Enter another field name in a separate line after two indentation units.
  - Place the comma (,) between two fields right before the second field.
  - Place the AS statement in the same line as the corresponding field. We recommend that you keep the AS statements of multiple fields in the same column.



- Clause arrangement for an INSERT statement

  Arrange the clauses of an INSERT statement in the same line.

- Clause arrangement for a SELECT statement

  The clauses such as FROM, WHERE, GROUP BY, HAVING, ORDER BY, JOIN, and UNION in a SELECT statement must be arranged according to the following requirements:
  - Use a line for each clause.
  - Make sure that the clauses are left aligned with the SELECT statement.
  - Add two indentation units between the first word and the other code in a clause.
  - Keep the logical operators such as AND and OR in a WHERE clause left aligned with WHERE.

- If the length of a clause name exceeds two indentation units such as ORDER BY and GROUP BY, add a space between the clause name and its content.

```
select      trim(channel) channel
            ,min(id)      id
from        ods_trd_trade_base_dd
where       channel is not null
and         dt = ${tmp_uuuummdd}
and         trim(channel) <> ''
group by    trim(channel)
order by    trim(channel)
```

- Spacing before and after operators

  Keep one space before and one space after the arithmetic and logical operators and keep the operators in the same line, unless the clause contains more than 80 characters.

```
select      trim(channel) channel
            ,min(id)      id
from        ods_trd_trade_base_dd
where       channel is not null
and         dt = ${tmp_uuuummdd}
and         trim(channel) <> ''
group by    trim(channel)
order by    trim(channel)
```

- CASE statement

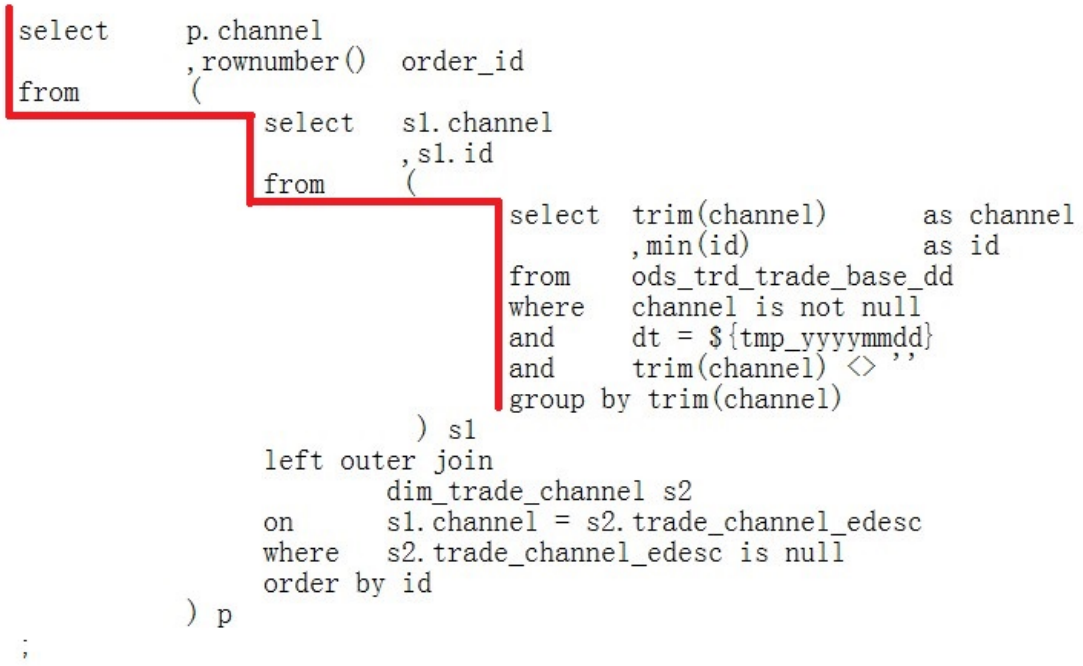
  The CASE statement can be used to determine the value of a field in a SELECT statement. Rules for writing CASE statements are as follows:

  - Place the WHEN clause in the same line as the CASE statement, with one indentation unit between them.
  - Keep a WHEN clause in one line whenever possible. If the statement is long, line breaks can be made.
  - A CASE statement must contain an ELSE clause. The ELSE clause must be aligned with the WHEN clause.

```
,case   when p1.trade_from = '3008' and p1.trade_email is null then 2
        when p1.trade_from = '4000' and p1.trade_email is null then 1
        when p9.trade_from_id is not null then p9.trade_from_id
 end                                as trade_from_id
,p1.trade_email                     as partner_id
```

- Nested query

Nested queries are often used in extract-transform-load (ETL) development of data warehouse systems. The following figure shows an example of a nested query.



```
select      p.channel
            ,rownumber()  order_id
from        (
                select    s1.channel
                          ,s1.id
                from      (
                                select  trim(channel)       as channel
                                        ,min(id)            as id
                                from    ods_trd_trade_base_dd
                                where   channel is not null
                                and     dt = ${tmp_yyyymmdd}
                                and     trim(channel) <> ''
                                group by trim(channel)
                           ) s1
                left outer join
                        dim_trade_channel s2
                on      s1.channel = s2.trade_channel_edesc
                where   s2.trade_channel_edesc is null
                order by id
            ) p
;
```

- Table alias
  - Once an alias is defined for a table in a SELECT statement, use the alias whenever you reference the table in the statement. Therefore, you must specify an alias for each table.
  - We recommend that you define the table aliases with simple characters, such as a, b, c, and d in sequence, and avoid using keywords.

- In the nested query, levels 1 to 4 of SQL statements are named part, segment, unit, and detail, which are abbreviated as P, S, U, and D. You can also use a, b, c, and d to represent levels 1 to 4.

  To differentiate multiple clauses at the same level, add numbers such as 1, 2, 3, and 4 next to the letters. Add comments to the table aliases as needed.

```
select     p.channel
           ,rownumber()  order_id
from       (
               select   s1.channel
                        ,s1.id
               from     (
                            select  trim(channel)      as channel
                                    ,min(id)           as id
                            from    ods_trd_trade_base_dd
                            where   channel is not null
                            and     dt = ${tmp_yyyymmdd}
                            and     trim(channel) <> ''
                            group by trim(channel)
                        ) s1
               left outer join
                       dim_trade_channel s2
               on      s1.channel = s2.trade_channel_edesc
               where   s2.trade_channel_edesc is null
               order by id
           ) p
;
```

- SQL comments
  - Add a comment for each SQL statement.
  - Use a separate line for the comment of each SQL statement and place the comment in front of the SQL statement.
  - Place the comment of a field right after the field.
  - Add comments for clauses that are difficult to understand.
  - Add comments for important code.
  - If a statement is long, we recommend that you add comments based on the purposes of each segment.
  - The description for a constant or variable is required. The comment on the valid value range is optional.

2.4.3. GUI elements

2.4.3.1. Overview

This topic describes the graphical user interface (GUI) elements on the DataStudio page and the configuration tab of an ODPS SQL node.

Log on to the DataWorks console. The **Data Analytics** page appears. You can double-click a created node to perform operations on the node configuration tab.

The following table describes the GUI elements.

No.	GUI element	Description
1	**Show My Nodes Only icon**	Click the icon to view your own nodes.
2	**Search Code icon**	Click the icon to search for a node or a code segment.
3	**Create icon**	Click the icon to create a solution, workflow, folder, node, table, resource, or function.
4	**Refresh icon**	Click the icon to refresh the directory tree in the left-side navigation pane.
5	**Locate icon**	Click the icon to find the current node in the left-side navigation pane.
6	**Import icon**	Click the icon to import local data to an online table. You must specify the encoding format. **Note** In a workspace of the standard mode, the local data is imported to a table in the development environment.
7	**Filter icon**	Click the icon to query nodes based on the specified filter conditions.
8	**Save icon**	Click the icon to save the code of the current node.
9	**Save as Ad-Hoc Query Node icon**	Click the icon to save the code of the current node in an ad-hoc query node. You can find the node on the Ad-Hoc Query tab.
10	**Commit icon**	Click the icon to commit the current node.
11	**Commit and Unlock icon**	Click the icon to commit and unlock the current node for editing.
12	**Steal Lock icon**	Click the icon to steal the lock of the current node and then edit it if you are not the owner of the node.
13	**Run icon**	Click the icon to run the code of the current node. You only need to assign values to variables in SQL statements once. The initial values are retained even if the node code changes.

No.	GUI element	Description
14	**Run with Arguments icon**	Click the icon to run the code of the current node with the configured parameters. You must manually assign values to variables in SQL statements each time you click this icon. The initial values are passed to the **Run with Arguments** feature, which replaces the initial values with the assigned values. For example, if the run date of a node is set to April 2, the node always runs on April 2 when you click the Run icon. After you click Run with Arguments icon and change the run date to April 3, the run date is updated. When you click the Run icon again, the node is run on April 3.
15	**Stop icon**	Click the icon to stop running the code of the current node.
16	**Reload icon**	Click the icon to reload the code of the current node. The code will be restored to the version last saved. Unsaved changes will be lost.
17	**Run Smoke Test icon**	Click the icon to test the code of the current node. A smoke test allows you to replace the values of scheduling parameters in the specified data timestamp with your simulated ones. This feature tests the effect of value changes for scheduling parameters. **Note** Each time after you modify the values of scheduling parameters, you must save and commit the modification before running the smoke test. Otherwise, the new values of scheduling parameters do not take effect.
18	**View Smoke Test Log icon**	Click the icon to view the runtime logs of the current script template.
19	**Format Code icon**	Click the icon to format the code to avoid excessively long code in a single line.
20	**Operation Center button**	Click the icon to go to Operation Center.
21	**Properties tab**	Click the tab to configure the properties such as the scheduling properties, parameters, and resource group for the current node.
22	**Lineage tab**	Click the tab to view the relationships between the current node and other nodes.
23	**Versions tab**	Click the tab to view the committed and deployed versions of the current node.
24	**Code Structure tab**	Click the tab to view the code structure of the current node. If the code is excessively long, you can quickly find a code segment based on the key information in the structure.

2.4.3.2. Schedule

2.4.3.2.1. Basic properties

On the Properties tab of a node, you can set parameters of the node in the General, Schedule, Dependencies, and Parameters sections. The General section allows you to set the basic properties of the node.

On the **Data Analytics** tab of the DataStudio page, double-click a node. On the node configuration tab that appears, click the **Properties** tab in the right-side navigation pane and set the parameters in the **General** section.

Parameter	Description
Node Name	The name of the node that you set when creating the node. To modify the name, right-click the node in the left-side navigation pane and select **Rename**.
Node ID	The unique ID of the node. The node ID is generated when the node is committed at the first time. The node ID cannot be modified.
Node Type	The type of the node that you set when creating the node. The node type cannot be modified.
Owner	The owner of the node. By default, the owner of a newly created node is the current logon user. You can change the owner. **Note** Only a member in the workspace where the node resides can be selected as the owner.
Description	The description of the node, such as the business and usage.
Arguments	The parameter used to assign a value to a variable in the code during node scheduling. You can enter multiple parameters. Separate multiple parameters with spaces.

Parameter value assignment formats for various node types

- Format for ODPS SQL and ODPS MR nodes: `Variable name 1=Parameter 1 Variable name 2=Parameter 2`. Separate multiple parameters with spaces.
- Format for Shell nodes: `Parameter 1 Parameter 2`. Separate multiple parameters with spaces.

For more information about the built-in scheduling parameters, see Parameter configuration.

2.4.3.2.2. Parameter configuration

In common data development scenarios, the code of different types of nodes may be subject to change from time to time. You must dynamically modify the values of some parameters, such as the date and time, based on the requirement changes and time changes.

In this case, you can use the parameter configuration feature of DataWorks. After relevant parameters are configured, auto triggered nodes can automatically parse the code to obtain required data. Configurable parameters in DataWorks are classified into system parameters and custom parameters. We recommend that you use custom parameters.

{ "data":[{ "beginRunningTime":"1564019679966", "beginWaitResTime":"1564019679966", "beginWaitTimeTime":"1564019679506", "bizdate":"1559318400000", "createTime":"1564019679464", "dagId":332455685, "dagType":5, "finishTime":"1564019679966", "instanceId":2427622331, "modifyTime":"1564019679966", "nodeName":"vi","status":6 }], "errCode":"0", "errMsg":"", "requestId":"E17535-8C06-43F6-B1EA-6236FE9", "success":true }

Auto-completion is supported when you specify a data type for a parameter.

Parameter types

Parameter type	Configuration method	Applicable to	Example
System parameters: including bdp.system.bizdate and bdp.system.cyctime	To use the system parameters in the scheduling system, directly reference ${bdp.system.bizdate} and ${bdp.system.cyctime} in the code, instead of configuring them in the Arguments field. The system can automatically replace the values of the parameters that reference the system parameters in the code.	All node types	None
Non-system parameters: custom parameters (recommended)	Reference ${key1} and ${key2} in the code and configure them in the Arguments field, for example, `"key1=value1 key2=value2"`.	Non-Shell nodes	• **Constant parameters**: param1="abc"param2=1234. • **Variables**: param1=$[yyyymmdd], the value of which is calculated based on the value of bdp.system.cyctime.
	Reference $1, $2, and $3 in the code and configure them in the Arguments field, for example, `"value1 value2 value3"`.	Shell nodes	• **Constant parameters**: "abc" 1234. • **Variables**: $[yyyymmdd], the value of which is calculated based on the value of bdp.system.cyctime.

As described in the preceding table, the values of custom variables are calculated based on the values of system parameters. You can use custom variables to flexibly define the data to be obtained and the data format. For custom parameters, different brackets are used as follows:

- Braces ({ }): defines the data timestamp. For example, the value of {yyyymmdd} is calculated based

on the value of bdp.system.bizdate.

- Brackets ([ ]): defines the running time. For example, the value of [yyyymmddhh] is calculated based on the value of bdp.system.cyctime.

> **Note** Nodes can only be scheduled in the production environment. Therefore, the values of scheduling variables are replaced only after nodes are run in the production environment.
>
> After configuring the scheduling properties for a node, you can click the **Run Smoke Test in Development Environment** icon on the node configuration tab to test whether the values of scheduling variables can be replaced as expected during node scheduling.
>
> You can click the **Properties** tab in the right-side navigation pane, and assign values to scheduling variables in the **Arguments** field in the **General** section. Note the following issues when configuring parameters:
>
> - Do not add spaces on either side of the equal sign (=) for a parameter. For example, enter `bizdate=$bizdate`.
> - Separate multiple parameters (if any) with spaces. For example, enter `bizdate=$bizdate datetime=${yyyymmdd}`.

System parameters

DataWorks provides the following system parameters:

- ${bdp.system.cyctime}: the scheduled time to run an instance. Default format: yyyymmddhh24miss. This parameter can specify the hour and minutes of the scheduled time.
- ${bdp.system.bizdate}: the timestamp of data to be analyzed by an instance. Default format: yyyymmdd. The default data timestamp is one day before the scheduled time.

The formula for calculating the running time and data timestamp is as follows: `Running time = Data timestamp + 1`.

To use the system parameters, you can directly reference them in the code, instead of configuring them in the Arguments field. The system can automatically replace the values of the parameters that reference the system parameters in the code.

> **Note** The scheduling properties of an auto triggered node are configured to define the scheduling rules of the running time. Therefore, you can calculate the data timestamp based on the scheduled time to run an instance and obtain the values of system parameters for the instance.
>
> The parameter configuration procedure of a PyODPS node is slightly different from that of other nodes. For more information, see PyODPS nodes.

Example of system parameters

For example, to set an ODPS SQL node to run once per hour from 00:00 to 23:59 every day, follow these steps if you want to use system parameters in the code:

1. Reference system parameters in the code as follows:

```
insert overwrite table tb1 partition(ds ='20150304') select
c1,c2,c3
from (
select * from tb2
where ds ='${bdp.system.cyctime}') t
full outer join(
select * from tb3
where ds = '${bdp.system.bizdate}') y
on t.c1 = y.c1;
```

2. After the preceding step, your node is partitioned by using the system parameters. Then, configure the scheduling properties and dependencies. For more information, see Schedule and Dependencies. In this example, the node is scheduled by hour.
3. After setting the recurrence and dependencies, commit and deploy the node. Then, you can check the node in Operation Center. The scheduling system generates instances for the auto triggered node from the second day. You can right-click an instance in the directed acyclic graph (DAG) and select **View Runtime Log** to view the parsed values of the system parameters.

   For example, the scheduling system generated 24 running instances for the node on January 14, 2019. The data timestamp is January 13, 2019 for all instances, that is, one day before the running date. Therefore, the value of ${bdp.system.bizdate} is 20190113. The running time is the running date plus the scheduled time. Therefore, the value of ${bdp.system.cyctime} is 20190114000000 plus the scheduled time of each instance.

   Open the runtime logs of each instance and search for the replaced values of the system parameters in the code:

   - The scheduled time for the first instance is 2019-01-14 00:00:00. Therefore, bdp.system.bizdate is replaced with 20190113 and bdp.system.cyctime is replaced with 20190114000000.
   - The scheduled time for the second instance is 2019-01-14 01:00:00. Therefore, bdp.system.bizdate is replaced with 20190113 and bdp.system.cyctime is replaced with 20190114010000, as shown in the preceding figure.
   - Similarly, the scheduled time for the twenty-fourth instance is 2019-01-14 23:00:00. Therefore, bdp.system.bizdate is replaced with 20190113 and bdp.system.cyctime is replaced with 20190114230000.

Custom parameters for non-Shell nodes

To configure scheduling variables for a non-Shell node, add ${Variable name} in the code to reference the function and assign a value to the scheduling variable.

> **Note** The name of a variable in the SQL code can contain only lowercase letters (a-z), uppercase letters (A-Z), digits, and underscores (_). If the variable name is date, the value of $bizdate is automatically assigned to this variable. For more information, see the Custom parameters section in this topic. You do not need to assign a value in the Arguments field. Even if another value is assigned, it is not used in the code because the value of $bizdate is automatically assigned in the code by default.

Example of custom parameters for non-Shell nodes

For example, to set an ODPS SQL node to run once per hour from 00:00 to 23:59 every day, follow these steps if you want to use the hour-related custom variables thishour and lasthour in the code:

1. Reference custom parameters in the code as follows:

```
insert overwrite table tb1 partition(ds ='20150304')  select
 c1,c2,c3
from (
 select * from tb2
 where ds ='${thishour}') t
full outer join(
 select * from tb3
 where ds = '${lasthour}') y
on t.c1 = y.c1;
```

2. Click the **Properties** tab in the right-side navigation pane of the node configuration tab. Assign values to the custom parameters referenced in the code in the **Arguments** field in the **General** section.

   Configure the custom parameters as follows:

   - thishour=$[yyyy-mm-dd/hh24:mi:ss]
   - lasthour=$[yyyy-mm-dd/hh24:mi:ss-1/24]

   > **Note** The value of yyyy-mm-dd/hh24:mi:ss corresponds to that of cyctime. For more information, see the Custom parameters section in this topic.

   You can enter `thishour=$[yyyy-mm-dd/hh24:mi:ss] lasthour=$[yyyy-mm-dd/hh24:mi:ss-1/24]` in the **Arguments** field.

3. Set the node to run once per hour.
4. After setting the recurrence and dependencies, commit and deploy the node. Then, you can check the node in Operation Center. The scheduling system generates instances for the auto triggered node from the second day. You can right-click an instance in the DAG and select **View Runtime Log** to view the parsed values of the custom parameters. The value of cyctime is 20190114010000. Therefore, the value of thishour is 2019-01-14/01:00:00 and the value of lasthour, which indicates the last hour, is 2019-01-14/00:00:00.

Custom parameters for Shell nodes

The parameter configuration procedure of a Shell node is similar to that of a non-Shell node, except that the variable naming rules are different. Variable names for a Shell node cannot be customized, but must follow the $1,$2,$3... format. For example, add $1 in the code of a Shell node and enter the built-in scheduling parameter $xxx in the Arguments field. Then, the value of $xxx can replace that of $1 in the code.

> **Note** If the number of parameters in a Shell node reaches 10, use ${10} to declare the tenth variable.

Example of custom parameters for Shell nodes

For example, set a Shell node to run at 01:00 every day. To use the custom constant parameter myname and the custom variable ct in the code, follow these steps:

1. Reference custom parameters in the code as follows:

   ```
   echo "hello $1, two days ago is $2, the system param is ${bdp.system.cyctime}";
   ```

2. Click the **Properties** tab in the right-side navigation pane of the node configuration tab. Assign values to the custom parameters referenced in the code in the **Arguments** field in the **General** section. Separate multiple parameters with spaces, for example, enter Parameter 1 Parameter 2 Parameter 3. The custom parameters are parsed based on the parameter sequence. For example, $1 is replaced with the value of Parameter 1. In this example, enter abcd $[yyyy-mm-dd-2] in the Arguments field to set $1 and $2 to abcd and $[yyyy-mm-dd-2], respectively.
3. Set the node to run at 01:00 every day.
4. After setting the recurrence and dependencies, commit and deploy the node. Then, you can check the node in Operation Center. The scheduling system generates instances for the auto triggered node from the second day. Right-click an instance in the DAG and select **View Runtime Log**. The logs show that $1 in the code is replaced with abcd, $2 is replaced with 2019-01-12 (two days before the running date), and ${bdp.system.cyctime} is replaced with 20190114010000.

Custom parameters

Custom parameters are divided into constant parameters and variables based on the value type. DataWorks provides some built-in scheduling parameters as variables.

- Constant parameters

  For example, for an SQL node, add ${Variable name} in the code and configure the following parameter for the node: Variable name=Fixed value.

  - Code: `select xxxxxx type='${type}'`
  - Value assigned to the scheduling variable: type='aaa'. When the node is run, the variable in the code is replaced as follows: type='aaa'.

- Variables

  Variables are built-in scheduling parameters whose values depend on the system parameters ${bdp.system.bizdate} and ${bdp.system.cyctime}.

  For example, for an SQL node, add ${Variable name} in the code and configure the following parameter for the node: Variable name=Scheduling parameter.

  - Code: `select xxxxxx dt=${datetime}`
  - Value assigned to the scheduling variable: datetime=$bizdate

    If the node is run on July 22, 2017, the variable in the code is replaced as follows: dt=20170721.

Built-in scheduling parameters

- $bizdate
  - Parameter description: the data timestamp in the format of yyyymmdd. By default, the value of this parameter is one day before the scheduled time to run a node.
  - For example, the code of an ODPS SQL node includes pt=${datetime}, and the parameter configured for the node is datetime=$bizdate. If the node is run on July 22, 2017, $bizdate is replaced as follows: pt=20170721.

- $cyctime
  - Parameter description: the scheduled time to run a node. If no scheduled time is configured for a node scheduled by day, $cyctime is set to 00:00 of the day. The time is accurate to seconds. This parameter is usually used for nodes scheduled by hour or minute.

    > **Note**
    > - Pay attention to the difference between the time parameters configured by using $[] and ${}. $bizdate specifies the data timestamp, which is one day before the current day by default.
    > - $cyctime specifies the scheduled time to run a node. If no scheduled time is configured for a node scheduled by day, $cyctime is set to 00:00 of the day. The time is accurate to seconds. This parameter is usually used for nodes scheduled by hour or minute.
    >
    >   For example, if a node is scheduled to run at 00:30 on the current day, $cyctime is set to yyyy-mm-dd 00:30:00.
    > - If a time parameter is configured by using ${}, $bizdate is used as the benchmark for running nodes. The time parameter is replaced with the data timestamp selected for retroactive data generation.
    > - If a time parameter is configured by using $[], $cyctime is used as the benchmark for running nodes. The time is calculated in the same way as the time in Oracle. The time parameter is replaced with the data timestamp selected for retroactive data generation plus one day.
    >
    >   For example, if the data timestamp is set to 20140510 for retroactive data generation, $cyctime is replaced with 20140511.

  - Examples: assume that $cyctime=20140515103000
    - $[yyyy] = 2014, $[yy] = 14, $[mm] = 05, $[dd] = 15, $[yyyy-mm-dd] = 2014-05-15, $[hh24:mi:ss] = 10:30:00, $[yyyy-mm-dd hh24:mi:ss] = 2014-05-1510:30:00
    - $[hh24:mi:ss - 1/24] = 09:30:00
    - $[yyyy-mm-dd hh24:mi:ss -1/24/60] = 2014-05-1510:29:00
    - $[yyyy-mm-dd hh24:mi:ss -1/24] = 2014-05-15 09:30:00
    - $[add_months(yyyymmdd,-1)] = 20140415
    - $[add_months(yyyymmdd,-12*1)] = 20130515
    - $[hh24] =10
    - $[mi] =30
  - Method for testing the $cyctime parameter:

    After an instance starts to run, right-click the instance in the DAG and select **More**. Check whether the scheduled time is the time at which the instance is run.

- $jobid
  - Parameter description: the ID of the workflow to which a node belongs.
  - Example: jobid=$jobid.
- $nodeid
  - Parameter description: the ID of a node.

  - Example: nodeid=$nodeid.

- $taskid
  - Parameter description: the instance ID of a node.
  - Example: taskid=$taskid.

- $bizmonth
  - Parameter description: the month of the data timestamp in the format of yyyymm. If the month of a data timestamp is the current month, the value of $bizmonth is the month of the data timestamp minus 1. Otherwise, the value of $bizmonth is the month of the data timestamp.
  - For example, the code of an ODPS SQL node includes pt=${datetime}, and the parameter configured for the node is datetime=$bizmonth.

    Assume that the current day is July 22, 2017. If the node is run on July 22, 2017, $bizmonth is replaced as follows: pt=201706.

- ${...} custom parameter
  - You can customize a time format based on the value of $bizdate, where yyyy indicates the four-digit year, yy indicates the two-digit year, mm indicates the month, and dd indicates the day. You can use any combination of these parameters, for example, ${yyyy}, ${yyyymm}, ${yyyymmdd}, and ${yyyy-mm-dd}.
  - $bizdate is accurate to the day. Therefore, ${...} can only specify the year, month, or day.
  - The following table describes how to specify other intervals based on $bizdate.

Interval	Expression
N years later	${yyyy+N}
N years before	${yyyy-N}
N months later	${yyyymm+N}
N months before	${yyyymm-N}
N weeks later	${yyyymmdd+7*N}
N weeks before	${yyyymmdd-7*N}
N days later	${yyyymmdd+N}
N days before	${yyyymmdd-N}

- $gmtdate
  - Parameter description: the current date in the format of yyyymmdd. By default, the value of this parameter is the current date. During retroactive data generation, the input value is the data timestamp plus one day.
  - For example, the code of an ODPS SQL node includes pt=${datetime}, and the parameter configured for the node is datetime=$gmtdate. Assume that the current day is July 22, 2017. If the node is run on July 22, 2017, $gmtdate is replaced as follows: pt=20170722.

- ${yyyymmdd}

- Parameter description: the data timestamp in the format of yyyymmdd. The value of this parameter is the same as that of $bizdate. This parameter supports delimiters, for example, yyyy-mm-dd.

  By default, the value of this parameter is one day before the scheduled time to run a node. You can customize a time format for this parameter, for example, yyyy-mm-dd for ${yyyy-mm-dd}.

- Examples:
  - The code of an ODPS SQL node includes pt=${datetime}, and the parameter configured for the node is datetime=${yyyy-mm-dd}. If the node is run on July 22, 2018, ${yyyy-mm-dd} is replaced as follows: pt=2018-07-21.
  - The code of an ODPS SQL node includes pt=${datetime}, and the parameter configured for the node is datetime=${yyyymmdd-2}. If the node is run on July 22, 2018, ${yyyymmdd-2} is replaced as follows: pt=20180719.
  - The code of an ODPS SQL node includes pt=${datetime}, and the parameter configured for the node is datetime=${yyyymm-2}. If the node is run on July 22, 2018, ${yyyymm-2} is replaced as follows: pt=201805.
  - The code of an ODPS SQL node includes pt=${datetime}, and the parameter configured for the node is datetime=${yyyy-2}. If the node is run on July 22, 2018, ${yyyy-2} is replaced as follows: pt=2016.
  - You can assign values to multiple parameters when configuring an ODPS SQL node. For example, set startdatetime=$bizdate enddatetime=${yyyymmdd+1} starttime=${yyyy-mm-dd} endtime=${yyyy-mm-dd+1}.

FAQ

- Q: The table partition format is pt=yyyy-mm-dd hh24:mi:ss, but spaces are not allowed in scheduling parameters. How can I configure the format of $[yyyy-mm-dd hh24:mi:ss]?

  A: Use the custom variables datetime=$[yyyy-mm-dd] and hour=$[hh24:mi:ss] to obtain the date and time. Then, join them together to form pt="${datetime} ${hour}" in the code. Separate the two variables with a space.

- Q: The table partition is pt="${datetime} ${hour}" in the code. To obtain the data for the last hour when the node is run, the custom variables datetime=$[yyyymmdd] and hour=$[hh24-1/24] can be used to obtain the date and time, respectively. However, for an instance running at 00:00, it analyzes data for 23:00 of the current day, instead of 23:00 of the previous day. What measures can I take in this case?

  A: Modify the formula of datetime to $[yyyymmdd-1/24] and keep the formula of hour unchanged at $[hh24-1/24]. The node is run as follows:

  - For an instance that is scheduled to run at 2015-10-27 00:00:00, the values of $[yyyymmdd-1/24] and $[hh24-1/24] are 20151026 and 23, respectively. This is because the scheduled time minus 1 hour is a time value that belongs to yesterday.
  - For an instance that is scheduled to run at 2015-10-27 01:00:00, the values of $[yyyymmdd-1/24] and $[hh24-1/24] are 20151027 and 00, respectively. This is because the scheduled time minus 1 hour is a time value that belongs to the current day.

DataWorks offers the following node running modes:

- Manually run a node in DataStudio: You must assign temporary values to parameters in the code to make sure the proper running of the node. The assigned values are not saved as node properties and do not take effect in other node running modes.

- Automatically run a node at specified intervals: No configuration is needed in the Arguments field. The scheduling system automatically replaces the values of parameters based on the scheduled time of the current instance.
- Test a node or generate retroactive data: You must specify the data timestamp. The scheduled time of each instance can be calculated according to the formula described earlier in this topic.

2.4.3.2.3. Scheduling properties

This topic describes how to configure the scheduling properties of a node, including the recurrence and dependencies.

You can click the **Properties** tab in the right-side navigation pane of the node configuration tab and set the parameters in the **Schedule** section.

Node status

- **Normal**: If you select this option, the node is run based on the recurrence. By default, this option is selected for a node.
- **Dry Run**: If you select this option, the node is run based on the recurrence. However, the scheduling system does not actually run the code but directly returns a success response.
- **Retry Upon Error**: If you select this check box, the node is rerun when it encounters an error. By default, a node can be automatically rerun for a maximum of three times at an interval of 2 minutes.
- **Skip Execution**: If you select this check box, the node is run based on the recurrence. However, the scheduling system does not actually run the code but directly returns a failure response. You can select this check box if you want to suspend a node and run it later.

Recurrence

After a node is committed and deployed, the scheduling system generates instances every day from the next day based on the scheduling properties of the node. Then, the scheduling system runs the instances based on the running results of ancestor instances and the scheduled time. If a node is committed and deployed after 23:30, the scheduling system generates instances for it from the third day.

> **Note**
>
> If you schedule a node to run every Monday, the node is run only on Mondays. On the other days, the scheduling system does not actually run the code but directly returns a success response. When you test a node scheduled by week or generate retroactive data for the node, you must set the data timestamp to one day earlier than the scheduled time to run the node.
>
> For an auto triggered node, its dependencies take priority over other scheduling properties. That is, when the scheduled time arrives, the scheduling system does not immediately run a node instance but first checks whether all the ancestor instances are run.
>
> - The node instance is in the Not Running state if any ancestor instances are not run when the scheduled time arrives.
> - The node instance is in the Pending (Schedule) state if the scheduled time does not arrive but all the ancestor instances are run.
> - The node instance is in the Pending (Resources) state if all the ancestor instances are run and the scheduled time arrives.

Cross-cycle dependencies

DataWorks supports the following three types of cross-cycle dependencies:

- Dependency on instances of child nodes
  - Node dependency: The current node depends on the last-cycle instances of its child nodes. For example, Node A has three child nodes B, C, and D. If you select this node dependency, Node A depends on the last-cycle instances of nodes B, C, and D.
  - Business scenario: The current node depends on instances of child nodes in the last cycle to cleanse the output tables of the current node and check whether the final result is generated properly.
- Dependency on instances of the current node
  - Node dependency: The current node depends on its last-cycle instances.
  - Business scenario: The current node depends on the data output result of its last-cycle instances.
- Dependency on instances of custom nodes: If you select this node dependency, enter the IDs of the nodes on which the current node depends. You can specify multiple nodes and separate their IDs with commas (,). For example, enter 12345,23456.
  - Node dependency: The current node depends on the last-cycle instances of custom nodes.
  - Business scenario: In the business logic, the current node depends on the proper output of other business data that is not processed by the current node.

> **Note** The difference between cross-cycle dependencies and dependencies in the current cycle lies in that cross-cycle dependencies are displayed as dotted lines in Operation Center.
>
> Before deleting a node from Operation Center, you must delete all dependencies of the node so that other nodes can run properly.

Scheduled by day

Nodes scheduled by day are automatically run once per day. When you create an auto triggered node, the node is set to run at 00:00 every day by default. You can specify another time as needed. In the example shown in the following figure, the time is specified as 13:00.

- If you select Customize Runtime, the node is run at the specified time every day. The time format is YYYY-MM-DD HH:MM:SS.

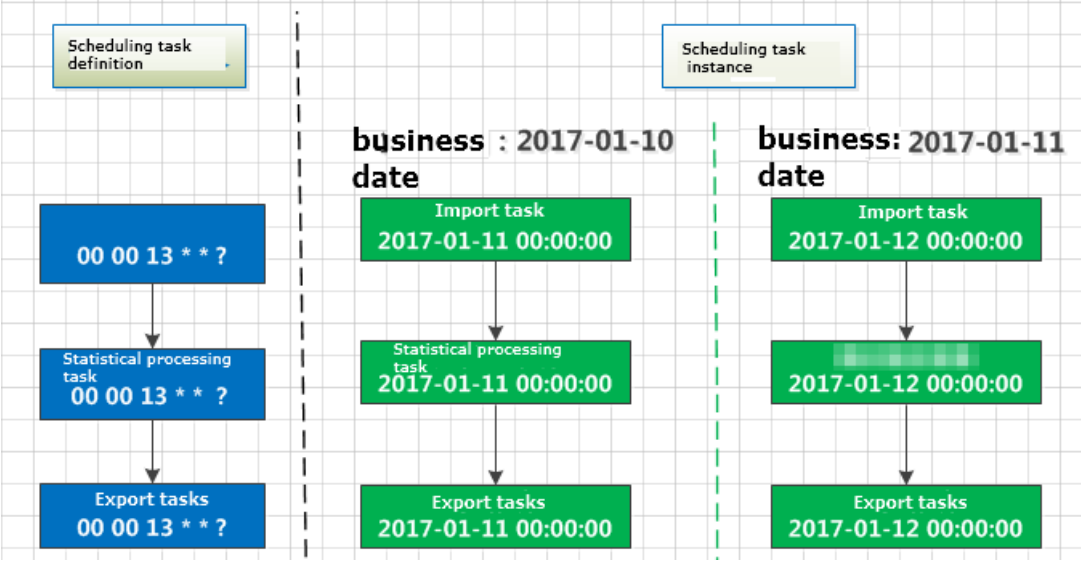
  > **Note** An auto triggered node can be run only when all the ancestor instances are run and the scheduled time arrives. Both prerequisites are indispensable and have no specific chronological order.

- If you clear Customize Runtime, the scheduled time of the node is randomly set in the range of 00:00 to 00:30.

Scenarios:

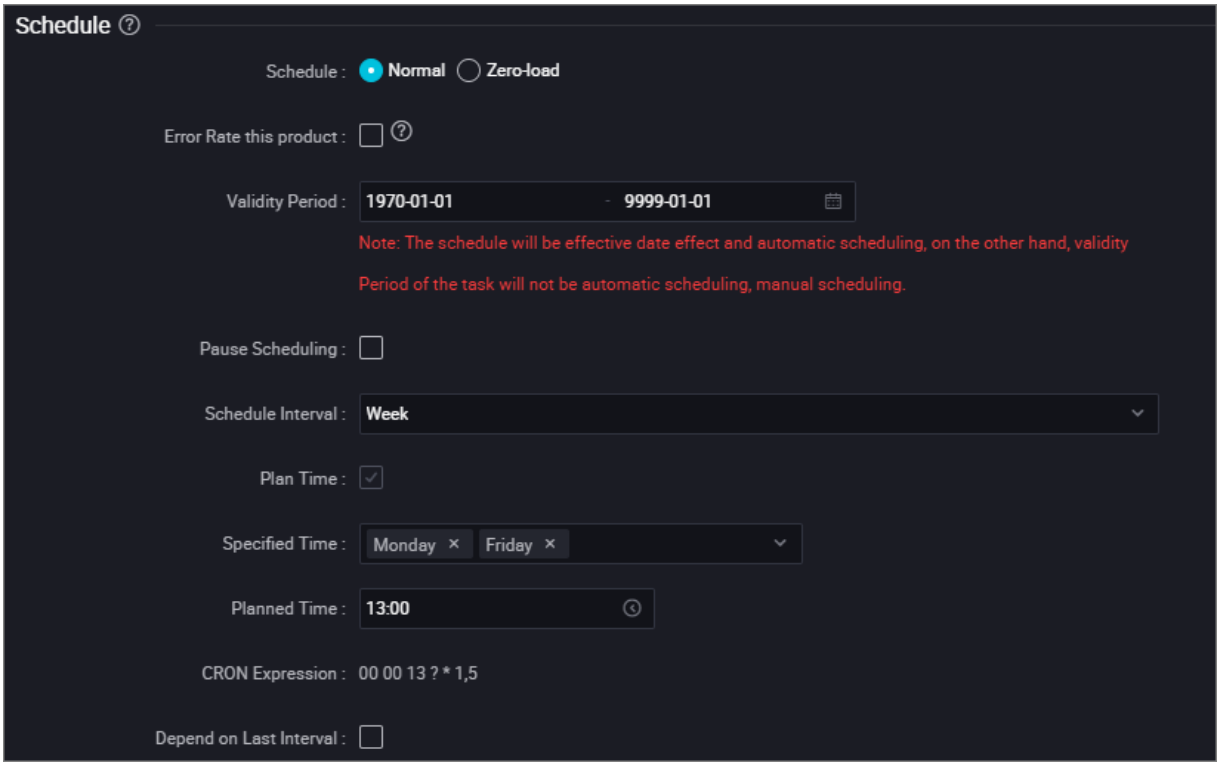
For example, you have created an import node, an analytics node, and an export node. They are all scheduled to run at 13:00 every day. The analytics node depends on the import node, and the export node depends on the analytics node. The following figure shows that the analytics node is configured to depend on the import node.

Based on the preceding node scheduling properties, the scheduling system automatically generates and runs instances for the nodes, as shown in the following figure.



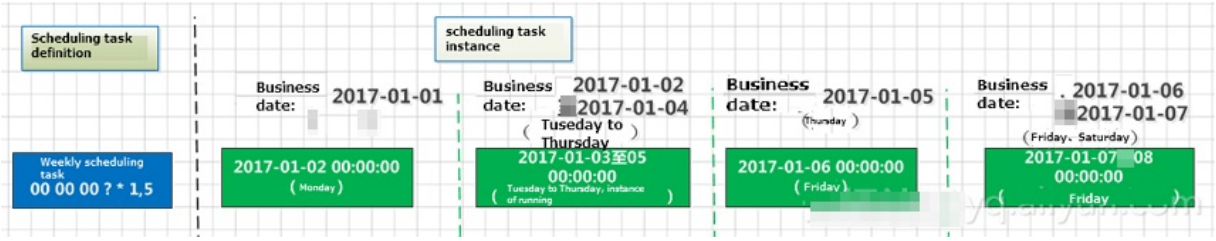
Scheduled by week

Nodes scheduled by week are automatically run at a specified time of specified days every week. On the other days, the scheduling system still generates instances to make sure the proper running of descendant instances. However, the system does not actually run the code or consume resources but directly returns a success response.



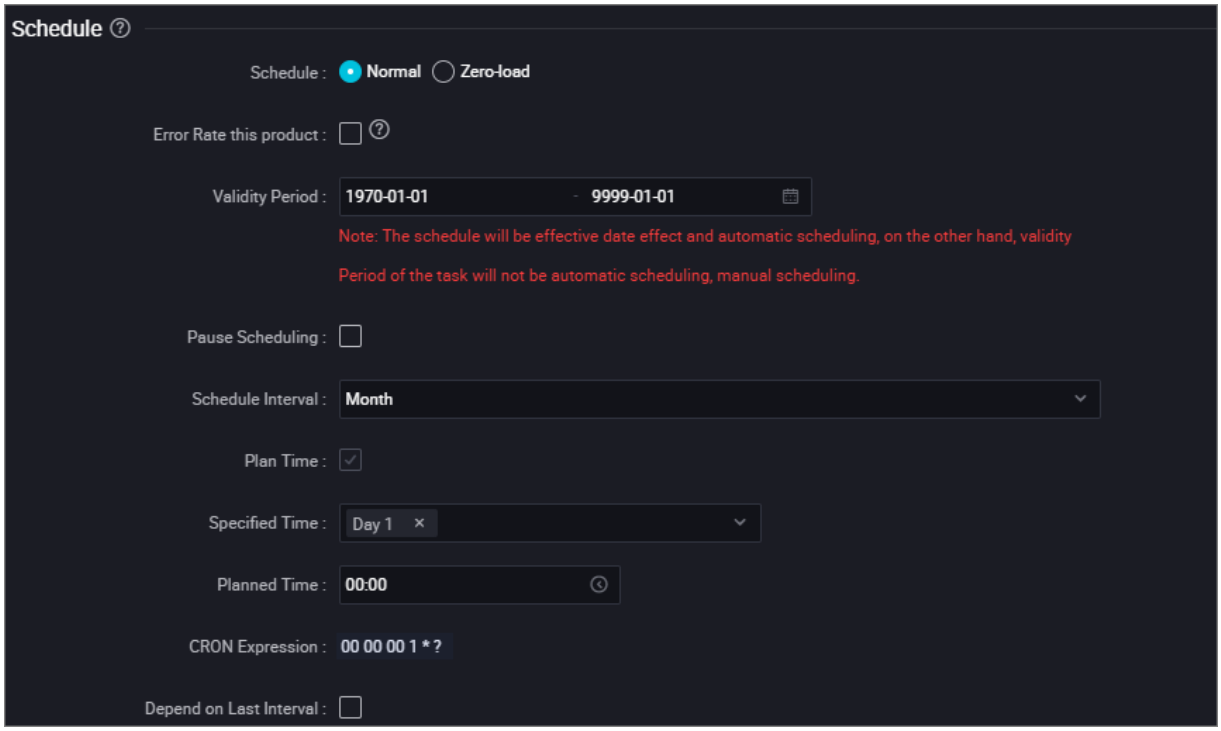
For example, you have created a node. As shown in the preceding figure, the scheduling system runs instances generated on Mondays and Fridays, but returns success responses without running the code for instances generated on Tuesdays, Wednesdays, Thursdays, Saturdays, and Sundays.

Based on the preceding node scheduling properties, the scheduling system automatically generates and runs instances for the node, as shown in the following figure.



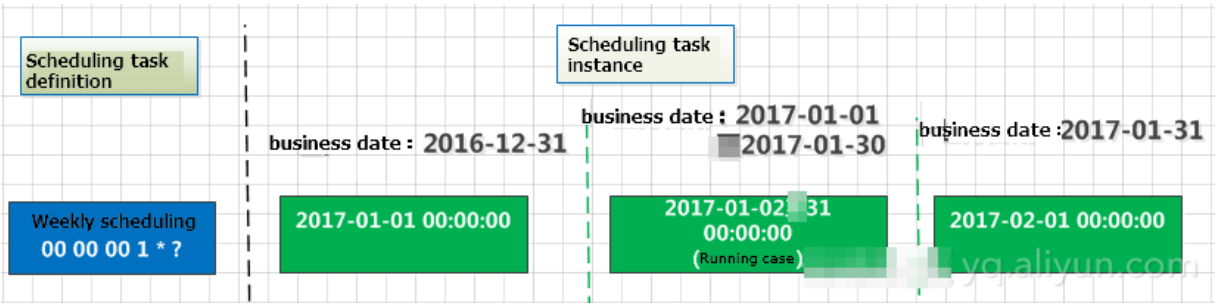
Scheduled by month

Nodes scheduled by month are automatically run at a specified time of specified days every month. On the other days, the scheduling system still generates instances to make sure the proper running of descendant instances. However, the system does not actually run the code or consume resources but directly returns a success response.



For example, you have created a node. As shown in the preceding figure, the scheduling system runs the instance generated on the first day of each month, but returns success responses without running the code for instances generated on the other days.

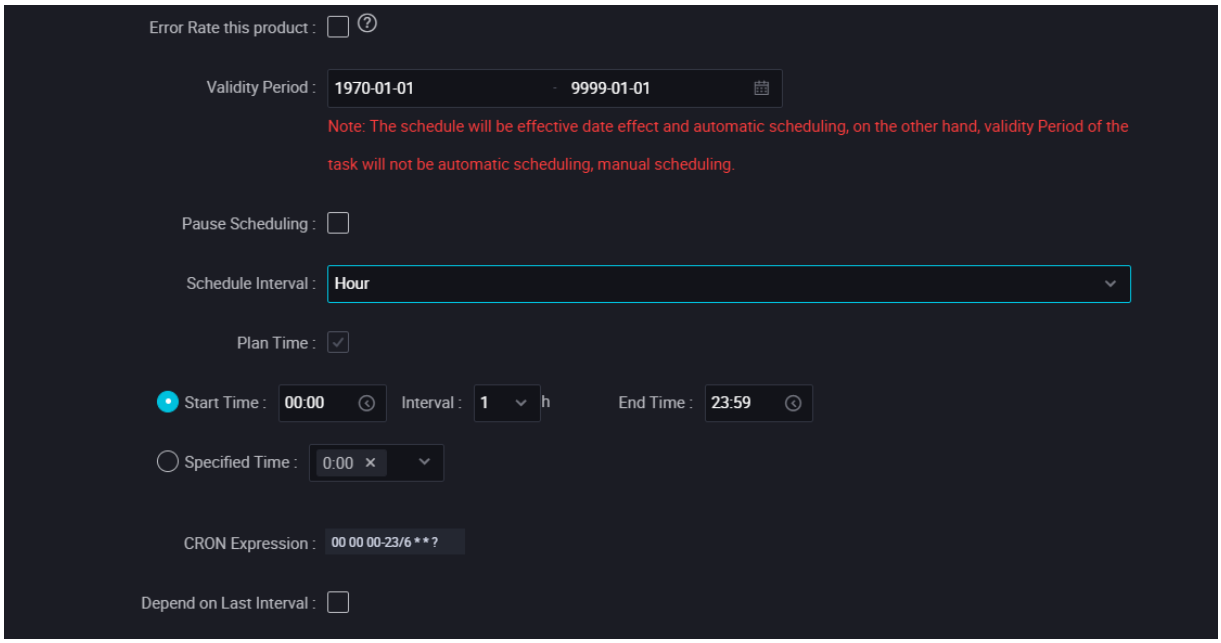
Based on the preceding node scheduling properties, the scheduling system automatically generates and runs instances for the node, as shown in the following figure.



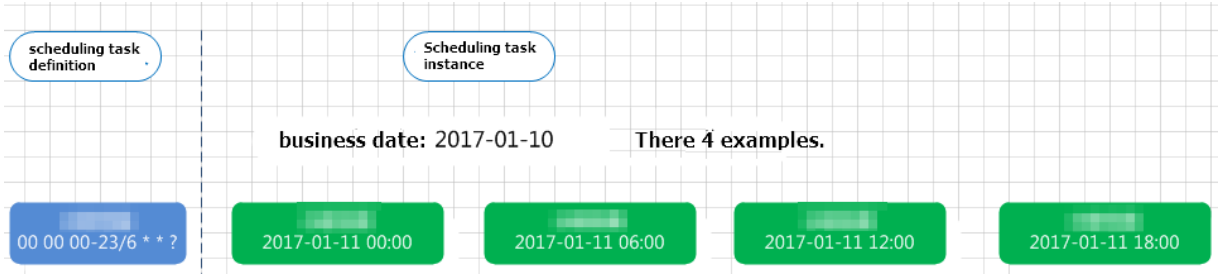
Scheduled by hour

Nodes scheduled by hour are automatically run once every N hours in a specific time period every day. For example, a node is run once per hour from 01:00 to 04:00 every day.

> **Note** The time period is a closed interval. For example, if a node is scheduled to run once per hour in the period from 00:00 to 03:00, the scheduling system generates four instances every day, which are run at 00:00, 01:00, 02:00, and 03:00, respectively.



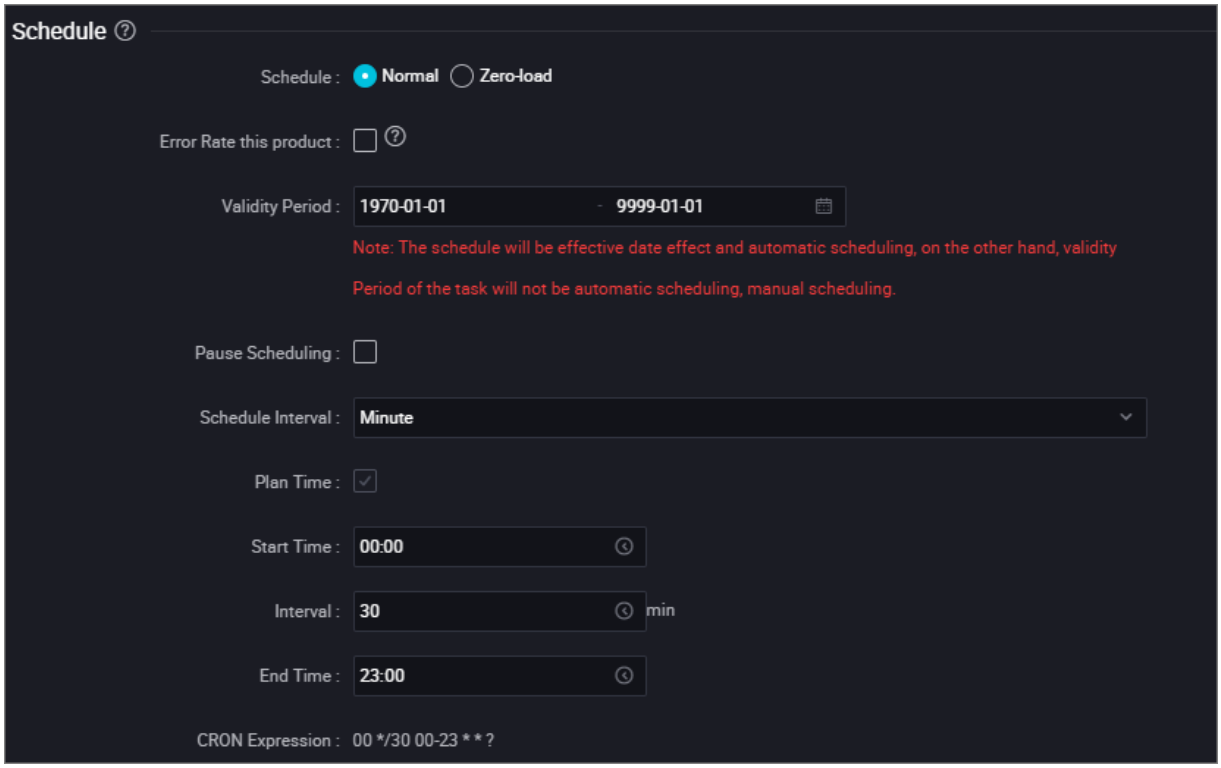
For example, you have created a node. As shown in the preceding figure, the node is automatically run every 6 hours in the period from 00:00 to 23:59 every day. In this case, the scheduling system automatically generates and runs instances for the node, as shown in the following figure.



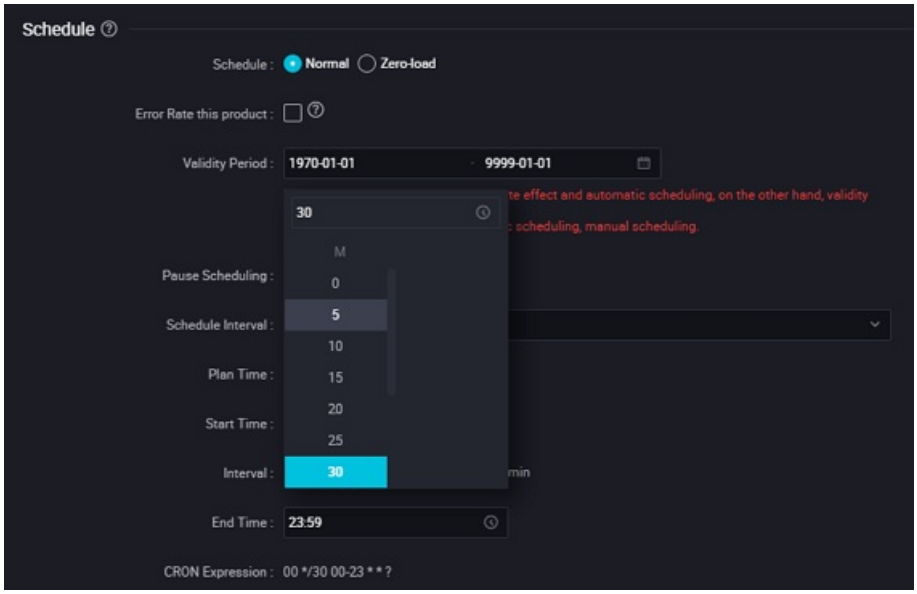
Scheduled by minute

Nodes scheduled by minute are automatically run once every N minutes in a specific time period every day.

For example, you have created a node. As shown in the following figure, the node is run every 30 minutes in the period from 00:00 to 23:00 every day.



Currently, a minimum interval of 5 minutes is supported. The time expression is automatically generated based on the time you select and cannot be modified.



FAQ

- Q: Node A is scheduled by hour and Node B is scheduled by day. How do I enable Node B to automatically run every day after all instances of Node A are run?

A: A node scheduled by day can depend on a node scheduled by hour. To enable Node B to automatically run every day after all 24 instances of Node A are run, do not specify the time to run Node B every day. Then, configure Node A as an ancestor of Node B. For more information, see the Dependencies topic. A node can depend on any other node, regardless of the recurrence. The recurrence of each node is specified in its scheduling properties.

- Q: Node A is run once per hour on the hour every day and Node B is run once per day. How do I enable Node B to automatically run after Node A is run for the first time every day?

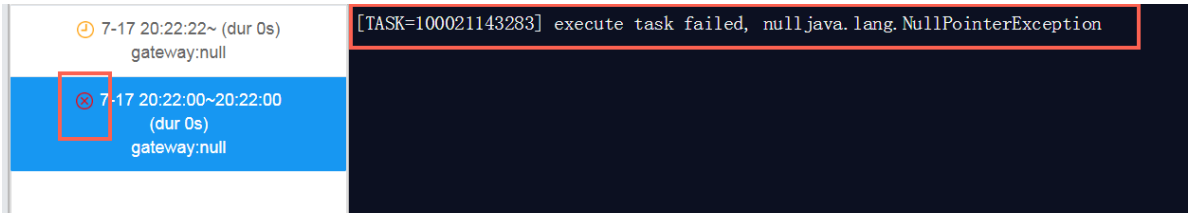
  A: When configuring the scheduling properties of Node A, select **Cross-Cycle Dependencies** and select **Instances of Current Node** from the Depend On drop-down list. When configuring the scheduling properties of Node B, configure Node B to depend on Node A and set the scheduled time of Node B to 00:00 every day. In this way, instances of Node B only depend on the instance of Node A generated at 00:00 every day, that is, the first instance of Node A.

- Q: Node A is run once every Monday and Node B depends on Node A. How do I enable Node B to run once every Monday?

  A: Set the scheduling properties of Node B to be the same as those of Node A. That is, select **Week** as the instance recurrence and select **Monday**.

- Q: How are the instances of a node affected when the node is deleted?

  A: When a node is deleted, its instances are retained because the scheduling system still generates one or more instances for the node based on the scheduling properties. However, when the scheduling system runs such instances after the node is deleted, an error message appears because the required code is unavailable, as shown in the following figure.

- Q: Can I enable a node to process monthly data on the last day of each month?

  A: No, DataWorks does not support setting a node to run on the last day of each month. If you enable a node to run on the thirty-first day of each month, the scheduling system runs a node instance in each month that has 31 days and returns a success response without running the code in any other month.

  We recommend that you configure a node to process the data of the past month on the first day of each month.

- Q: If a node scheduled by day depends on a node scheduled by hour, how do I enable the node scheduled by day to run at 00:00 every day?

  A: You can configure the node scheduled by day to depend on the data generated on the day before for the node scheduled by hour. If the node scheduled by day depends on the data generated on the current day for the node scheduled by hour, the instances of the node scheduled by day can be run only on the next day.

  In the Schedule section of the node scheduled by day, select **Cross-Cycle Dependencies**, select **Instances of Custom Nodes** from the Depend On drop-down list, and then enter the ID of the node scheduled by hour on which the node scheduled by day depends. Commit and deploy the node scheduled by day.

- Q: What can I do if I do not know when the output data of the ancestor node is generated?

A: You can set the cross-cycle dependency for the current node to depend on the last-cycle instances of the ancestor node.

- Q: After a modified node is committed and deployed to the production environment, will the node instances that were originally faulty in the production environment be overwritten?

  A: No, the node instances that have been generated will not be overwritten. The updated code is used to run the node instances that are newly generated and have not been run. If the scheduling properties are modified, the modified configuration also applies to the newly generated node instances.

2.4.3.2.4. Dependencies

Scheduling dependencies are the foundation for building orderly workflows. You must configure correct dependencies between nodes to make sure that business data is produced effectively and in a timely manner. This helps standardize data development activities.

DataWorks allows you to automatically parse node dependencies from the code or manually customize node dependencies. You can configure correct relationships between ancestor and descendant nodes and monitor the running status of nodes to make sure the orderly production of business data.

The purpose of configuring node dependencies is to check the data output time of the table queried by SQL statements and check whether data is properly produced from an ancestor node based on the node status.

You can set the output of an ancestor node as the input of a descendant node to configure a dependency between the two nodes.

Regardless of the dependency configuration mode, the overall scheduling logic is that descendant nodes can be run only after ancestor nodes are run. Therefore, each node in a workflow must have at least one parent node. The dependencies between the parent nodes and child nodes are the core of scheduling dependencies. The following sections describe the principles and configuration methods of scheduling dependencies in detail.

Differences between automatic parsing and custom dependencies

DataWorks can automatically parse the input and output of a node based on the lineage parsed from the code.

If the lineage parsed from the code is inaccurate, you can add custom dependencies as needed. We recommend that you write the code correctly to parse the lineage from the code and reduce custom dependencies. The following example shows how to configure the input and output of a node.

Auto Parse: If you select Yes, node dependencies are automatically parsed from the code.

For example, the code of an ODPS SQL node is as follows:

```
insert overwrite table table_a as select * from project_b_name.table_b;
```

From the code, DataWorks determines that the current node depends on the node that generates table_b and the current node generates table_a. Therefore, the output name of the parent node is project_b_name.table_b and the output name of the current node is project_name.table_a.

- If you do not want to parse node dependencies from the code, select **No** for Auto Parse.
- If a table in an SQL statement is both an output table and a referenced table on which another node depends, the table is parsed only as an output table.

- If a table in an SQL statement is used as an output table or a referenced table multiple times, only one scheduling dependency is parsed.
- If the SQL code contains a temporary table, the table is not involved in a scheduling dependency. Temporary tables are prefixed with t_. For more information, see Project Configuration.

Parent nodes

In the Dependencies section of a node, you must specify an ancestor node as the parent node on which the current node depends. You must enter the output name of the ancestor node, rather than the ancestor node name. A node may have multiple output names. Enter an output name as needed. You can search for an output name of the ancestor node to be added, or click Parse I/O to parse the output name based on the lineage parsed from the code.

> **Note** You must enter an output name or output table name to search for the ancestor node.
>
> If you enter an output name to search for the ancestor node, DataWorks searches for the output name among the output names of nodes that have been committed to the scheduling system.

- Search by entering an output name

  You can enter an output name to search for the ancestor node and configure the node as the parent node of the current node to create a dependency.

- Search by entering an output table name

  When using this method, make sure that the entered output table name of the ancestor node is the table name used in the INSERT or CREATE statement of the current node, such as Project name.Table name . Such output names can be automatically parsed.

  After you click the **Submit** icon, the output table name of the parent node configured for the current node can be found when you enter an output table name to search for the ancestor node for other nodes.

Outputs

You can click the **Properties** tab in the right-side navigation pane to view and configure the output of the current node.

DataWorks assigns a default output name that ends with .out to each node. You can also customize an output name or click Parse I/O to parse the output name based on the lineage parsed from the code.

> **Note** The output name of each node must be globally unique.

FAQ

- Q: After DataWorks automatically parses the input and output of a node, the node fails to be committed. An error message appears to indicate that the parsed output name workshop_yanshi.tb_2 of the parent node does not exist and you must commit the parent node before committing the current node. Why does this error occur?

  A: The possible causes are as follows:

  - The ancestor node is not committed. Commit the ancestor node and try again.
  - The ancestor node is committed, but workshop_yanshi.tb_2 is not an output name of the ancestor node.

> **Note** Usually, the output names of the parent node and the current node are automatically parsed based on the table name that is used in the INSERT or CREATE statement or follows the FROM keyword. Make sure that you follow the principles of automatic parsing in the Differences between automatic parsing and custom dependencies section.

- Q: In the output of the current node, the descendant node name and ID are empty and cannot be specified. Why does this happen?

  A: If the current node does not have a descendant node, the descendant node name and ID are empty. After a descendant node is configured for the current node, the corresponding content can be automatically parsed.

- Q: What is the output name of a node used for?

  A: The output name of a node is used to establish dependencies between nodes. For example, if the output name of Node A is ABC and Node B uses ABC as its input, a dependency is established between nodes A and B.

- Q: Can a node have multiple output names?

  A: Yes, a node can have multiple output names. If a descendant node references an output name of the current node as the output name of the parent node, a dependency is established between the descendant node and the current node.

- Q: Can multiple nodes have the same output name?

  A: No, the output name of each node must be unique under your Apsara Stack tenant account. If multiple nodes export data to the same MaxCompute table, we recommend that you use Table name_Partition ID as the output name format of these nodes.

- Q: How can I avoid intermediate tables when I enable DataWorks to automatically parse node dependencies?

  A: Right-click an intermediate table name in the SQL code and select **Delete Input** or **Delete Output**. Then, click Parse I/O to parse the input and output of the node.

- Q: How do I configure dependencies for the upmost node in a workflow?

  A: You can set the node to depend on the root node of the current workspace.

- Q: Why do I find a non-existent output name of Node B when I enter an output name to search for the ancestor node for Node A?

  A: DataWorks searches for the output name among the output names of nodes that have been committed to the scheduling system. After Node B is committed, if you delete the output name of Node B and does not commit Node B to the scheduling system again, the deleted output name of Node B can still be found.

- Q: How do I enable nodes A, B, and C to run in sequence once per hour?

  A: Set the output of Node A as the input of Node B and the output of Node B as the input of Node C. Also, set nodes A, B, and C to run once per hour.

- Q: An error message is returned to indicate that the parent node ID fails to be automatically parsed based on an output table name. Why does this error occur?

  A: This error does not indicate that the table does not exist. Instead, it indicates that the table is not the output of a specific node. Therefore, the table name cannot be used to find the node that generates the table data. In this case, the dependency on the node cannot be created.

According to the principles of automatic parsing described in this topic, a dependency is created after the output of an ancestor node is set as the input of a descendant node. If no ancestor node can be parsed based on the xc_demo_partition table referenced in SQL statements, no node uses the xc_demo_partition table as its output.

You can resolve this problem in the following way:

i. Find the node that generates the table data and view the node output.

   If you do not know which the target node is, you can enter keywords to search the code for the node in fuzzy match mode.

ii. If the table data is uploaded from a local server or you do not need to depend on the node, you can right-click the table name in the code and select **Delete Input**.

> **Note** We recommend that you write the code correctly to parse the lineage from the code and reduce custom dependencies.

2.4.3.3. Lineage

The Lineage tab displays the relationships between a node and other nodes. You can view the node dependencies and the lineage parsed from the code of the node.

Go to the Lineage tab

1. Log on to the DataWorks console.
2. Double-click the target node. For more information about how to create a node, see ODPS SQL nodes.
3. On the node configuration tab that appears, click the **Lineage** tab in the right-side navigation pane.

   On the **Lineage** tab that appears, you can click **Dependencies** to view the dependencies or click **Auto-Captured Lineage** to view the lineage.

Dependencies

You can check the node dependencies displayed based on the current configuration. If the displayed node dependencies fail to meet your expectations, you can reconfigure the node dependencies on the Properties tab.

Lineage

The lineage is parsed based on the code of the current node. For example, an ODPS SQL node contains the following SQL statements:

```
INSERT OVERWRITE TABLE dw_user_info_all_d PARTITION (dt='${bdp.system.bizdate}')
SELECT COALESCE(a.uid, b.uid) AS uid
 , b.gender
 , b.age_range
 , b.zodiac
 , a.region
 , a.device
 , a.identity
 , a.method
 , a.url
 , a.referer
 , a.time
FROM (
 SELECT *
 FROM ods_log_info_d
 WHERE dt = ${bdp.system.bizdate}
) a
LEFT OUTER JOIN (
 SELECT *
 FROM ods_user_info_d
 WHERE dt = ${bdp.system.bizdate}
) b
ON a.uid = b.uid;
```

The following figure shows the lineage parsed from the preceding SQL statements. The results queried from the ods_log_info_d and ods_user_info_d tables are joined and then inserted into the dw_user_info_all_d table.

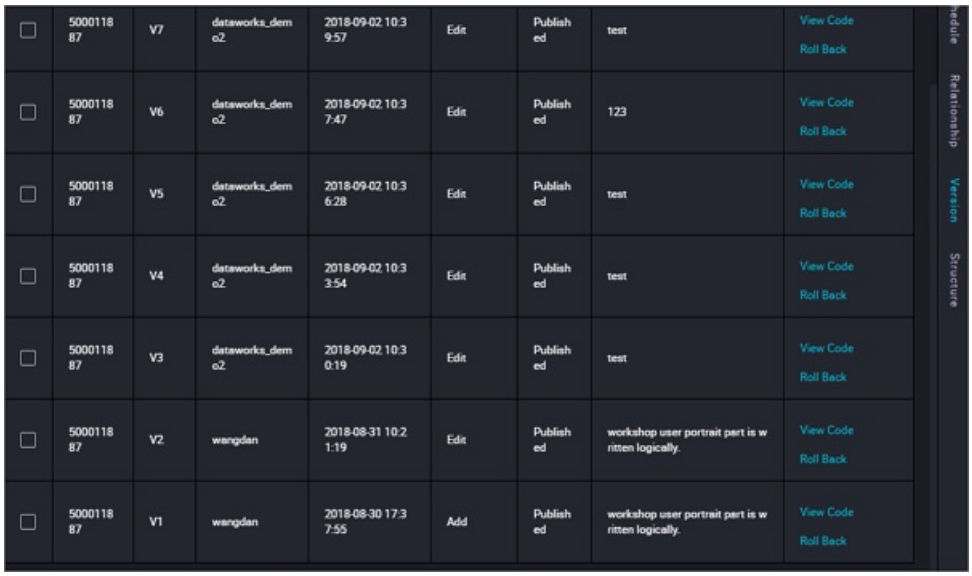
2.4.3.4. Versions

The Versions tab displays all committed and deployed versions of a node. A new version is generated each time a node is committed.

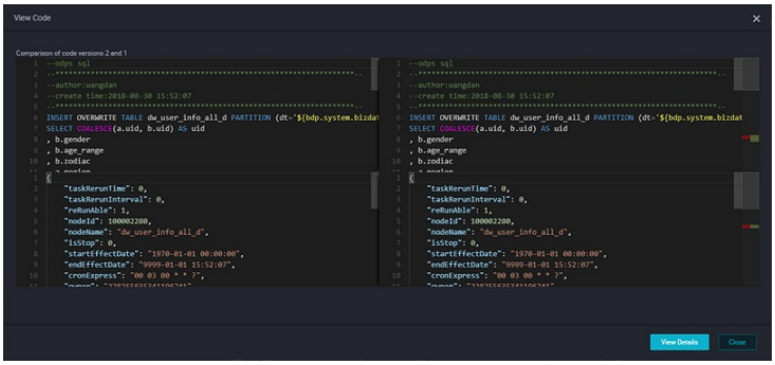
You can check version information such as the status, change type, and description to manage the node as required.

> **Note** Only committed nodes have version information on the Versions tab.

1. Log on to the DataWorks console.
2. On the **DataStudio** page that appears, double-click the target node.
3. On the node configuration tab that appears, click the **Versions** tab in the right-side navigation pane. On the Versions tab that appears, view the committed and deployed versions of the current node.



Parameter or button	Description
File ID	The ID of the node.
Versions	The version of the node. A version is generated each time the node is committed and deployed. V1 indicates version 1 and V2 indicates version 2. The version number is incremented by 1 each time.
Committed By	The user who committed the node.
Committed At	The time when the version was committed. If a version is committed and then deployed, the value of this parameter is updated to the time when the version is deployed.
Change Type	The operation on the node. The value of this parameter is Create if the node is committed and deployed for the first time or Change if the node is modified, committed, and then deployed.
Status	The status of the node.

Parameter or button	Description
Description	The change description of the node when it is committed. This description helps other users find the relevant version when they manage the node.
Actions	The operations that you can perform on the version. Two actions are available: **View Code** and **Roll Back**. ○ **View Code**: Click the button to view the code of the current version. ○ **Roll Back**: Click the button to roll back the node to the required version. After rolling back a node, you must commit and deploy it again.
Compare	Click the button to compare code and parameters between two selected versions.  Click **View Details**. On the details page that appears, you can view the changes in code and properties. **Note** You can only compare two versions, but cannot compare one or more than two versions at a time.

2.4.3.5. Code structure

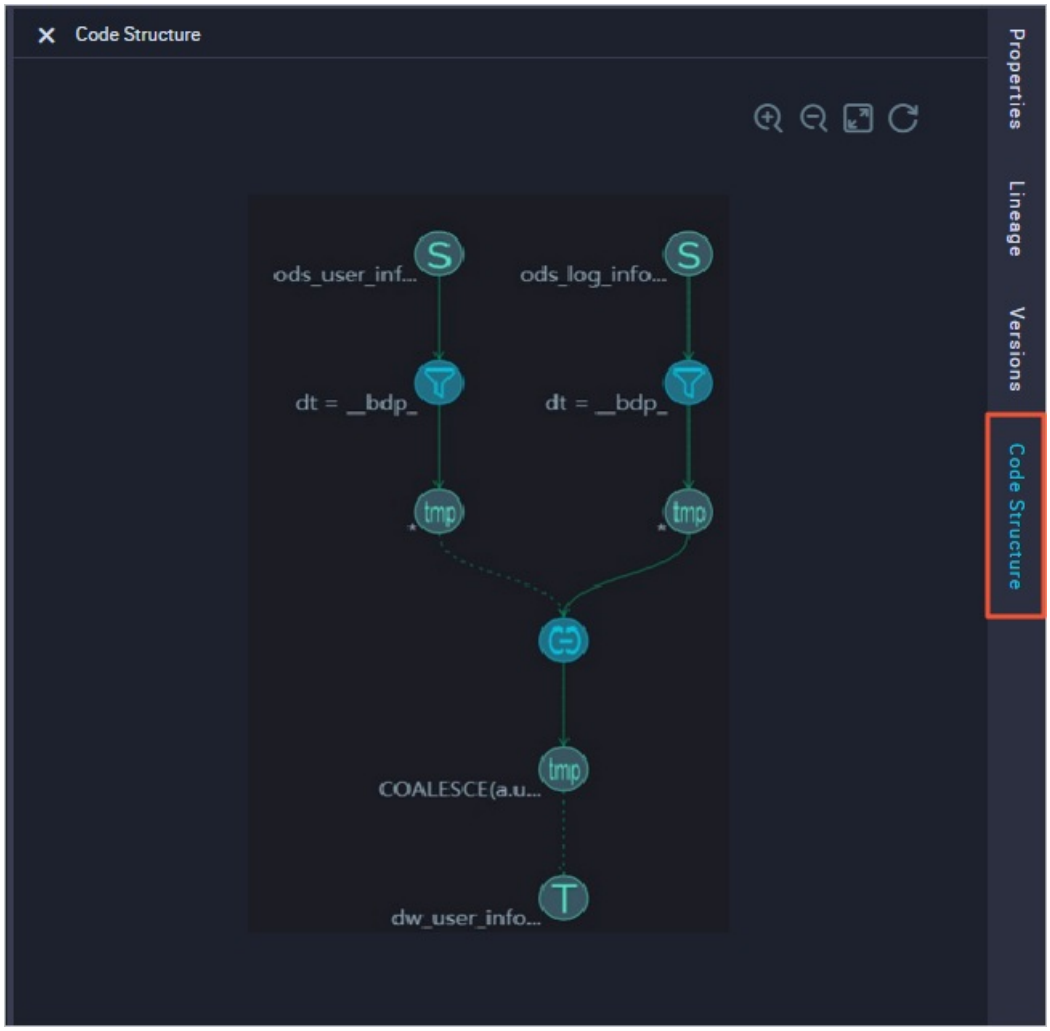
The Code Structure tab displays the SQL code structure parsed from the code of a node. The code structure helps you easily view and modify the code.

1. Log on to the DataWorks console.
2. Double-click the target node. For more information about how to create a node, see ODPS SQL nodes.
3. On the node configuration tab that appears, click the **Code Structure** tab in the right-side navigation pane.

For example, an ODPS SQL node contains the following SQL statements:

```
INSERT OVERWRITE TABLE dw_user_info_all_d PARTITION (dt='${bdp.system.bizdate}')
SELECT COALESCE(a.uid, b.uid) AS uid
 , b.gender
 , b.age_range
 , b.zodiac
 , a.region
 , a.device
 , a.identity
 , a.method
 , a.url
 , a.referer
 , a.time
FROM (
 SELECT *
 FROM ods_log_info_d
 WHERE dt = ${bdp.system.bizdate}
) a
LEFT OUTER JOIN (
 SELECT *
 FROM ods_user_info_d
 WHERE dt = ${bdp.system.bizdate}
) b
ON a.uid = b.uid;
```

The following figure shows the code structure parsed from the preceding SQL statements.



Move the pointer over a circle to view the description.

- **Source Table**: the table to be queried.
- **Filter**: finds the partitions in the table to be queried.
- **Intermediate Table**: the temporary table that stores the query result.
- **Join**: joins the query results.
- **Intermediate Table**: the temporary table that stores the results of the JOIN operation. This table can be stored for three days. After three days, this table is automatically deleted.
- **Target Table**: the destination table to which the query results are inserted by using an **INSERT OVERWRITE** statement.

2.4.4. Business flows

2.4.4.1. Overview

DataWorks organizes different types of nodes in a workflow by business category to develop code of business.

DataWorks provides you with a dashboard for different types of nodes in each workflow. DataWorks also provides tools for you to optimize and manage nodes in each workflow. This promotes easy and intelligent development and management.

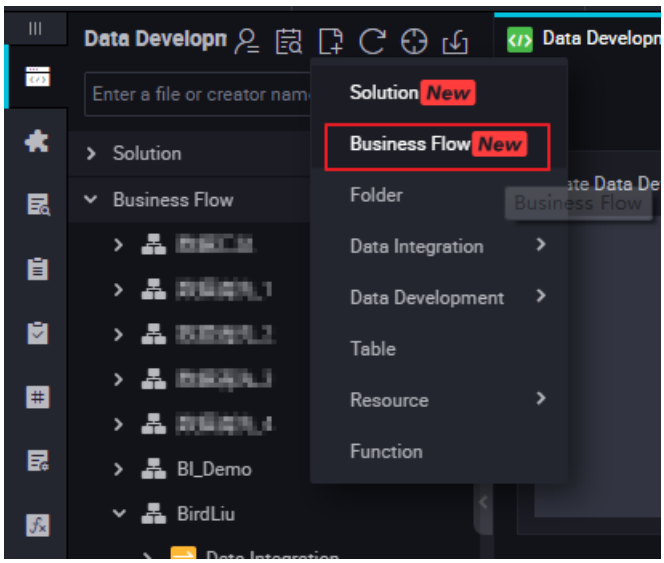
Workflow structure

A workspace supports multiple types of compute engines and multiple workflows. A workflow is a collection of various types of nodes that are closely associated with each other. DataWorks automatically generates a directed acyclic graph (DAG) so that you can view the workflow. Supported node types include data integration node, data analytics node, table, resource, function, and algorithm.

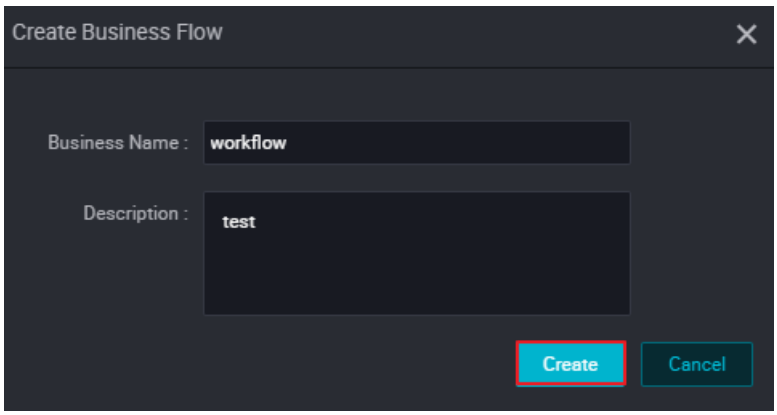
Each type of node has an independent folder. You can also create subfolders in each folder. To facilitate management, we recommend that you create a maximum of four levels of subfolders. If more than four subfolder levels are required, your workflow is too complex. We recommend that you split the workflow into two or more workflows and add the split workflows to one solution.

Create a workflow

1. Log on to the DataWorks console.
2. In the left-side navigation pane, click **Data Analytics** to go to the **Data Analytics** tab.
3. On the Data Analytics tab, right-click **Workflow** and select **Create Workflow**.



4. In the **Create Workflow** dialog box that appears, set **Workflow Name** and **Description**.



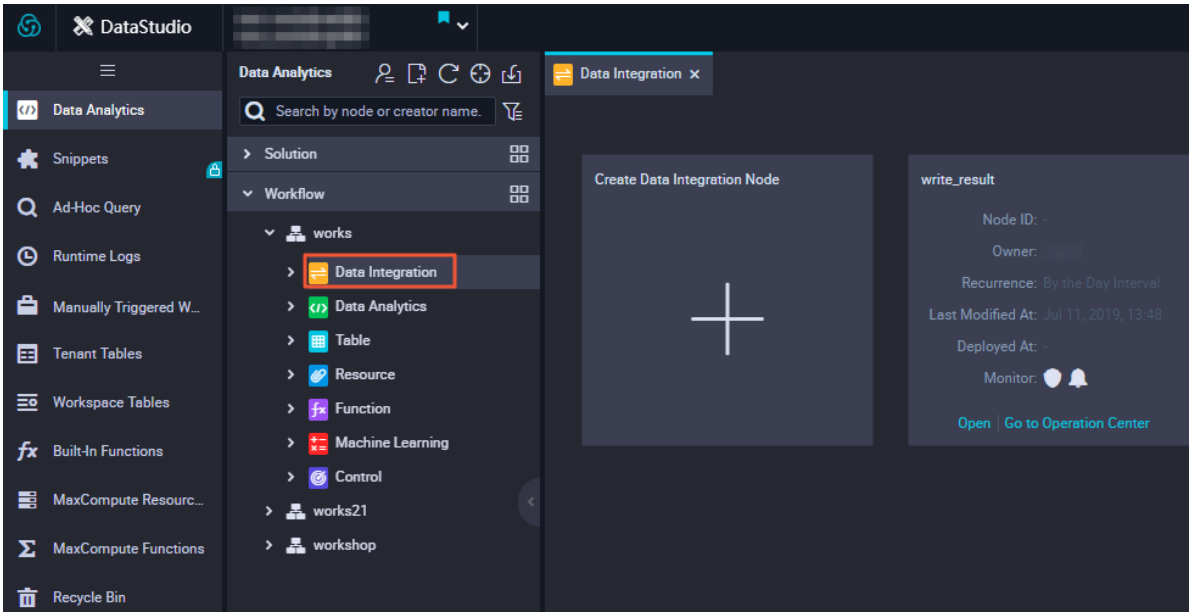
5. Click **Create**.

Workflow nodes

A workflow consists of nodes of the following types:

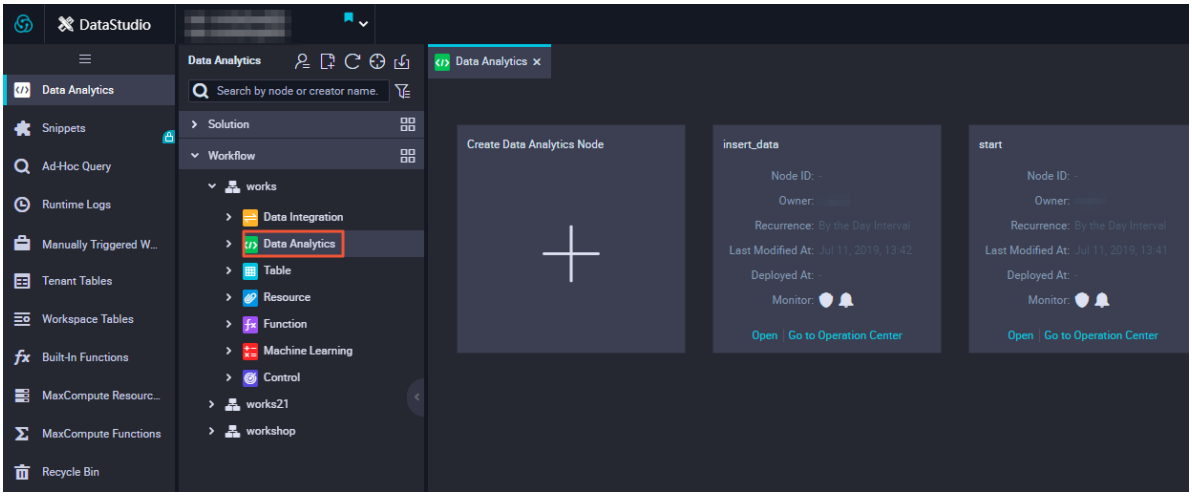
- **Data integration**

  Click the target workflow and double-click **Data Integration** to view all data integration nodes of the workflow.



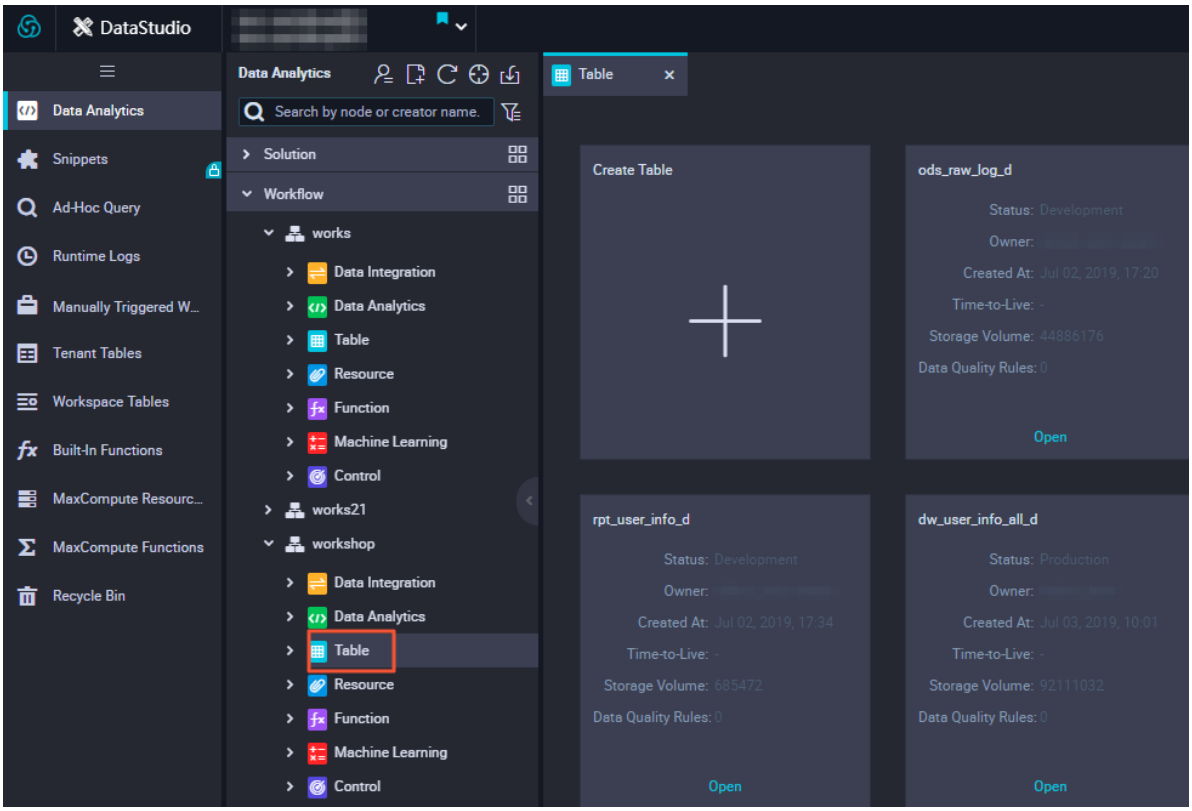
- **Data analytics**

  Click the target workflow and double-click **Data Analytics** to view all data analytics nodes of the workflow.



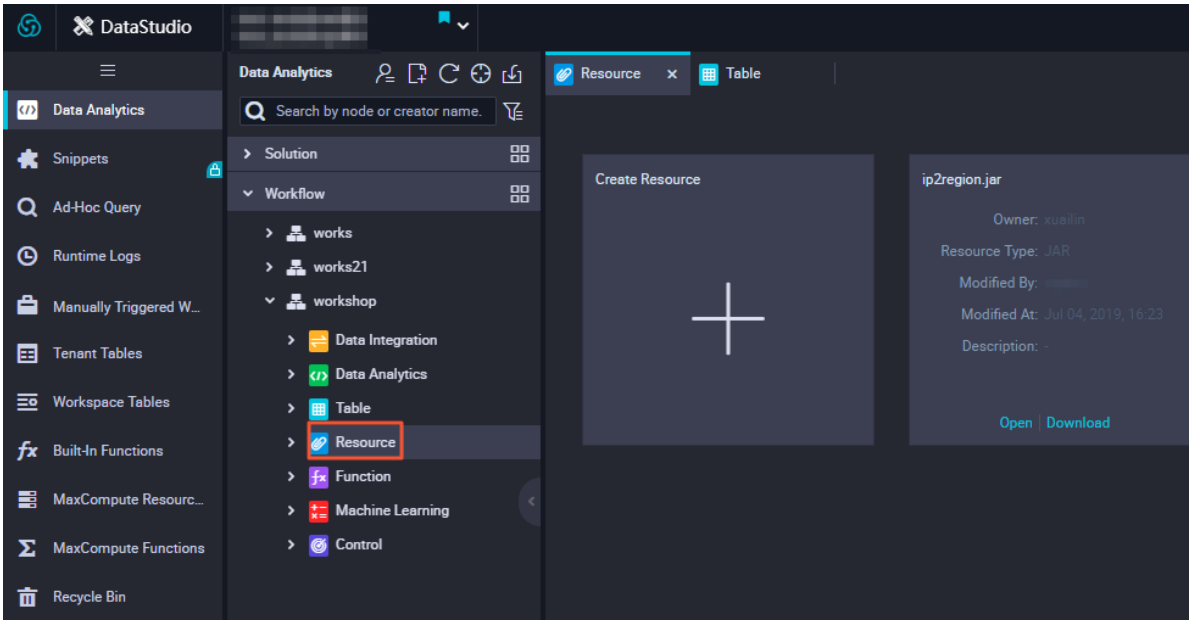
- **Table**

Click the target workflow and double-click **Tables** to view all tables of the workflow.



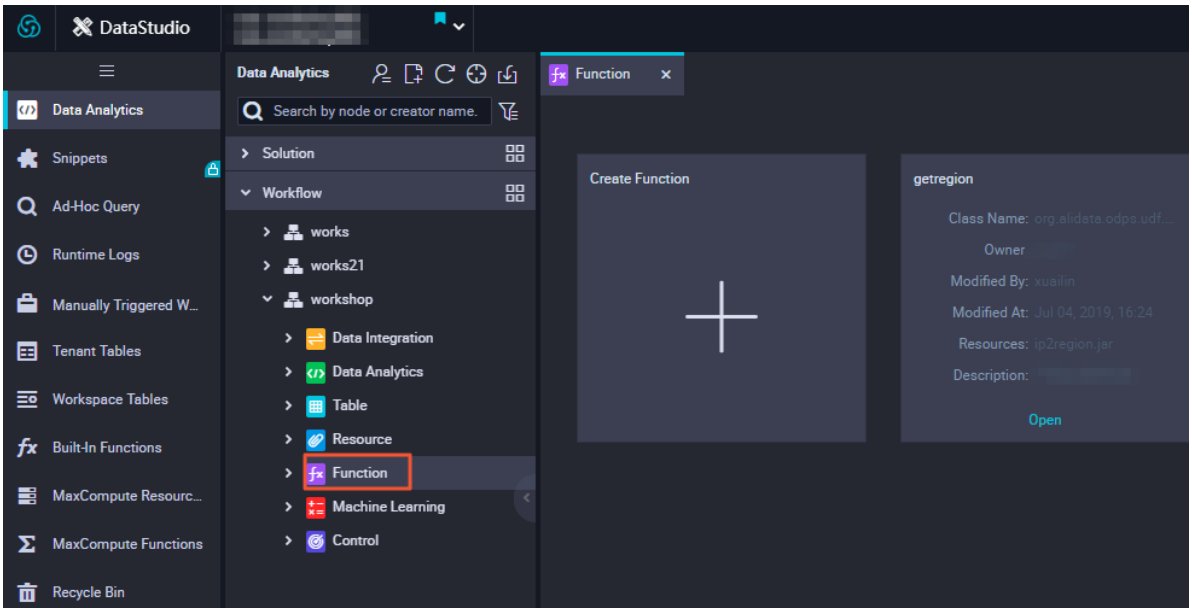
- Resource

  Click the target workflow and double-click **Resources** in a workflow to view all the created resources.



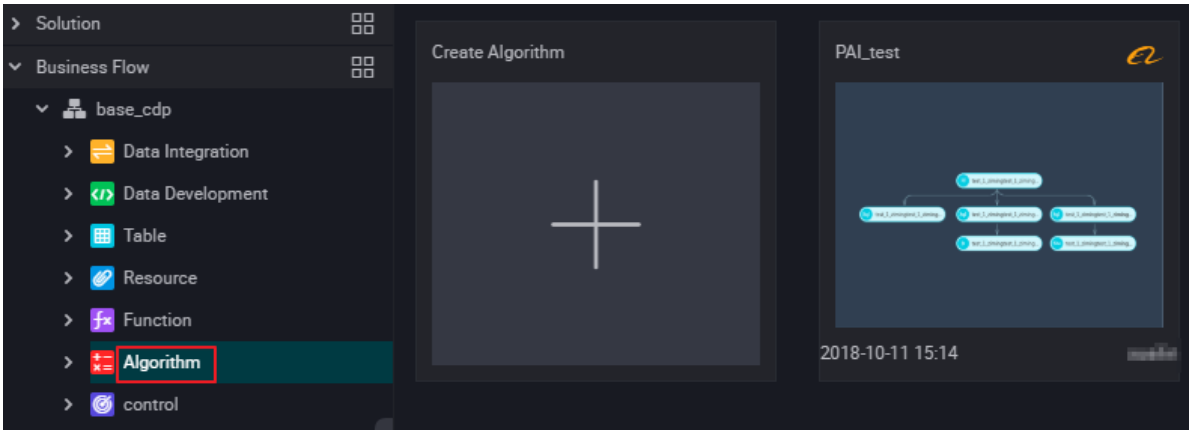
- Functions

Double-click **Functions** to view all functions of the workflow.



- **Algorithm**

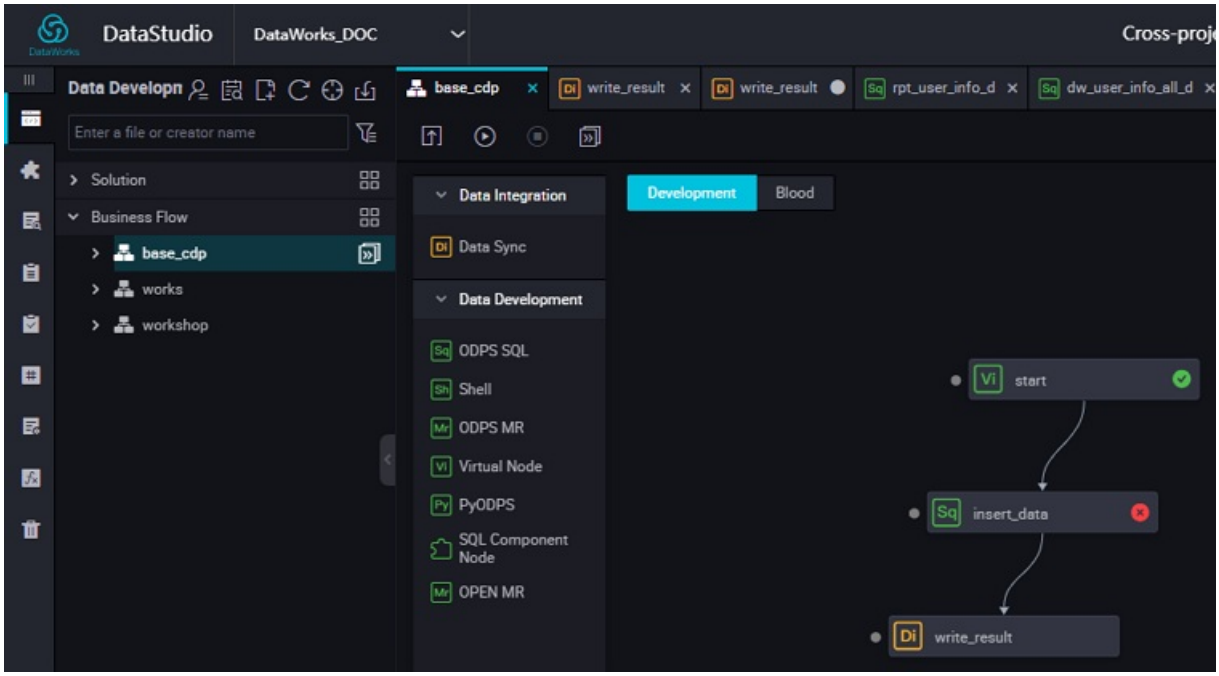
  You can create a Machine Learning Platform for Artificial Intelligence (PAI) node. Click the target workflow and double-click **Algorithms** to view all algorithms of the workflow.



- **Control**

  Control nodes include **assignment node**, **branch node**, **merge node**, **cross-tenant collaboration node**, **do-while node**, and **for-each node**.

You can double-click the name of a workflow to view the relationships among nodes in the DAG of the workflow.



Note We recommend that you create no more than 100 nodes in a workflow.

View all workflows

On the **Data Analytics** tab, right-click **Workflow** and select **All Workflows**. On the dashboard that appears, you can view all workflows in the current workspace.

Click a workflow. The dashboard of the workflow appears.

Dashboard for each node type

DataWorks provides a dashboard for each type of node in a workflow. On the dashboard, each node is presented by a card that offers operation and optimization suggestions, so that you can intelligently manage nodes.

For example, the card of each data analytics node provides two indicators to show whether baseline-based monitoring and event notification are enabled for the node. This allows you to understand the status of each node.

You can double-click a folder in a workflow. The dashboard of the selected node type appears.

Commit a workflow

1. Go to the dashboard of a workflow. Click the **Commit** icon.
2. In the **Commit** dialog box, select the nodes to be committed, set **Description**, and then select **Ignore I/O Inconsistency Alerts**.
3. Click **Commit**.

> **Note** If all nodes of a workflow are committed and you only modify the workflow or node properties, you do not need to select the nodes. If a node is committed but the node code is not changed, the node cannot be selected again. In this case, you can enter the description and commit the workflow. The changes are automatically committed.

2.4.4.2. Create and use resources

If your code or function requires resource files such as .jar files, you can upload resources to your workspace and reference them.

If the existing built-in functions do not meet your requirements, DataWorks enables you to create user-defined functions (UDFs) and customize processing logic. You can upload the required JAR packages to your workspace so that you can reference them when creating UDFs.

The resources that you can upload to MaxCompute include text files, MaxCompute tables, Python code, and compressed packages in .zip, .tgz, .tar.gz, .tar, and .jar formats. You can read or use these resources when running UDFs or MapReduce.

MaxCompute provides API operations for you to read and use resources. Currently, the following types of MaxCompute resources are available:

- File
- Archive: the compressed files that can be identified by the resource name extension. Supported file types include .zip, .tgz, .tar.gz, .tar, and .jar.
- JAR: the compiled Java JAR packages.
- Python: the Python code you have written. You can use Python code to register Python UDFs.

Currently, DataWorks only supports creating JAR and file resources on the graphical user interface (GUI). Follow similar steps to create JAR and file resources. The differences are described as follows:

- To create a JAR resource, you must compile the Java code in the offline Java environment, compress the code into a JAR package, and then upload the package as the JAR resource to DataWorks.
- To create a file resource that is smaller than or equal to 500 KB in size, you can directly create and edit it in the DataWorks console.
- To create a file resource that is larger than 500 KB in size, you can select Larger than 500 KB and upload a local file.

> **Note** Each resource file to be uploaded cannot exceed 30 MB.

Create a JAR resource

1. Log on to the DataWorks console.
2. On the **Data Analytics** tab, move the pointer over the **Create** icon and select **Workflow**.
3. In the **Create Workflow** dialog box that appears, set **Workflow Name** and **Description**. Then, click **Create**.
4. In the left-side navigation pane, click the created workflow. Then, right-click **Resource** and choose **Create Resource > JAR**.
5. In the **Create Resource** dialog box that appears, set a resource name based on the naming convention, make sure that the resource type is set to **JAR**, select a local JAR package to upload, and then click **OK**.

> Note
>
> - If the selected JAR package has been uploaded from the MaxCompute client, clear **Upload to MaxCompute**. If you do not clear it, an error will occur during the upload process.
> - The resource name can be different from the name of the uploaded file.
> - Convention for naming resources: A resource name can contain letters (case-insensitive), digits, underscores (_), and periods (.). It must be 1 to 128 characters in length. A JAR resource name must end with .jar.

6. After the resource is uploaded, click the **Submit** icon on the configuration tab of the created resource.
7. In the **Commit Node** dialog box that appears, enter information in the **Description** field and click **OK**.
8. When the message **Committed successfully** appears, click **Deploy** in the upper-right corner to deploy the resource. For more information, see Publish nodes.

Reference and download resources

- For more information about how to reference resources for functions, see Create a function.
- For more information about how to reference resources for nodes, see ODPS MR nodes.

To download a resource, double-click **Resource** in the left-side navigation pane. On the Resource tab that appears, find the required resource and click **Download**.

2.4.4.3. Create a function

DataWorks provides the SQL computing feature. You can use the built-in functions of MaxCompute SQL for data analysis and computing. This topic describes how to create a Java user-defined function (UDF).

Context

To view a list of built-in functions, you can go to the **DataStudio** page and click **Built-In Functions** on the left-side navigation submenu.

If the existing built-in functions do not meet your requirements, you can define UDFs in Java and Python. You can use UDFs in the same way as the built-in functions of MaxCompute SQL.

Procedure

1. Log on to the DataWorks console.
2. On the **Data Analytics** tab, move the pointer over the **Create** icon and select **Workflow**.
3. In the **Create Workflow** dialog box that appears, set **Workflow Name** and **Description**. Then, click **Create**.
4. Create a JAR resource.
5. Create a function.
   i. In the left-side navigation pane, click the created workflow. Then, right-click **Function** and select **Create Function**.
   ii. In the **Create Function** dialog box that appears, set **Function Name** and click **Commit**.

6. Register the function.
   i. On the configuration tab of the created function, set the parameters in the **Register Function** section.

Parameter	Description
Function Type	The type of the function. Valid values: **Mathematical Function**, **Aggregate Function**, **String Function**, **Date Function**, **Analytic Function**, and **Other**.
Function Name	The name of the function, that is, the name used to reference the function in SQL. The function name must be globally unique and cannot be modified after the function is registered.
Owner	The owner of the function. By default, this parameter is automatically set.
Class Name	The name of the class for implementing the function. This parameter is required. **Note** If the resource type is Python, enter the class name in the Python resource name.Class name format. Do not include the .py extension in the resource name.
Resources	The list of resources. You can search for existing resources in the current workspace in fuzzy match mode. This parameter is required.
Description	The description of the function.
Expression Syntax	The instructions on how to use the function, for example, `test`.
Parameter Description	The description of supported input and output parameters.
Return Value	The value to return, for example, 1. This parameter is optional.

ii. Click the **Submit** icon to complete the registration of the function.

> **Note**
>
> You must develop and compile functions in compliance with the MaxCompute UDF framework.
>
> - By default, MaxCompute UDFs support Java 1.7 and Python 2.7.
> - Java UDFs must inherit from the com.aliyun.odps.udf.UDF class.
> - A Python UDF must have its signature specified through annotation.
>
> ```
> /***-----Sample of specifying the signature of a Python UDF through annotation------***
> /
> from odps.udf import annotate
> @annotate("bigint,bigint->bigint")
> /***-----------------------------------------------***/
> ```

2.4.5. Node types

2.4.5.1. Sync node

Currently, sync nodes support various connections, including MaxCompute, MySQL, Distributed Relational Database Service (DRDS), SQL Server, PostgreSQL, Oracle, MongoDB, Db2, Table Store, Object Storage Service (OSS), FTP, HBase, LogHub, Hadoop Distributed File System (HDFS), and Stream.

For more information about the supported connections, see Supported data sources.

When you enter a table name, the drop-down list displays all matched tables. Currently, only exact match is supported. You must enter a complete table name. Tables are labeled as unsupported if they are not supported by sync nodes.

If you move the pointer over a table in the list, the details of the table appear, including the database, IP address, and owner of the table. After you select a table, the column information is automatically entered. You can add, move, and delete columns.

> **Note** DataWorks supports synchronizing partitioned tables of MaxCompute across multiple partitions.

Create a sync node

1. Log on to the DataWorks console. On the **Data Analytics** tab, move the pointer over the **Create** icon and choose **Data Integration > Sync**.

   > **Note** Alternatively, you can click a created workflow, right-click **Data Integration**, and then choose **Create Data Integration Node > Sync**.

2. In the **Create Node** dialog box that appears, set the parameters and click **Commit**.
3. Configure the sync node. For more information, see Configure a data synchronization node by using the codeless UI.

4. Configure the node properties.

   Click the **Properties** tab in the right-side navigation pane. On the **Properties** tab that appears, set the parameters. For more information, see Schedule.

5. Commit the node.

   After the node properties are configured, click the **Save** icon in the upper-left corner. Then, commit or commit and unlock the node to the development environment.

6. Deploy the node.

   For more information, see Deploy.

7. Test the node in the production environment.

   For more information, see Recurring tasks.

2.4.5.2. ODPS SQL node

Using the SQL-like syntax, ODPS SQL nodes can process terabytes of data in distributed scenarios that do not require real-time processing.

ODPS SQL nodes are online analytical processing (OLAP) applications designed to deal with large amounts of data. Generally, it takes a long time from preparing to committing a job. You can use ODPS SQL nodes to process thousands to ten thousands of transactions.

1. Log on to the DataWorks console.
2. Create a workflow.
   i. On the **Data Analytics** tab, right-click **Workflow** and select **Create Workflow**.
   ii. In the **Create Workflow** dialog box that appears, set **Workflow Name** and **Description**.
   iii. Click **Create**.
3. Create an ODPS SQL node.

   In the left-side navigation pane, click the created workflow. Then, right-click **Data Analytics** and choose **Create Data Analytics Node > ODPS SQL**.
4. Edit the code of the ODPS SQL node. The code must conform to the syntax.

   For example, create a table, insert data into the table, and then query data in the table.

   i. Create a table named test1.

```
CREATE TABLE IF NOT EXISTS test1
( id BIGINT COMMENT '',
 name STRING COMMENT '',
 age BIGINT COMMENT '',
 sex STRING COMMENT '');
```

ii. Insert data into the table.

```
INSERT INTO test1 VALUES (1,'Jack',43,'Male') ;
INSERT INTO test1 VALUES (1,'John',32,'Male') ;
INSERT INTO test1 VALUES (1,'Mary',27,'Female') ;
INSERT INTO test1 VALUES (1,'Tom',24,'Male') ;
INSERT INTO test1 VALUES (1,'Jane',35,'Female') ;
INSERT INTO test1 VALUES (1,'Kate',22,'Female') ;
INSERT INTO test1 VALUES (1,'Chris',55,'Male') ;
```

iii. Query data in the table.

```
select * from test1;
```

iv. After you enter the preceding SQL statements in the code editor, click the **Run** icon in the upper-left corner or press F8. DataWorks runs your SQL statements from top to bottom and generates logs.

> **Note**
>
> When DataWorks runs the INSERT INTO statement, the following information appears in logs:
>
> The INSERT INTO statement may result in unexpected data duplication. Although DataWorks does not rerun the INSERT SQL statement, it may rerun corresponding nodes. We recommend that you avoid using the INSERT INTO statement. If you continue to use the INSERT INTO statement, we deem that you are aware of the associated risks and are willing to take the consequences of potential data duplication.

You can use the INSERT INTO statement as needed. After SQL statements are run and data is inserted into the table, do not rerun SQL statements. If you rerun SQL statements, data may be duplicated.

After the code is edited, click the **Save** icon in the upper-left corner or press Ctrl+S to save the code.

5. View the query result.

   DataWorks displays the query result in a workbook.

   You can view or manage the query result in the workbook, or copy the query result to a local Excel file.

   Right-click the heading of each column and select **Copy**, **Hide**, or **Unhide** to perform the relevant operation.

   You can also click **Hide Column**, **Copy Row**, **Copy Column**, **Copy Selected**, or **Search** at the bottom of the page to perform the relevant operation.

Button	Description
Hide Column	Click the button to hide one or more columns.
Copy Row	Select one or more rows and click the button to copy the selected rows.

Button	Description
Copy Column	Select one or more columns and click the button to copy the selected columns.
Copy Selected	Select one or more cells and click the button to copy the selected cells.
Search	Click the button. In the search box that appears in the upper-right corner of the Result tab, enter a keyword to search for data in the table.

6. Configure the node properties.

   Click the **Properties** tab in the right-side navigation pane. On the **Properties** tab that appears, set the parameters. For more information, see Schedule.

7. Commit the node.

   After the node properties are configured, click the **Save** icon in the upper-left corner. Then, commit or commit and unlock the node to the development environment.

8. Deploy the node.

   For more information, see Deploy.

9. Test the node in the production environment.

   For more information, see Recurring tasks.

2.4.5.3. ODPS Spark node

DataWorks supports ODPS Spark nodes. This topic describes how to create and configure an ODPS Spark node.

WordCount

1. Log on to the DataWorks console.
2. Create a workflow.
   i. On the **Data Analytics** tab, move the pointer over the **Create** icon and select **Workflow**.
   ii. In the **Create Workflow** dialog box that appears, set **Workflow Name** and **Description**.
   iii. Click **Create**.
3. Create JAR resources. For more information, see Create a JAR resource.
4. Create an ODPS Spark node.
   i. In the left-side navigation pane, click the created workflow. Then, right-click **Data Analytics** and choose **Create Data Analytics Node > ODPS Spark**.
   ii. In the **Create Node** dialog box that appears, set **Node Name**.
   iii. Click **Commit**.
5. Configure the ODPS Spark node.

   You can set **Spark Version** and **Language** as needed. The parameters vary with the value of the **Language** parameter. You can set the parameters as prompted.

   The following table describes the parameters that appear after you set the Language parameter to **Java/Scala**.

Parameter	Description
Spark Version	The Spark version of the node. Valid values: **Spark1.x** and **Spark2.x**.
Language	The programming language of the node. Valid values: **Java/Scala** and **Python**. Select **Java/Scala**.
Main JAR Resource	The main JAR resource referenced by the node. Select a JAR resource that you uploaded from the drop-down list.
Configuration Items	The configuration items of the node. Click **Add** and set key and value.
Main Class	The class name of the node.
Arguments	The parameter used to assign a value to a variable in the code during node scheduling. For example, enter ${bizdate} ${yesterday}. Separate multiple parameters with spaces.
JAR Resources	The JAR resource referenced by the node. Select a JAR resource that you uploaded from the drop-down list. The ODPS Spark node automatically finds the uploaded JAR resources based on the resource type.
File Resources	The file resource referenced by the node. Select a file resource that you uploaded from the drop-down list. The ODPS Spark node automatically finds the uploaded file resources based on the resource type.
Archive Resources	The archive resource referenced by the node. Select an archive resource that you uploaded from the drop-down list. The ODPS Spark node automatically finds the uploaded archive resources based on the resource type. Only compressed resources appear.

6. After the configuration is completed, click the **Save** and **Submit** icons to save and commit the node.

Python

1. In the left-side navigation pane, click the created workflow. Then, right-click **Resource** and choose **Create Resource > Python**. In the Create Resource dialog box that appears, create and upload Python resources.
2. Create and configure an ODPS Spark node.

   The following table describes the parameters that appear after you set the Language parameter to **Python**.

Parameter	Description
Spark Version	The Spark version of the node. Valid values: **Spark1.x** and **Spark2.x**.
Language	The programming language of the node. Valid values: **Java/Scala** and **Python**. Select **Python**.
Main Python Resource	The main Python resource referenced by the node. Select a Python resource that you uploaded from the drop-down list.
Configuration Items	The configuration items of the node. Click **Add** and set key and value.
Main Class	The class name of the node.
Arguments	The parameter used to assign a value to a variable in the code during node scheduling. For example, enter ${bizdate} ${yesterday}. Separate multiple parameters with spaces.
Python Resources	The Python resource referenced by the node. Select a Python resource that you uploaded from the drop-down list. The ODPS Spark node automatically finds the uploaded Python resources based on the resource type.
File Resources	The file resource referenced by the node. Select a file resource that you uploaded from the drop-down list. The ODPS Spark node automatically finds the uploaded file resources based on the resource type.
Archive Resources	The archive resource referenced by the node. Select an archive resource that you uploaded from the drop-down list. The ODPS Spark node automatically finds the uploaded archive resources based on the resource type. Only compressed resources appear.

3. After the configuration is completed, click the **Save** and **Submit** icons to save and commit the node.

Lenet (BigDL)

1. Upload resource files to create JAR or archive resources. For example, upload the mnist.zip file to create an archive resource.
2. Create and configure an ODPS Spark node.
3. After the configuration is completed, click the **Save** and **Submit** icons to save and commit the node.

2.4.5.4. ODPS MR node

MaxCompute supports the MapReduce API. You can call the Java API operations of MapReduce to develop MapReduce programs for processing data in MaxCompute. You can also create and run ODPS MR nodes in DataWorks.

Before creating ODPS MR nodes, you must upload, commit, and then deploy required resources.

Create a resource

1. Log on to the DataWorks console.
2. On the **Data Analytics** tab, right-click **Workflow** and select **Create Workflow**.
3. In the **Create Workflow** dialog box that appears, set **Workflow Name** and **Description**. Then, click **Create**.
4. In the left-side navigation pane, click the created workflow. Then, right-click **Resource** and choose **Create Resource > JAR**.
5. In the **Create Resource** dialog box that appears, set a resource name based on the naming convention, make sure that the resource type is set to **JAR**, select a local JAR package to upload, and then click **OK**.

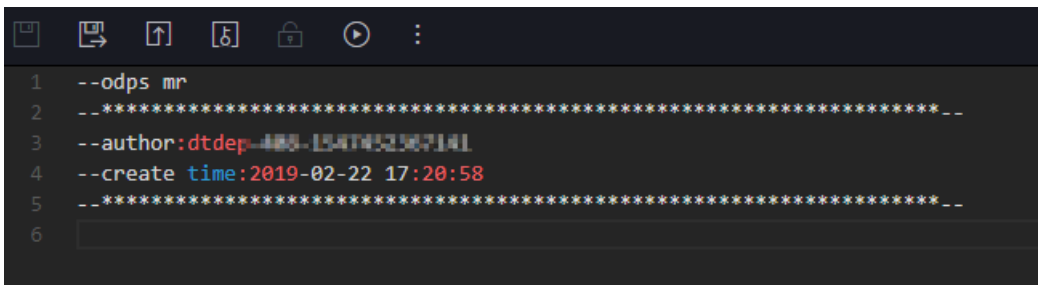
   > Note
   > - If the selected JAR package has been uploaded from the MaxCompute client, clear **Upload to MaxCompute**. If you do not clear it, an error will occur during the upload process.
   > - The resource name can be different from the name of the uploaded file.
   > - Convention for naming resources: A resource name can contain letters (case-insensitive), digits, underscores (_), and periods (.). It must be 1 to 128 characters in length. A JAR resource name must end with .jar. A Python resource name must end with .py.

6. On the configuration tab of the created resource, click the **Submit** icon to commit the resource to the development environment.
7. Deploy the resource.

   For more information, see Deploy.

Create an ODPS MR node

1. In the left-side navigation pane, click the created workflow. Then, right-click **Data Analytics** and choose **Create Data Analytics Node > ODPS MR**.
2. In the **Create Node** dialog box that appears, set **Node Name** and click **Commit**.
3. Edit the code of the ODPS MR node. Double-click the created ODPS MR node. The node configuration tab appears, as shown in the following figure.



Use the following sample code:

```
jar -resources base_test.jar -classpath ./base_test.jar com.taobao.edp.odps.brandnormalize.Word.NormalizeWordAll
```

The code is described as follows:

- `-resources base_test.jar` : the name of the JAR resource.
- `-classpath` : the path of the JAR resource. You can right-click the resource in the left-side navigation pane and select **Insert Resource Path** to insert the path of the resource into the code.

  > **Note** Make sure that the configuration tab of the ODPS MR node is active when you attempt to insert the path of a JAR resource.

- `com.taobao.edp.odps.brandnormalize.Word.NormalizeWordAll` : the main class in the JAR resource.

If you use multiple JAR resources in a single ODPS MR node, separate the resource paths with commas (,), for example, `-classpath ./xxxx1.jar,./xxxx2.jar` .

4. Configure the node properties.

   Click the **Properties** tab in the right-side navigation pane. On the **Properties** tab that appears, set the parameters. For more information, see Schedule.

5. Commit the node.

   After the node properties are configured, click the **Save** icon in the upper-left corner. Then, commit or commit and unlock the node to the development environment.

6. Deploy the node.

   For more information, see Deploy.

7. Test the node in the production environment.

   For more information, see Recurring tasks.

2.4.5.5. PyODPS node

DataWorks supports PyODPS nodes, which are integrated with the Python SDK of MaxCompute. You can edit Python code in PyODPS nodes of DataWorks to process data in MaxCompute.

You can also use the Python SDK of MaxCompute to process data in MaxCompute.

Create a PyODPS node

1. Log on to the DataWorks console.
2. On the **Data Analytics** tab, right-click **Workflow** and select **Create Workflow**.
3. In the **Create Workflow** dialog box that appears, set **Workflow Name** and **Description**. Then, click **Create**.
4. In the left-side navigation pane, click the created workflow. Then, right-click **Data Analytics** and choose **Create Data Analytics Node > PyODPS**.
5. Edit the code of the PyODPS node.

i. Use the MaxCompute entry.

Each PyODPS node includes the global variable odps or o, which is the MaxCompute entry. Therefore, you do not need to manually specify the MaxCompute entry.

```
print(odps.exist_table('pyodps_iris'))
```

ii. Run SQL statements.

In PyODPS nodes, you can run MaxCompute SQL statements to query data and obtain the query results. You can use the execute_sql or run_sql method to run MaxCompute job instances.

> **Note** To run statements that are not directly compatible with the MaxCompute console, you can use some methods. For example, you cannot directly run statements other than DDL and DML in the MaxCompute console. To run a GRANT or REVOKE statement, use the run_security_query method. To run a PAI command, use the run_xflow or execute_xflow method.

```
o.execute_sql('select * from dual') # Run the statement in synchronous mode. Other nodes are blocked until the SQL statement is run.
instance = o.run_sql('select * from dual') # Run the statement in asynchronous mode.
print(instance.get_logview_address()) # Obtain the Logview URL of an instance.
instance.wait_for_success() # Other nodes are blocked until the SQL statement is run.
```

iii. Set runtime parameters.

You can use the hints parameter to set the runtime parameters. The data type of the hints parameter is DICT.

```
o.execute_sql('select * from pyodps_iris', hints={'odps.sql.mapper.split.size': 16})
```

If you set the sql.settings parameter for the global configuration, you must set the runtime parameters each time you run the code.

```
from odps import options
options.sql.settings = {'odps.sql.mapper.split.size': 16}
o.execute_sql('select * from pyodps_iris') # The hints parameter is automatically set based on the global configuration.
```

iv. Obtain SQL query results.

You can use the open_reader method to obtain query results if the SQL statement returns structured data.

```
with o.execute_sql('select * from dual').open_reader() as reader:
for record in reader: # Process each record.
```

You can also use this method to obtain raw query results if a DESC statement is run.

```
with o.execute_sql('desc dual').open_reader() as reader:
print(reader.raw)
```

> **Note** If you use a custom time variable in data development, fix the variable to a time. PyODPS nodes do not support relative time variables.

6. Configure the node properties.

   Click the **Properties** tab in the right-side navigation pane. On the **Properties** tab that appears, set the parameters. For more information, see Schedule.

7. Commit the node.

   After the node properties are configured, click the **Save** icon in the upper-left corner. Then, commit or commit and unlock the node to the development environment.

8. Deploy the node.

   For more information, see Deploy a node.

9. Test the node in the production environment.

   For more information, see Recurring tasks.

2.4.5.6. Shell node

Shell nodes support standard shell syntax but not interactive syntax.

You can run Shell nodes in the default resource group. To enable a Shell node to access an IP address or a domain name, add the IP address or domain name to the whitelist.

Create a Shell node

1. Log on to the DataWorks console. On the **Data Analytics** tab, move the pointer over the **Create** icon and choose **Data Analytics > Shell**.

   > **Note** Alternatively, you can click a created workflow, right-click **Data Analytics**, and then choose **Create Data Analytics Node > Shell**.

2. In the **Create Node** dialog box that appears, set **Node Name** and **Location**, and then click **Commit**.
3. Edit the code of the Shell node.

   Edit the code on the configuration tab of the Shell node.

   To call the system scheduling parameters for the Shell node, run the following statement:

```
echo "$1 $2 $3"
```

> **Note** Separate multiple parameters with spaces. For more information about the system scheduling parameters, see Parameter configuration.

4. Configure the node properties.

   Click the **Properties** tab in the right-side navigation pane. On the **Properties** tab that appears, set the parameters. For more information, see Schedule.

5. Commit the node.

   After the node properties are configured, click the **Save** icon in the upper-left corner. Then, commit or commit and unlock the node to the development environment.

6. Deploy the node.

   For more information, see Deploy a node.

7. Test the node in the production environment.

   For more information, see Recurring tasks.

2.4.5.7. SQL script template

Procedure

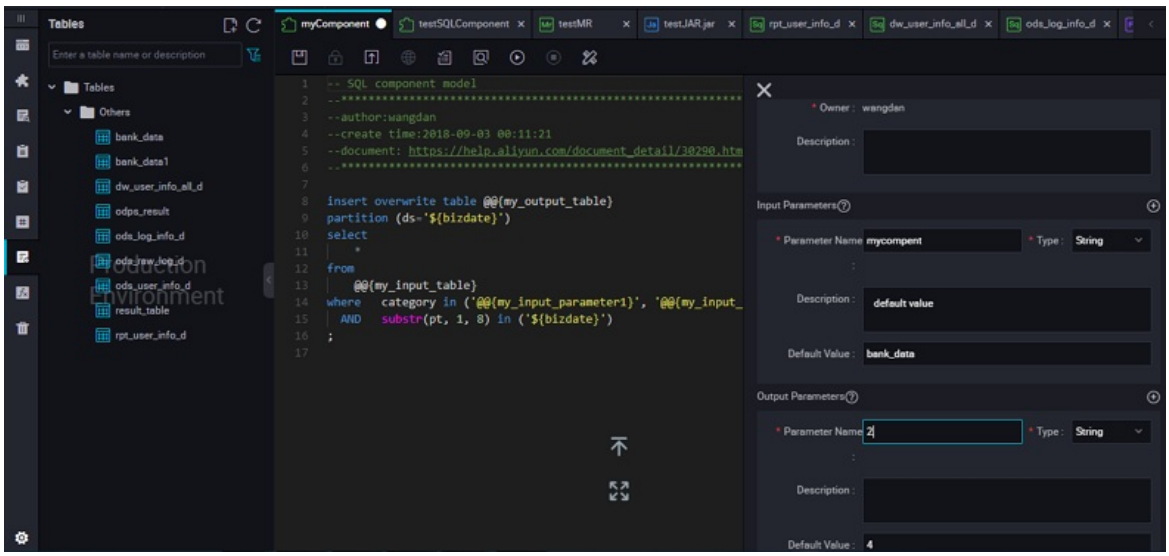
1. Log on to the DataWorks console.
2. On the **Data Analytics** tab, right-click **Workflow** and select **Create Workflow**.
3. In the left-side navigation pane, click the created workflow. Then, right-click **Data Analytics** and choose **Create Data Analytics Node > SQL Snippet**.
4. In the **Create Node** dialog box that appears, make sure that **Node Type** is set to **SQL Snippet**, set **Node Name** and **Location**, and then click **Commit**.

   To improve development efficiency, you can also create data analytics nodes by using the script templates provided by workspace members and tenants.

   - The script templates provided by members of the current workspace are available on the **Workspace-Specific** tab.
   - The script templates provided by tenants are available on the **Public** tab.

   On the left-side navigation submenu, click **Snippets**. On the **Workspace-Specific** tab, right-click **Components** and choose **Create Node > Snippet** to create an SQL script template.

On the configuration tab of the created SQL script template, set **Snippet**. Then, click the **Parameters** tab in the right-side navigation pane to set parameters for the selected script template.



Enter the parameter name and set the data type to Table or String.

For example, specify the myinputtable, topn, and myoutput parameters for the get_top_n script template.

For parameters whose data type is Table, specify the test_project.test_table as the input table.

5. Configure the node properties.

   Click the **Properties** tab in the right-side navigation pane. On the **Properties** tab that appears, set the parameters. For more information, see Schedule.

6. Commit the node.

   After the node properties are configured, click the **Save** icon in the upper-left corner. Then, commit or commit and unlock the node to the development environment.

7. Deploy the node.

   For more information, see Deploy a node.

8. Test the node in the production environment.

   For more information, see Recurring tasks.

Upgrade the version of an SQL script template

When a new version is released for a script template, you can decide whether to upgrade the version of the script template used in your nodes to the latest version.

The script template upgrade mechanism allows developers to continuously upgrade script template versions and users to enjoy the enhanced process execution efficiency and optimized business performance.

For example, User A uses V1.0 of a script template that belongs to User B. Then, User B releases V2.0 for the script template. User A receives a notification of the new version. After comparing the code of the two versions, User A can decide whether to upgrade the script template to the latest version.

SQL script templates are easy to upgrade because they are developed based on a template. To upgrade the version of an SQL script template, properly set parameters for the SQL script template of the new version according to the version description. Then, save the node and commit it for deployment in the same way as common SQL nodes.

GUI elements

The following table describes the graphical user interface (GUI) elements on the configuration tab of an SQL script template.

No.	GUI element	Description
1	Save icon	Click the icon to save the settings of the current script template.
2	Steal Lock icon	Click the icon to steal the lock of the current script template and then edit it if you are not the owner of the script template.
3	Submit icon	Click the icon to commit the current script template to the development environment.
4	Publish Snippet icon	Click the icon to make the current general-purpose script template public to the current Apsara Stack tenant account so that all users under the account can view and use the script template.
5	Parse I/O Parameters icon	Click the icon to parse input and output parameters from the code.
6	Precompile icon	Click the icon to edit custom and system parameters for the current script template.
7	Run icon	Click the icon to run the current script template in the development environment.
8	Stop icon	Click the icon to stop running the current script template.
9	Format Code icon	Click the icon to format the code based on keywords.
10	Parameters tab	Click the tab to view the basic information and set input and output parameters for the current script template.
11	Versions tab	Click the tab to view the committed and deployed versions of the current script template.
12	Snippet Nodes tab	Click the tab to view the records that the current script template is used.

2.4.5.8. Zero-load node

A zero-load node is a control node, which only supports dry-run scheduling and does not generate any data. It usually serves as the root node of a workflow.

> **Note** You can configure an output table for a zero-load node so that the output table can be used as an input table of another node. However, the zero-load node does not process the table data.

Create a zero-load node

1. Log on to the DataWorks console.
2. On the **Data Analytics** tab, right-click **Workflow** and select **Create Workflow**.
3. In the **Create Workflow** dialog box that appears, set **Workflow Name** and **Description**. Then, click **Create**.
4. In the left-side navigation pane, click the created workflow. Then, right-click **Data Analytics** and choose **Create Data Analytics Node > Zero-Load Node**.
5. In the Create Node dialog box that appears, make sure that Node Type is set to **Zero-Load Node**, set **Node Name** and **Location**, and then click **Commit**.
6. You do not need to edit the code for the zero-load node.
7. Configure the node properties.

   Click the **Properties** tab in the right-side navigation pane. On the **Properties** tab that appears, set the parameters. For more information, see Schedule.
8. Commit the node.

   After the node properties are configured, click the **Save** icon in the upper-left corner. Then, commit or commit and unlock the node to the development environment.
9. Deploy the node.

   For more information, see Deploy a node.
10. Test the node in the production environment.

    For more information, see Recurring tasks.

2.4.5.9. Cross-tenant collaboration node

Cross-tenant collaboration nodes are used to associate nodes from different tenants. Cross-tenant collaboration nodes are classified into sender nodes and receiver nodes.

Prerequisites

A sender node and its receiver node use the same CRON expression. You can click the **Properties** tab in the right-side navigation pane of a node configuration tab and view the CRON expression in the **Schedule** section.

Create a cross-tenant collaboration node

1. Log on to the DataWorks console.
2. On the **Data Analytics** tab, move the pointer over the **Create** icon and choose **Control > Cross-Tenant Collaboration**.

   > **Note** Alternatively, you can click a created workflow, right-click **Control**, and then choose **Create Control Node > Cross-Tenant Collaboration**.

3. In the **Create Node** dialog box that appears, set the parameters.
4. Click **Commit**.

Configure the cross-tenant collaboration node

1. On the configuration tab of the created node, set the parameters in the **Cross-Tenant Collaboration** section.

Parameter	Description
Type	The type of the cross-tenant collaboration node. Valid values: **Sender** and **Receiver**.
Location	The path of the cross-tenant collaboration node. The node path cannot be modified.
Collaborative Workspaces	The authorized collaborative workspace of the cross-tenant collaboration node. You must enter the workspace and Apsara Stack tenant account to which the peer end belongs. For example, if you are configuring the sender node, you must enter the authorized workspace and Apsara Stack tenant account to which the receiver node belongs.

2. After the sender node is created, follow the same procedure to create the receiver node under the workspace and Apsara Stack tenant account to which the peer end belongs.

   Set the node type to **Receiver**. The information about available sender nodes appears. You must also set the **Timeout** parameter. This parameter specifies the timeout period of the receiver node after it starts to run.

   The sender node first sends a message to the message center. After the message is delivered, the status of the sender node is set to successful. The receiver node continuously pulls messages from the message center. If a message is received within the timeout period, the status of the receiver node is set to successful.

   If the receiver node does not receive any messages within the timeout period, the receiver node fails. The lifecycle of a message is 24 hours.

   Assume that an auto triggered instance was run on October 8, 2018. A message indicating the completion of the instance was then sent to the message center. If you create a retroactive instance for the receiver node with the data timestamp set to October 7, 2018, the status of the generated receiver node instance is set to successful.

3. After the configuration is completed, click the **Save** and **Submit** icons to save and commit the node.

2.4.5.10. Assignment node

The assignment node is a special type of node. It allows you to assign values to output parameters by writing code in the node and passes them with the node context to descendant nodes for reference.

Create an assignment node

1. Open the **DataStudio** page, move the pointer over the **Create** icon, and then choose **Control > Assignment Node**.

> **Note** Alternatively, you can navigate to the corresponding workflow, right-click **Control**, and then choose **Create Control Node > Assignment Node**.

2. In the **Create Node** dialog box that appears, set the relevant parameters.
3. Click **Commit**.

Write the value assignment logic

The assignment node has a fixed output parameter named outputs. You can view the information about this parameter in the **Parameters** section. You can use ODPS SQL, Shell, or Python to write code for assigning values to parameters. The value of each parameter can be computed after the corresponding code is run. Only one language can be specified for a single assignment node.

> **Note**
>
> - The value of the outputs parameter is taken only from the output of the last line of the code.
>   - For ODPS SQL, use the output of the SELECT statement in the last line.
>   - For Shell, use the output of the ECHO statement in the last line.
>   - For Python, use the output of the PRINT statement in the last line.
> - The passed value of the outputs parameter is limited to 2 MB in size. If the output of the assignment statement exceeds this limit, the assignment node fails to run.

Use an assignment node as a parent node

An assignment node can be added as the parent node of a node. After setting the dependency, you can define the output of the assignment node as the input parameter of the child node in the node context. Then, reference the node in the code. In this way, the child node can obtain the specific values from the output of the assignment node.

Example of the assignment node

1. Create a workflow and then create the nodes.
2. When you configure an assignment node, the system displays the **outputs** parameter by default. Its value can be found in the **Parameters** section after you run the assignment node.
3. The outputs parameter of the parent node serves as the input parameter of the child node.

Run the assignment node

> **Note** The preceding configuration parameters can take effect through data patching in Operation Center, but the parameters for operation test cannot take effect.

1. After a node is configured and submitted for scheduling, a running instance is generated on the next day.
2. When the node is running, you can view the input and output parameters in the node context, and click the link next to each parameter to view your input and output results.
3. In the operational logs, you can view the final output of the code in finalResult.

Summary

> **Note** The value of the outputs parameter is the output of the last line of the code.

This section describes the general usage of ODPS SQL, Shell, and Python arrays. In the examples, the input parameter of a Shell node is used to generate output data.

- ODPS SQL: The output is a one-dimensional or two-dimensional array.

  In this example, the query result is a two-dimensional array.

  ```
  2,this is name6
  1,this is name5
  ```

  The following figure shows the output code in Shell.

  ```
  echo ${input[0][0]};
  echo ${input[0][1]};
  echo ${input[1][0]};
  echo ${input[1][1]};
  echo ${input[0]};
  ```

  The following figure shows the output.

  ```
  2019-02-21 11:11:55 INFO --- Invoking Shell command line now ---
  2019-02-21 11:11:55 INFO ================================================================
  2
  this is name6
  1
  this is name5
  2,this is name6
  ```

- Shell: The output is a one-dimensional array.

  The following figure shows the output code in Shell.

  ```
  #********************************************************************
  echo ${input};
  echo ${input[0]};
  echo ${input[1]}
  ```

  The following figure shows the output.

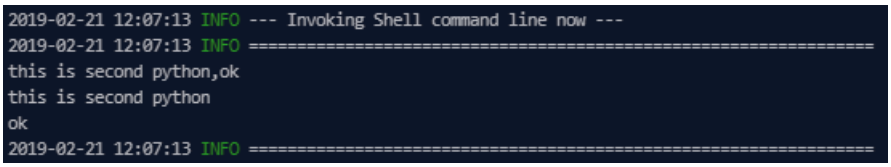
  ```
  2019-02-21 11:59:13 INFO --- Invoking Shell command line now ---
  2019-02-21 11:59:13 INFO ================================================================
  this is password,ok
  this is password
  ok
  ```

- Python: The output is a one-dimensional array.

  The following figure shows the output code in Shell.

  ```
  #********************************************************************#
  echo ${input};
  echo ${input[0]};
  echo ${input[1]}
  ```

The following figure shows the output.



2.4.5.11. Branch node

A branch node is a logical control node in DataStudio. It can define the branch logic and the direction of branches under different logical conditions.

> **Note** Generally, branch nodes need to be used with assignment nodes.

Create a branch node

1. Log on to the DataWorks console. On the **Data Analytics** tab, move the pointer over the **Create** icon and choose **Control > Branch Node**.

   > **Note** Alternatively, you can click a created workflow, right-click **Control**, and then choose **Create Control Node > Branch Node**.

2. In the **Create Node** dialog box that appears, set the parameters.
3. Click **Commit**.

Define the branch logic

1. After the branch node is created, the node configuration tab appears.
2. Click **Add Branch**. In the **Branch Definition** dialog box that appears, set **Condition**, **Associated Node Output**, and **Description**.

Parameter	Description
Condition	◦ The condition of the branch. You can only use Python comparison operators to define logical conditions for the branch node. ◦ If the result of the expression is true when the node is running, the corresponding branch condition is met. Otherwise, the branch condition is not met. ◦ If the expression fails to be parsed when the node is running, the whole branch node fails. ◦ To define branch conditions, you can use global variables and parameters defined in the node context. For example, the *${input}* variable in the figure can be used as an input parameter of the branch node.

Parameter	Description
Associated Node Output	○ The associated node output of the branch. The node output is used to configure dependencies for the child nodes of the branch node. ○ If the branch condition is met, the child node corresponding to the node output is run. If the child node also depends on the output of other nodes, the status of these nodes is considered. ○ If the branch condition is not met, the child node corresponding to the node output is not run. The child node is set to the Not Running state.
Description	The description of the branch. For example, the branches *${input}==1* and *${input}>2* are defined. They are described as 1 and 2, respectively. ○ **Change**: You can click **Change** to modify the branch and related dependencies. ○ **Delete**: You can click **Delete** to delete the branch and related dependencies.

3. After the configuration is completed, click **OK**.

Configure the node properties

After the branch conditions are defined, the output names are automatically added to the **Outputs** section on the **Properties** tab. Then, you can associate child nodes with the branch node based on the output names.

> **Note** The dependencies established by drawing lines between nodes on the dashboard of a workflow are not recorded on the Properties tab. You must manually enter these dependencies.

Example: Configure child nodes for a branch node

You can associate child nodes with different output results of a branch node to define the branches under different conditions. For example, in the workflow shown in the following figure, the branches **Branch_1** and **Branch_2** are defined as child nodes of the branch node.

Branch_1 depends on the output named autotest.fenzhi121902_1.

Branch_2 depends on the output named autotest.fenzhi121902_2.

Commit and run the branch node

Commit the branch node and run it in Operation Center. In this example, the condition of Branch_1 is met. Branch_1 depends on the autotest.fenzhi121902_1 output of the branch node.

- The condition of Branch_1 is met. The child node of this branch is run. You can select the branch and view the running details on the **Runtime Log** tab.
- The condition of Branch_2 is not met. The child node of this branch is skipped. You can select the branch and view relevant information on the **Runtime Log** tab.

Supported Python comparison operators

In the following table, assume that the value of the a variable is 10 and that of the b variable is 20.

Comparison operator	Description	Example
==	Equal: checks whether two objects are equal.	(a==b) returns false.
! =	Not equal: checks whether two objects are not equal.	(a! =b) returns true.
<>	Not equal: checks whether two objects are not equal.	(a<>b) returns true. This operator is similar to ! =.
>	Greater than: checks whether the variable on the left side of the operator is greater than that on the right side.	(a>b) returns false.
<	Less than: checks whether the variable on the left side of the operator is less than that on the right side. If the return result is 0 or 1, 0 indicates false and 1 indicates true. These two results are equivalent to the special variables true and false, respectively.	(a<b) returns true.
>=	Greater than or equal to: checks whether the variable on the left side of the operator is greater than or equal to that on the right side.	(a>=b) returns false.
<=	Less than or equal to: checks whether the variable on the left side of the operator is less than or equal to that on the right side.	(a<=b) returns true.

2.4.5.12. MERGE node

This topic describes the definition of MERGE nodes and how to create a MERGE node and define the merging logic. An example is also provided to show the scheduling configuration and running details of a MERGE node.

Definition

- The MERGE node is a type of logical control node in DataStudio.
- A MERGE node can merge the running results of its parent nodes, regardless of their running statuses. It aims to fix the issue that a node that depends on the output of the child nodes of a branch node only starts to run after its parent nodes are successfully run.
- Currently, you cannot change the running status of a MERGE node. A MERGE node merges multiple child nodes of a branch node and sets the running status to Successful. To guarantee the proper running of a node that depends on the output of the child nodes of a branch node, you can configure the node to directly depend on the MERGE node.

For example, the branch node C defines two logically exclusive branches C1 and C2. These two branches use different logic to write data to the same MaxCompute table. Assume that node B depends on the output of this MaxCompute table. To make sure that node B can run properly, you must use the MERGE node J to merge branches C1 and C2, and then set the MERGE node J as the parent node of node B. If node B directly depends on branches C1 and C2, one of the branches will fail to run because only one branch meets the branch condition each time the branch node runs. In this case, node B cannot be triggered as scheduled.

Create a MERGE node

1. Go to the **DataStudio** page. Move the pointer over the **Create** icon and then choose **Control > MERGE Nodes**.

   > **Note** Alternatively, you can navigate to the corresponding workflow, right-click **Control**, and then choose **Create Control Node > MERGE Nodes**.

2. In the **Create Node** dialog box that appears, set the relevant parameters.
3. Click **Submit**.

Define the merging logic

After creating the MERGE node, specify the branches to be merged for the node. Enter the output name or output table name of the child node of a branch node, and click the **Add** icon. You can view the running status in the execution results. Currently, the running statuses include **Successful** and **Failed**.

Click the **Properties** tab in the right sidebar to configure the scheduling properties of the MERGE node.

Example of the MERGE node

You can associate child nodes with different output results of a branch node to define the branches under different conditions. For example, in the workflow shown in the following figure, the branches **Branch_1** and **Branch_2** are both child nodes of the branch node.

Branch_1 depends on the output autotest.fenzhi121902_1.

Branch_2 depends on the output autotest.fenzhi121902_2.

Run the MERGE node

If a branch meets the specified condition, the branch is run. You can select the branch and view the running details in the **Runtime Log** section.

If a branch does not meet the specified condition, the branch is skipped. You can select the branch and view related information in the **Runtime Log** section.

The child node of the MERGE node runs properly.

2.4.5.13. do-while node

You can define mutually dependent nodes, including a loop decision node named end, on a do-while node. DataWorks repeatedly runs the nodes and exits the loop only when the end node returns False.

> **Note** A loop can be repeated for a maximum of 128 times. If the loop count exceeds this limit, an error occurs.

The do-while node supports the ODPS SQL, Shell, and Python languages. If you use ODPS SQL, you can use a `case when` statement to evaluate whether the specified condition for exiting the loop is met.

Simple example

This section describes how to use a do-while node to repeat a loop five times and display the loop count each time the loop runs.

1. On the **DataStudio** page, click Data Analytics in the left-side navigation pane. Move the pointer over the **Create** icon and choose **Control > do-while**.
2. In the **Create Node** dialog box that appears, set the parameters and click **Submit**.
3. Double-click the created do-while node and define the loop body.

   The do-while node consists of the start, sql, and end nodes.

   - The start node marks the startup of a loop and does not have any business effect.
   - DataWorks provides the sql node as a sample business processing node. You must replace the sql node with your own business processing node, for example, a Shell node named Display loop count.
   - The end node marks the end of a loop and determines whether to start the loop again. In this example, it defines the condition for exiting the loop for the do-while node.

     The end node only assigns values True and False, indicating whether to start a loop again or exit the loop.

     The ${dag.loopTimes} variable is used in both the Display loop count node and the end node. It is a reserved variable of the system. This variable indicates the loop count and increments from 1. The internal nodes of the do-while node can directly reference this variable.

     In the code shown in the preceding figure, the value of the `${dag.loopTimes}` variable is compared with 5 to limit the total number of loops. The value of the ${dag.loopTimes} variable is 1 for the first loop, 2 for the second loop, and so on. When the loop runs for the fifth time, the value is 5. In this case, the conditional statement ${dag.loopTimes}<5 is False, and the do-while node exits the loop.
4. Run the do-while node.

   You can configure the scheduling settings for the do-while node as needed and submit it to **Operation Center** for running.

   - do-while node: The do-while node is displayed as a whole node in Operation Center. To view the loop details about the do-while node, right-click the node and select **View Internal Nodes**.
   - Internal loop body: This view is divided into three parts.
     - The left pane of the view lists the rerun history of the do-while node. A record is generated for each run of the whole do-while instance.
     - The middle pane of the view shows a loop record list. Each record corresponds to each run of the do-while node. The running status of the node for each run is also displayed.

- The right pane of the view shows the details about the do-while node each time the loop runs. You can click a record in the loop record list to view the running status of the corresponding instance.

5. View the running result.

   Access the internal loop body. In the loop record list, click the record corresponding to the third run. The loop count is 3 in the runtime logs.

   You can also view the runtime logs of the end node that are generated when the loop runs for the third time and for fifth time, respectively.

   As shown in the preceding figures, the conditional statement 3<5 is True when the loop runs for the third time, while the conditional statement 5<5 is False when the loop runs for the fifth time. Therefore, the do-while node exits the loop after the fifth run.

Based on the preceding simple example, the do-while node works in the following process:

1. Run from the start node.
2. Run nodes in sequence based on the defined node dependencies.
3. Define the condition for exiting a loop for the end node.
4. Run the conditional statement of the end node after the loop ends for the first time.
5. Record the loop count as 1 and start the loop again if the conditional statement returns True in the runtime logs of the end node.
6. Exit the loop if the conditional statement returns False in the runtime logs of the end node.

Complex example

Besides the preceding simple scenarios, do-while nodes can also be used in complex scenarios where each row of data is processed in sequence by using a loop. Before processing data in such scenarios, make sure that:

- You have deployed a parent node that can export queried data to the do-while node. You can use an assignment node to meet this condition.
- The do-while node can obtain the output of the parent node. You can configure the context and dependencies to meet this condition.
- The internal nodes of the do-while node can reference each row of data. In this example, the existing node context is enhanced and the system variable ${dag.offset} is assigned to help you reference the context of the do-while node.

This section describes how to use the do-while node to respectively display records 0 and 1 in two rows of the tb_dataset table each time the loop runs.

1. On the **DataStudio** page, click Data Analytics in the left-side navigation pane. Move the pointer over the **Create** icon and choose **Control > do-while**.
2. In the **Create Node** dialog box that appears, set the parameters and click **Submit**.
3. Double-click the created do-while node and define the loop body.
   i. Create a parent node named Initialize dataset for the do-while node. The parent node generates a test dataset.
   ii. Click Properties in the upper-right corner to configure a dedicated **context** for the do-while node. Set Parameter Name to input and Value Source to the output of the parent node.

iii. Type the code for the business processing node named Print each data row.

- `${dag.offset}` : a reserved variable of DataWorks. This variable indicates the offset of the loop count to 1. The offset is 0 for the first run, 1 for the second run, and so on. The offset equals to the loop count minus 1.
- `${dag.input}` : the context that you configure for the do-while node. As mentioned above, the do-while node is configured with the input parameter, with Value Source set to the output of the parent node named Initialize dataset.

  The internal nodes of the do-while node can directly use ${dag.${ctxKey}} to reference the context. In this example, ${ctxKey} is set to input. Therefore, you can use ${dag.input} to reference the context.
- `${dag.input[${dag.offset}]}` : The node Initialize dataset exports a table. DataWorks can obtain a row of data in the table based on the specified offset. The value of ${dag.offset} increments from 0. Therefore, the returned results are ${dag.input[0]}, ${dag.input[1]}, and so on until all data in the dataset is returned.

iv. Define the condition for exiting the loop for the end node. As shown in the following figure, the values of the ${dag.loopTimes} and ${dag.input.length} variables are compared. If the value of ${dag.loopTimes} is less than that of ${dag.input.length}, the end node returns True and the do-while node continues the loop. Otherwise, the end node returns False and the do-while node exits the loop.

> **Note** The system automatically sets the ${dag.input.length} variable to the number of rows in the array specified by the input parameter based on the context configured for the do-while node.

4. Run the nodes and view the running result.

   The loop count is less than the number of the rows when the loop runs for the first time. Therefore, the end node returns True and the loop continues. The loop count equals to the number of the rows when the loop runs for the second time. Therefore, the end node returns False and the loop stops.

Summary

- Compared with the while, foreach, and do...while statements, a do-while node:
  - Contains a loop body that runs a loop before evaluating the conditional statement, providing the same function as the do...while statement. A do-while node can also use the system variable ${dag.offset} and the node context to implement the function of the foreach statement.
  - Cannot achieve the function of the while statement because a do-while node runs a loop before evaluating the conditional statement.
- The do-while node works in the following process:
  i. Run nodes in the loop body starting from the start node based on node dependencies.
  ii. Run the code defined for the end node.
    - Run the loop again if the end node returns True.
    - Stop the loop if the end node returns False.
- Method to use the context: The internal nodes of the do-while node can use ${dag.${ctxKey}} to reference the context defined for the do-while node.

- System parameters: DataWorks automatically issues the following system variables for the internal nodes of the do-while node:
  - ${dag.loopTimes}: the loop count, starting from 1.
  - ${dag.offset}: the offset of the loop count to 1, starting from 0.

2.4.5.14. EMR MR node

This topic describes how to create an EMR MR node.

> **Note** You can create E-MapReduce nodes only after an E-MapReduce compute engine instance is added. For more information about how to add an E-MapReduce compute engine instance, see Use EMR in DataWorks. ·

1. Log on to the DataWorks console.
2. On the **Data Analytics** tab, move the pointer over the **Create** icon and choose **Data Analytics > EMR MR**.

   > **Note** Alternatively, you can click a created workflow, right-click **Data Analytics**, and then choose **Create Data Analytics Node > EMR MR**.

3. In the **Create Node** dialog box that appears, set **Node Name** and **Location**, and then click **Commit**.
4. On the node configuration tab that appears, select an E-MapReduce compute engine instance from the drop-down list and edit the node code.
5. Configure the node properties.

   Click the **Properties** tab in the right-side navigation pane. On the **Properties** tab that appears, set the parameters. For more information, see Schedule.
6. Commit the node.

   After the node properties are configured, click the **Save** icon in the upper-left corner. Then, commit or commit and unlock the node to the development environment.
7. Deploy the node.

   For more information, see Deploy a node.
8. Test the node in the production environment.

   For more information, see Recurring tasks.

2.4.5.15. EMR SPARK SQL node

This topic describes how to create an EMR SPARK SQL node.

> **Note** You can create E-MapReduce nodes only after an E-MapReduce compute engine instance is added. For more information about how to add an E-MapReduce compute engine instance, see Use EMR in DataWorks. ·

1. Log on to the DataWorks console.
2. On the **Data Analytics** tab, move the pointer over the **Create** icon and choose **Data Analytics >**

EMR SPARK SQL.

> **Note** Alternatively, you can click a created workflow, right-click **Data Analytics**, and then choose **Create Data Analytics Node > EMR SPARK SQL**.

3. In the **Create Node** dialog box that appears, set **Node Name** and **Location**, and then click **Commit**.
4. On the node configuration tab that appears, select an E-MapReduce compute engine instance from the drop-down list and edit the node code.
5. Configure the node properties.

   Click the **Properties** tab in the right-side navigation pane. On the **Properties** tab that appears, set the parameters. For more information, see Schedule.
6. Commit the node.

   After the node properties are configured, click the **Save** icon in the upper-left corner. Then, commit or commit and unlock the node to the development environment.
7. Deploy the node.

   For more information, see Deploy a node.
8. Test the node in the production environment.

   For more information, see Recurring tasks.

2.4.5.16. EMR SPARK node

This topic describes how to create an EMR SPARK node.

> **Note** You can create E-MapReduce nodes only after an E-MapReduce compute engine instance is added. For more information about how to add an E-MapReduce compute engine instance, see Use EMR in DataWorks. ·

1. Log on to the DataWorks console.
2. On the **Data Analytics** tab, move the pointer over the **Create** icon and choose **Data Analytics > EMR SPARK**.

> **Note** Alternatively, you can click a created workflow, right-click **Data Analytics**, and then choose **Create Data Analytics Node > EMR SPARK**.

3. In the **Create Node** dialog box that appears, set **Node Name** and **Location**, and then click **Commit**.
4. On the node configuration tab that appears, select an E-MapReduce compute engine instance from the drop-down list and edit the node code.
5. Configure the node properties.

   Click the **Properties** tab in the right-side navigation pane. On the **Properties** tab that appears, set the parameters. For more information, see Schedule.
6. Commit the node.

After the node properties are configured, click the **Save** icon in the upper-left corner. Then, commit or commit and unlock the node to the development environment.

7. Deploy the node.

   For more information, see Deploy a node.

8. Test the node in the production environment.

   For more information, see Recurring tasks.

2.4.5.17. EMR HIVE node

This topic describes how to create an EMR HIVE node.

> **Note** You can create E-MapReduce nodes only after an E-MapReduce compute engine instance is added. For more information about how to add an E-MapReduce compute engine instance, see Use EMR in DataWorks. ·

1. Log on to the DataWorks console.
2. On the **Data Analytics** tab, move the pointer over the **Create** icon and choose **Data Analytics > EMR HIVE**.

   > **Note** Alternatively, you can click a created workflow, right-click **Data Analytics**, and then choose **Create Data Analytics Node > EMR HIVE**.

3. In the **Create Node** dialog box that appears, set **Node Name** and **Location**, and then click **Commit**.
4. On the node configuration tab that appears, select an E-MapReduce compute engine instance from the drop-down list and edit the node code.
5. Configure the node properties.

   Click the **Properties** tab in the right-side navigation pane. On the **Properties** tab that appears, set the parameters. For more information, see Schedule.

6. Commit the node.

   After the node properties are configured, click the **Save** icon in the upper-left corner. Then, commit or commit and unlock the node to the development environment.

7. Deploy the node.

   For more information, see Deploy a node.

8. Test the node in the production environment.

   For more information, see Recurring tasks.

2.4.5.18. Custom node type

2.4.5.18.1. Overview

DataStudio supports default node types such as ODPS SQL and Shell nodes. You can also create custom node types to meet your requirements.

To create a custom node type, you need to create a custom wrapper and use it to define a custom node type.

Entry

1. Log on to the DataWorks console.
2. Click **Node Market** in the upper-right corner to go to the node configuration page.

> **Note** Only the workspace owner and administrators can access this page.

View the list of wrappers

The Wrappers page displays all the wrappers you have created. You can click **Create** in the upper-right corner to create a custom wrapper.

The values displayed in the Latest Version, Version in Development, and Version in Production Environment columns for the created wrappers follow these rules:

- If a created wrapper has not been deployed, the values of both the Version in Development and Version in Production Environment columns are **Not Deployed**.
- If a wrapper has been deployed, the version and the deployment time appear in these columns.
- If a wrapper is under deployment, the values of both the Version in Development and Version in Production Environment columns are **Deploying**.

You can click **Settings**, **View Versions**, or **Delete** in the Actions column of each wrapper.

Action	Description
Settings	You can click **Settings** to configure the wrapper. The page that appears depends on the wrapper status. The **Deploy in Production Environment** page appears if the wrapper has been deployed in the production environment.
View Versions	You can click **View Versions** to view all historical versions of the wrapper. • **View**: You can click this button to view the settings of the selected version. • **Roll Back**: You can click this button to roll back to the selected version. After you click this button, the system creates a new version for the wrapper. In the new version, the wrapper uses the basic settings and the resource file of the selected version. The new version number equals the latest version number among all the versions plus 1. • **Download**: You can click **Download** to download the resource file of the selected version.
Delete	If an error occurs while a node type is using the wrapper, you need to delete the node type. **Note** Before deleting a wrapper, ensure that no node type is associated with the wrapper.

Create a custom wrapper

A wrapper is the core processing logic of a node type. For example, after you compile an SQL statement in the editor for an ODPS SQL node and submit the statement, the system calls the corresponding wrapper to parse and run the statement. You need to create a wrapper before creating a custom node type. Currently, only the Java programming language is supported.

The procedure of creating a wrapper includes four steps: specify settings for the wrapper, deploy the wrapper in the development environment, test the wrapper in the development environment, and deploy the wrapper in the production environment. For more information, see Create a custom wrapper.

View the list of custom node types

The Custom Node Types page displays all custom node types in the workspace. You can click **Create** in the upper-right corner to create a custom node type. For more information, see Create a custom node type.

Currently, you can only create custom node types in DataStudio.

The workspace owner or node type creator can **change** or **delete** existing node types.

- **Change**: You can click **Change** to edit the settings for the node type as needed.
- **Delete**: You can click this button to delete the node type that no node uses. If any node uses the node type, a message appears, indicating that you need to disable the node first before deleting the node type.

Use a custom node type

After creating a custom node type, go to the **Data Analytics** page.

Move the pointer over the **Create** icon and click **Data Analytics**. In the list that appears, select the created node type to create a node.

2.4.5.18.2. Create a custom wrapper

The procedure of creating a wrapper includes four steps: specify settings for a wrapper, deploy the wrapper in the development environment, test the wrapper in the development environment, and deploy the wrapper in the production environment.

Specify settings for a wrapper

1. Click **Wrappers** in the left-side navigation pane. On the page that appears, click **Create** in the upper-right corner.
2. Specify the parameters in the **Settings** step.

Parameter	Description
Name	The name of the wrapper. It must start with a letter and can only contain letters, digits, and underscores (_).
Owner	The owner of the wrapper. You can select an owner from the workspace members. You are not allowed to edit wrappers owned by other members even if you are an administrator. Only the workspace owner can edit the wrappers of other members.
Resource Type	The type of the resource package for configuring the wrapper. Valid values: **JAR** and **Archive**. The size of the resource package can be up to 50 MB.

Parameter	Description
Resource File	The local resource file or OSS object for configuring the wrapper. **Note** The size of a local file can be up to 50 MB, and the size of a file that is stored in an OSS bucket can be up to 200 MB.
Class Name	The full path of the class for implementing the user wrapper.
Parameter Example	The parameters designed based on the JAR package you upload.
Version	The version of the configured wrapper. Select Create Version if you are creating a new wrapper. Select Overwrite Version if you are editing and rolling back a version. **Note** The version number is automatically generated.
Description	The description of the wrapper version.

3. Click **Save** and then click **Next**.

Note The settings are updated to the database after you click Save.

- If you only modify basic settings of a wrapper without changing the resource file, the modification takes immediate effect after you click Save.
- If you change the resource file, the change only applies after deployment.

Deploy the wrapper in the development environment

After you specify the parameters in the **Settings** step and click **Next**, the information in the Deploy in Development Environment step is updated accordingly. You can identify the changes by checking the file name and MD5 checksum.

Click **Deploy in Development Environment**. You can view the **deployment progress** in real time. After the wrapper is deployed, click **Next**.

Test the wrapper in the development environment

Specify the parameters for testing and click **Test** to send the parameters to the wrapper. This step is to validate the deployment and logic of the wrapper. You can also locally test the wrapper before uploading it for deployment.

After the test, review the output logs in the Test Results section on the right to determine whether the test is passed. If the test is passed, select **Test Passed** and click **Next**.

Note The **Next** button is operable only after you select **Test Passed**.

Deploy the wrapper in the production environment

Click **Deploy in Production Environment**. In the **Confirm** dialog box that appears, click **OK**. The wrapper is deployed in the production environment. You can view the deployment progress in real time.

> **Note** The wrapper to be deployed in the production environment must be of the latest version, have been deployed in the development environment, and have passed the test. Otherwise, a message appears, indicating that the deployment in the production environment fails.

Click **Complete**. You can view and edit the created wrapper on the **Wrappers** page.

2.4.5.18.3. Create a custom node type

The Configure Custom Node Type page consists of three sections: Basic Information, Interaction, and Wrapper.

1. On the DataStudio page, click **Node Market** in the top navigation bar. On the page that appears, click **Custom Node Types** in the left-side navigation pane.
2. Click **Create** in the upper-right corner.
3. Specify the parameters in the **Basic Information** section.

Parameter	Description
Name	The name of the node type, which cannot be changed after being saved. Each node type has a unique name within the workspace. The name can be up to 20 characters in length, and can only contain letters, spaces, and underscores (_).
Icon	The icon of the node type.
Tabs	The template of the node type. Currently, only **Data Analytics** is available.
Folder	The folder where the node type belongs. You can select **Data Integration** or **Data Analytics**.

4. Specify the parameters in the **Interaction** section.

Parameter	Description
Shortcut Menu	◦ The options to appear in the shortcut menu. The following options are selected by default: Rename, Move, Clone, Steal Lock, View Versions, Locate in Operation Center, Delete, and Submit for Review. ◦ More options include Edit, Copy Resource Name, and Send to DataWorks Desktop (Shortcut).

Parameter	Description
Tool Bar	◦ The options to appear in the top navigation bar. The following options are selected by default: Save, Commit, Commit and Unlock, Steal Lock, Run, Show/Hide, Run with Arguments, Stop, Reload, Run Smoke Test in Development Environment, View Smoke Test Log in Development Environment, Run Smoke Test, View Smoke Test Log, Go to Operation Center of Development Environment, and Format. ◦ More options include Operation Center, Deploy, and Precompile.
Editor Type	The type of the editor. Currently, only **Editor Only** is available.
Right-Side Bar	◦ The options to appear in the right-side bar. The following options are selected by default: Code Structure and Properties. ◦ More options include Version, Lineage, and Parameters.
Auto Parse Option	Specifies whether to display the Auto Parse option for this type of node. If you turn on this switch, the Auto Parse option is displayed on the Properties tab. Otherwise, it is not displayed. In an automatic parsing process, the system parses the input and output of a node based on the lineage specified in the code.

5. Specify the parameters in the **Wrapper** section.

Parameter	Description
Wrapper	The wrapper used for running the type of node. Select a wrapper that has been deployed.
Editor Language	The language used for writing the code in the editor. Currently, only ODPS SQL is available.
Use MaxCompute as Engine	Specifies whether to use MaxCompute as the compute engine. If your wrapper uses MaxCompute as the compute engine, select Yes. Otherwise, select No. Default value: Yes.

6. Click **Save and Exit**. Then, go to the **Data Analytics** page to use the custom node type that is created.

2.4.6. Manage configurations

2.4.6.1. Overview

DataWorks allows you to configure the graphical user interface (GUI) of the DataStudio page. For example, you can configure the code editor, manage table folders, and add or remove tabs in the left-side navigation pane.

To go to the configuration management page, follow these steps: Log on to the DataWorks console. On the **DataStudio** page that appears, click the Settings icon in the lower-left corner.

For more information about the configuration management modules, see the following topics:

- Configuration Center
- Project Configuration
- Templates
- Theme Management
- Table Levels

2.4.6.2. Configuration Center page

On the Configuration Center page, you can configure common features in the **DataStudio Tabs** and **Editor Settings** sections.

DataStudio Tabs section

In the DataStudio Tabs section, you can click tags to add or remove the tabs that appear in the left-side navigation pane of the DataStudio page. You can also drag and drop the tags to sort the tabs.

If you move the pointer over a tag in the Other Available Tabs section, the tag turns into a blue **Create** button.

If you move the pointer over a tag in the Tabs on DataStudio Page section, the tag turns into a red **Delete** button.

> **Note** The tab settings take effect immediately in the current workspace. If you want the settings to take effect for all workspaces, click **Apply to All Workspaces** at the bottom of the page.

Editor Settings section

In the Editor Settings section, you can configure the code editor and keywords. The settings take effect immediately in the current workspace without the need to refresh the page.

- Minimap: If you select this check box, a thumbnail of your code appears on the right of the code editor. If the code is long, you can click a code segment in the thumbnail to view the code.
- Error Annotation

  If you select this check box, DataWorks marks potential syntax errors in the code with a red squiggly line. You can move the pointer over the underlined code to view the error message.
- Auto Save

  If you select this check box, DataWorks automatically saves the code being edited at certain intervals. If the code editor of a node is closed unexpectedly, you can re-open the node and click **Use Version Saved on Server** or **Use Version Saved in Local Cache** in the dialog box that appears.
- Auto-Completed Code Style

  You can select whether the code completed based on hints is uppercase or lowercase.
- Code Font Size

  Valid values: 12 to 18. You can change the font size based on your habits and code size.
- Auto Completion

If you are typing in the code editor, DataWorks provides a hint list. You can select a keyword from the list and click the keyword or press Enter to enter the automatically completed code in the code editor.

- Add Space: specifies whether to automatically add a space after each automatically completed keyword, table name, or field name.
- Keyword: specifies whether to enable keyword hints.
- Syntax Template: specifies whether to enable syntax template hints.
- Project: specifies whether to enable workspace name hints.
- Table Name: specifies whether to enable table name hints.
- Field: specifies whether to enable field name hints.

- Theme

  You can select the black or white theme for the DataStudio page.

- Apply to All Workspaces

  Click **Apply to All Workspaces**. The tab settings and editor settings can be applied to all existing workspaces under the current Apsara Stack tenant account.

2.4.6.3. Project Configuration

The Project Configuration page provides five parameters: Partition Date Format, Partition Field Name, Temporary Table Prefix, Upload Table (Import Table) Prefix, and Mask Data in Page Query Results.

Click the settings icon in the lower-left corner of the **DataStudio** page to open the **Configuration Center** page.

In the left-side navigation bar, click **Project Configuration**.

Parameter	Description
Partition Date Format	The default date format of partition field values. You can modify the format as required.
Partition Field Name	The default name of a partition field.
Temporary Table Prefix	The prefix of temporary table names. By default, tables with the prefix t_ in their names are identified as temporary tables.
Upload Table (Import Table) Prefix	The prefix of the names of tables uploaded on the **DataStudio** page.
Mask Data in Page Query Results	When the switch is turned on, the result returned for a temporary search task in the current workspace will be desensitized.

Enable data desensitization for DataWorks workspaces

Data desensitization for DataWorks needs to be enabled in workspaces one by one. After data desensitization is enabled, the result returned for the temporary query task in the current workspace is desensitized. The underlying storage data is not affected because only dynamic desensitization is performed.

> **Note** For example, data desensitization has been set for workspace A, but not workspace B. If you access a table in workspace A from workspace B, the plaintext result is displayed.

On the **Project Configuration** page, turn on the switch Mask Data in Page Query Results, and click **Save** to enable data desensitization for DataWorks workspaces.

> **Note** By default, DataWorks does not allow you to download desensitized data or enable data desensitization.

Enter a query statement in the SQL node to check whether data desensitization is enabled for DataWorks workspaces.

2.4.6.4. Templates

The Templates page displays code template. Workspace administrators can change the templates.

Currently, templates are only available for ODPS SQL, ODPS MR, and shell nodes.

2.4.6.5. Theme Management page

Each workspace can hold a great number of tables. You can store the tables in two levels of folders. These folders are also known as themes.

A workspace administrator can create multiple folders to classify tables as needed, for example, by purpose or name.

On the **Configuration Center** page, click **Theme Management** in the left-side navigation pane. On the Theme Management page that appears, you can click **Create** to create a folder, or click **Change** or **Delete** to modify or delete an existing folder.

- Create a folder

  Enter a folder name in the **Folder** field, select a parent folder from the **Parent Folder** drop-down list, and then click **Create**.

- Modify a folder

  Click **Change** in the Actions column of the target folder. In the **Change Folder** dialog box that appears, enter a new folder name and click **OK**.

- Delete a folder

  Click **Delete** in the Actions column of the target folder. In the **Delete Folder** dialog box that appears, click **OK**.

2.4.6.6. Hierarchical Management page

On the Hierarchical Management page, you can manage table levels.

You can classify tables by importance. If a table is not properly organized and cannot be found, nodes that reference this table may fail to run.

On the **Configuration Center** page, click **Hierarchical Management** in the left-side navigation pane. On the Hierarchical Management page that appears, you can click **Create** to create a table category or level, or click **Change** or **Delete** to modify or delete an existing table category or level.

A workspace has no default table category or level. The workspace owner or a workspace administrator can create table categories or levels as required.

2.4.6.7. Backup and Restore page

On the Backup and Restore page, you can back up and restore data for a workspace. When you back up your data, your resources are also backed up.

> **Note** Only workspace administrators can download backup files and restore data from backup files. For more information about how to go to the configuration management page, see Configuration Center.

To create a backup for a workspace, you can select **Full Backup** or **Incremental Backup**. In the **Version** field, you can select **Alibaba Cloud Version 2**, **Apsara Stack Version 3.6.1 or Later**, or **Apsara Stack Version 3.6 or Earlier**.

> **Note**
>
> - You can download backup files in XML format.
> - You can restore data for a workspace from backup files. However, errors may occur during restoration. We recommend that you use full backup whenever possible.

2.4.7. Deploy

2.4.7.1. Deploy nodes

In a rigorous data development process, developers develop and debug code and configure dependencies and scheduling properties for nodes in the development environment. Then, developers commit and deploy the nodes to run them in the production environment.

DataWorks workspaces in standard mode can process data seamlessly from the development environment to the production environment within a single workspace. We recommend that you use workspaces in standard mode to develop and produce data.

Deploy nodes in a workspace in standard mode

Each DataWorks workspace in standard mode is linked with two MaxCompute projects, one as the development environment and the other as the production environment. You can directly commit and deploy nodes from the development environment to the production environment.

Follow these steps:

1. On the **DataStudio** page, configure and debug the code of nodes. Then, double-click the target workflow in the left-side navigation pane. On the dashboard of the workflow that appears, click the **Submit** icon to check whether the dependencies between nodes are correct and commit the nodes.
2. After the nodes are committed, click the **Deploy** icon.
3. On the **Create Deploy Task** page that appears, select the target nodes and click **Add to List**. The nodes are added to the to-be-deployed node list.

You can search for nodes by condition, such as the committer, node type, change type, time when a node is committed, node name, and node ID. If you click Deploy Selected, the selected nodes are deployed to the production environment.

4. Click **View List**. In the Nodes to Deploy dialog box that appears, click **Deploy All**. All nodes in the list are deployed to the production environment.

> **Note** Workspaces in standard mode protect tables in the production environment from being manipulated, and therefore provide the stable, secure, and reliable production environment. We recommend that you use workspaces in standard mode to deploy and run nodes.

Clone nodes between workspaces in basic mode

You cannot deploy nodes in workspaces in basic mode. If you want to isolate the development environment from the production environment for workspaces in basic mode, create two workspaces, one for development and the other for production. You can clone nodes from the development workspace to the production workspace.

As shown in the following figure, two workspaces in basic mode are created, one for development and the other for production. You can use the cross-workspace cloning feature to clone nodes from Workspace A to Workspace B, and then commit the cloned nodes to the scheduler for scheduling.

> **Note**
> - Permission requirement: Only workspace administrators and Resource Access Management (RAM) users who have the O&M permissions can clone nodes.
> - Workspace type: You can only clone nodes in workspaces in basic mode, but cannot clone those in workspaces in standard mode.
> - Prerequisites: The source workspace in basic mode and the destination workspace in basic mode are created.

1. Commit nodes.

   After you create and configure nodes in the source workspace, commit the nodes on the dashboard of the target workflow.

2. Click **Cross-Workspace Cloning**.
3. On the Create Clone Task page that appears, select the target nodes and the destination workspace, and then click **Add to List**.
4. Clone the nodes. Click **View List**. In the To-Be-Cloned Nodes dialog box that appears, check the nodes to be cloned and click **Clone All**.

   In the Create Clone Task dialog box that appears, click **Clone**.

5. View the cloned nodes.

   You can view the successfully cloned nodes on the View Clone Tasks page of the source workspace.

   Switch to the destination workspace. You can find that the nodes are cloned from the source workspace.

2.4.7.2. Clone nodes across workspaces

For workspaces in basic mode under the same Apsara Stack tenant account, you can use the cross-workspace cloning feature to isolate the development environment from the production environment. You can also use this feature to clone and migrate nodes, such as computing or sync nodes, between workspaces. This topic describes how to process the dependencies between nodes during cross-workspace cloning.

If you clone nodes across workspaces by using the cross-workspace cloning feature, DataWorks automatically modifies output names in the destination workspace to distinguish nodes in different workspaces of the same Apsara Stack tenant account. This allows you to successfully clone node dependencies.

Clone a workflow

Assume that the output of the task_A node in the project_1 workspace is project_1.task_A_out. If you clone a workflow that contains the task_A node to the destination workspace project_2, the node output name changes to project_2.task_A_out in the destination workspace.

Clone a single node

If you only clone the task_B node in the project_1 workspace to the destination workspace project_2, DataWorks automatically sets the root node of the destination workspace as the parent node and the output of the root node as the input for the task_B node cloned to the destination workspace. This allows the task_B node to automatically depend on the root node in the destination workspace.

Clone cross-workspace node dependencies

Assume that the task_ B node in the project_1 workspace depends on the task_A node in the project_3 workspace. If you clone the task_B node in the project_1 workspace to the destination workspace project_2, the dependency between the task_A and task_B nodes is also cloned. The task_B node in the project_2 workspace also depends on the task_A node in the project_3 workspace.

2.4.8. Ad-hoc business flows

2.4.8.1. Overview

In a manually triggered workflow, all nodes can only be manually triggered, but cannot be automatically triggered by DataWorks. Therefore, you do not need to configure parent nodes or outputs for nodes in manually triggered workflows.

1. Log on to the DataWorks console.
2. On the left-side navigation submenu, click **Manually Triggered Workflows** to go to the **Manually Triggered Workflows** tab.
3. In the left-side navigation pane, right-click **Manually Triggered Workflows** and select **Create Workflow**.
4. In the **Create Workflow** dialog box that appears, set **Workflow Name** and **Description**. Then, click **Create**. The workflow dashboard appears.

   The following table describes the graphical user interface (GUI) elements on the workflow dashboard.

No.	GUI element	Description
1	Submit icon	Click the icon to commit all nodes in the current manually triggered workflow.
2	Run icon	Click the icon to run all nodes in the current manually triggered workflow. Nodes in a manually triggered workflow can run simultaneously because they do not have dependencies.
3	Stop icon	Click the icon to stop running all nodes in the current manually triggered workflow.
4	Deploy icon	Click the icon to go to the node deployment page. You can deploy some or all nodes that are committed but not deployed to the production environment.
5	Go to Operation Center icon	Click the icon to go to Operation Center.
6	Refresh icon	Click the icon to refresh the dashboard of the current manually triggered workflow.
7	Auto Layout icon	Click the icon to sort the nodes in the current manually triggered workflow.
8	Zoom In icon	Click the icon to zoom in the dashboard of the current manually triggered workflow.
9	Zoom Out icon	Click the icon to zoom out the dashboard of the current manually triggered workflow.
10	Search icon	Click the icon to search for a node in the current manually triggered workflow.
11	Toggle Full Screen View icon	Click the icon to view the nodes in the current manually triggered workflow in full screen.
12	Workflow Parameters tab	Click the tab to set the workflow parameters. Workflow parameters have a higher priority than node parameters. This means that a workflow parameter takes precedence if it has the same key as a node parameter.
13	Change History tab	Click the tab to view the operation records of all nodes in the current manually triggered workflow.
14	Versions tab	Click the tab to view the committed and deployed versions of all nodes in the current manually triggered workflow.

2.4.8.2. Functions

Register functions

You can define MaxCompute functions in the DataWorks console. This feature is similar to the **add function** command of MaxCompute.

Currently, DataWorks supports Python and Java functions. To use a user-created function, upload the function code as a resource and then register the function.

Procedure

1. Right-click the Ad-Hoc Business Flows folder on the **Ad-Hoc Business Flows** tab, and select **Create Business Flow**.
2. In a Java environment, complete the code for the function, and then package and publish the code.

   Alternatively, in the DataWorks console, create a Python resource, edit the code in the resource file, and then save, submit, and publish the resource. For more information, see Create resources.
3. Choose **Function > Create Function**. In the dialog box that appears, specify the function name and click **Submit**.
4. Configure the function.

Parameter	Description
Class Name	The main class name of a Python function in the format of pythonResourceName. className. Do not include the .py extension in the resource name.
Resources	The resource list. Separate the resource names by a comma (,).
Description	(Optional) The description of the function.

5. Submit the function.

   After the function configuration is complete, click the **Save** in the tool bar and submit the function to the development environment. After the function is submitted, it is unlocked.
6. Publish the function.

   For more information, see Deploy.

2.4.8.3. Resources

You need to upload files as MaxCompute resources if you need to use them in user-defined MaxCompute functions or ODPS MR nodes.

- MaxCompute SQL functions: You can upload compiled JAR packages to MaxCompute as JAR resources. Then, if you run a function that uses a JAR resource, MaxCompute automatically downloads the corresponding package.
- ODPS MR nodes: You can upload compiled JAR packages to MaxCompute as JAR resources. Then, if you run an ODPS MR node that uses a JAR resource, MapReduce automatically downloads the corresponding package.

You can also upload text files, MaxCompute tables, and various compressed packages (such as .zip, .tgz, .tar.gz, .tar, and .jar) to MaxCompute so that you can use them in user-created functions and ODPS MR nodes.

Available MaxCompute resource types are listed as follows:

- File

- Archive: DataWorks automatically identifies the file format based on the extension. Supported formats: .zip, .tgz, .tar.gz, .tar, and .jar.
- JAR: compiled Java JAR packages.

In wizard mode, you can upload resources of the JAR, Python, or file type. The method of creating resources differs as follows:

- JAR resource: You need to compile Java code in a Java environment, compress the code into a JAR package, and then upload the package as a JAR resource to MaxCompute.
- File resource: For a file that is smaller than or equal to 500 KB, you can create a file resource and edit it in the DataWorks console.
- If you need to upload a local file, select Larger than 500 KB while creating the resource.

Create a resource

1. Right-click the Ad-Hoc Business Flows folder on the **Ad-Hoc Business Flows** tab, and select **Create Business Flow**.
2. In the new business flow folder, right-click the **Resource** folder, and choose **Create Resource > JAR**.
3. The **Create Resource** dialog box appears. Specify a resource name according to the naming convention, set the resource type to JAR, select a local JAR package, and click **Submit**.

   > Note
   > - If the selected JAR package has been uploaded from the ODPS client, deselect **Upload to ODPS**. Otherwise, an error will occur during the upload process.
   > - The resource name can be different from the name of the uploaded file.
   > - Convention for naming resources: A resource name can contain letters (case insensitive), numbers, underscores (_), and periods (.). It must be 1 to 128 characters in length. A JAR resource name must end with .jar.

4. Click **Submit** to submit the resource to the development environment.
5. Publish the resource.

   For more information, see Deploy.

2.4.8.4. Tables

Create a table

1. Log on to the DataWorks console.
2. Create a manually triggered workflow.
   i. On the **DataStudio** page, click **Manually Triggered Workflows** in the left-side navigation bar.
   ii. In the **Create Workflow** dialog box that appears, set **Workflow Name** and **Description**.
   iii. Click **Create**.
3. Expand the created workflow in the left-side navigation pane. Right-click **Table**, and select **Create Table**.

4. In the **Create Table** dialog box that appears, enter a name in **Table Name** and click **Commit**.
5. Configure the basic attributes of the table.

Parameter	Description
Display Name	The alias of the table.
Level 1 Folder	The name of the level-1 target folder where the table is located.
Level 2 Folder	The name of the level-2 target folder where the table is located.
Create Folder	Click **Create Folder** to redirect to the Theme Management page. On this page, you can create table folders of levels 1 and 2.
Description	The description of the table.

6. Create a table.

   Use either of the following methods to create a table:

   - Create a table in DDL mode.

     Click **Use DDL Statement** in the tool bar. In the dialog box that appears, enter a standard statement for creating a table.

     After you finish editing the statement, click **Generate Table Schema**. The Basic Information, Physical Model, and Schema sections are automatically filled.

   - Create a table by using a wizard.

     If the DDL mode is inappropriate for you to create a table, try using a wizard. The relevant parameters are described as follows.

Category	Parameter	Description
Physical Model	**Partitioning**	Indicates whether a table is partitioned. Valid values: Partitioned Table and Non-Partitioned Table.
	Time-to-Live	The time-to-live of data in MaxCompute. The entered number indicates the number of days. Data in a table (or partition) that has not been updated in the specified number of days is automatically cleared.
	Table Level	Generally, tables are divided into three levels: DW, ODS, and RPT.

Category	Parameter	Description
	Categories	Physically, tables are categorized into basic services, advanced services, and other services. If you need to create a table level, click **Create Level** to redirect to the **Hierarchical Management** page. **Note** Physical categories are designed only for your management convenience and do not involve underlying implementation.
Schema	**Field Name**	The name of a field. The value contains letters, digits, and underscores (_).
	Display Name	The alias of a field.
	Data Type	The type of MaxCompute data. Currently, DataWorks supports only the data of STRING, BIGINT, DOUBLE, DATETIME, and BOOLEAN types.
	Description	The detailed description of a field.
	Primary Key Field	The field that serves as the primary key or part of a composite primary key.
	Create Field	Adds a field.
	Delete Field	Deletes a created field. **Note** If you delete a field from a created table and then commit the table, DataStudio deletes the created table and creates a new table with the same name. This operation is not permitted in the production environment.
	Move Up	Adjusts the field sequence of a table that has not been created. If you adjust the sequence of fields in a created table, DataStudio deletes the created table and creates a new table with the same name. This operation is not permitted in the production environment.
	Move Down	The description is the same as that of the **Move Up** operation.
	Add	Creates a partition for the current table. If you add a partition to a created table, DataStudio deletes the created table and creates a new table with the same name. This operation is not permitted in the production environment.

Category	Parameter	Description
	Delete	Deletes a partition. If you delete a partition from a created table, DataStudio deletes the created table and creates a new table with the same name. This operation is not permitted in the production environment.
Partition Field Design Note This parameter is available only when Table Type under Physical Model is set to Partitioned Table.	**Data Type**	We recommend that you use the STRING type globally.
	Partition Key Column Date Format	The format of a date partition. If the partition field is a date (although the data type may be STRING), select or enter a date format, such as yyyymmmdd or yyyy-mm-dd.
	Partition Key Column Date Granularity	The granularity of a date partition. The value can be second, minute, hour, day, month, quarter, or year. You can enter a partition granularity as required. If you need to specify multiple partition granularities, note that a greater granularity corresponds to a higher partition level by default. For example, there are three partitions whose granularities are day, hour, and month, respectively. The multi-level partition hierarchy is as follows: level-1 partition (month), level-2 partition (day), and level-3 partition (hour).

Commit the table

After editing the schema of a table, you can commit the new table to the development environment and the production environment.

Operation	Description
Load from the development environment	If the table has been committed to the development environment, the button is highlighted. After you click the button, the information about the table you create in the development environment overwrites the table information on the current page.
Commit to the development environment	The system first checks whether you have configured all the required items on the current editing page. If any item is missing, an alert is triggered and the table cannot be committed.
Load from the production environment	The detailed information of the table committed to the production environment overwrites the table information on the current page.
Commit to the production environment	The table is created in the production environment.

2.4.9. Ad-hoc nodes

2.4.9.1. ODPS SQL node

Using the SQL-like syntax, ODPS SQL nodes can process terabytes of data in distributed scenarios that do not require real-time processing.

Generally, it takes a long time from preparing to committing a job. You can use ODPS SQL nodes to process thousands to ten thousands of transactions. ODPS SQL nodes are online analytical processing (OLAP) applications designed to deal with large amounts of data.

1. Create a workflow.
   i. Log on to the DataWorks console.
   ii. On the left-side navigation submenu, click **Manually Triggered Workflows** to go to the **Manually Triggered Workflows** tab.
   iii. On the Manually Triggered Workflows tab, move the pointer over the **Create** icon and select **Workflow**.
   iv. In the **Create Workflow** dialog box that appears, set **Workflow Name** and **Description**. Then, click **Create**.
2. Create an ODPS SQL node.

   In the left-side navigation pane, click the created workflow. Then, right-click **Data Analytics** and choose **Create Data Analytics Node > ODPS SQL**.
3. Edit the code of the ODPS SQL node. The code must conform to the syntax.
4. Configure the node properties.

   Click the **General** tab in the right-side navigation pane. On the **General** tab that appears, set the parameters. For more information, see Schedule.
5. Commit the node.

   After the node properties are configured, click the **Save** icon in the upper-left corner. Then, commit or commit and unlock the node to the development environment.
6. Deploy the node.

   For more information, see Deploy.
7. Test the node in the production environment.

   For more information, see Recurring tasks.

2.4.9.2. PyODPS node

DataWorks supports PyODPS nodes, which are integrated with the Python SDK of MaxCompute.

You can edit Python code in PyODPS nodes of DataWorks to process data in MaxCompute.

Create a PyODPS node

1. Create a workflow.
   i. Log on to the DataWorks console.
   ii. On the left-side navigation submenu, click **Manually Triggered Workflows** to go to the **Manually Triggered Workflows** tab.
   iii. On the Manually Triggered Workflows tab, move the pointer over the **Create** icon and select **Workflow**.
   iv. In the **Create Workflow** dialog box that appears, set **Workflow Name** and **Description**. Then, click **Create**.

2. Create a PyODPS node.

   In the left-side navigation pane, click the created workflow. Then, right-click **Data Analytics** and choose **Create Data Analytics Node > PyODPS**.

   In the **Create Node** dialog box that appears, set **Node Name** and click **Commit**.

3. Edit the code of the PyODPS node.

   i. Use the MaxCompute entry.

   Each PyODPS node includes the global variable odps or o, which is the MaxCompute entry. Therefore, you do not need to manually specify the MaxCompute entry.

```
print(odps.exist_table('pyodps_iris'))
```

   ii. Run SQL statements.

   In PyODPS nodes, you can run MaxCompute SQL statements to query data and obtain the query results. You can use the execute_sql or run_sql method to run MaxCompute job instances.

> **Note**
>
> To run statements that are not directly compatible with the MaxCompute console, you can use some methods. For example, you cannot directly run statements other than DDL and DML in the MaxCompute console. To run a GRANT or REVOKE statement, use the run_security_query method. To run a PAI command, use the run_xflow or execute_xflow method.

```
o.execute_sql('select * from dual') # Run the statement in synchronous mode. Other nodes are blocked until the SQL statement is run.
instance = o.run_sql('select * from dual') # Run the statement in asynchronous mode.
print(instance.get_logview_address()) # Obtain the Logview URL of an instance.
instance.wait_for_success() # Other nodes are blocked until the SQL statement is run.
```

   iii. Set runtime parameters.

   You can use the hints parameter to set the runtime parameters. The data type of the hints parameter is DICT.

```
o.execute_sql('select * from pyodps_iris', hints={'odps.sql.mapper.split.size': 16})
```

   If you set the sql.settings parameter for the global configuration, you must set the runtime parameters each time you run the code.

```
from odps import options
options.sql.settings = {'odps.sql.mapper.split.size': 16}
o.execute_sql('select * from pyodps_iris') # The hints parameter is automatically set based on the global configuration.
```

iv. Obtain SQL query results.

You can use the open_reader method to obtain query results if the SQL statement returns structured data.

```
with o.execute_sql('select * from dual').open_reader() as reader:
for record in reader: # Process each record.
```

You can also use this method to obtain raw query results if a DESC statement is run.

```
with o.execute_sql('desc dual').open_reader() as reader:
print(reader.raw)
```

> **Note** If you use a custom time variable in data development, fix the variable to a time. PyODPS nodes do not support relative time variables.

4. Configure the node properties.

   Click the **General** tab in the right-side navigation pane. On the **General** tab that appears, set the parameters. For more information, see Schedule.

5. Commit the node.

   After the node properties are configured, click the **Save** icon in the upper-left corner. Then, commit or commit and unlock the node to the development environment.

6. Deploy the node.

   For more information, see Deploy.

7. Test the node in the production environment.

   For more information, see Recurring tasks.

2.4.9.3. Manual sync node

Currently, sync nodes support various connections, including MaxCompute, MySQL, Distributed Relational Database Service (DRDS), SQL Server, PostgreSQL, Oracle, MongoDB, Db2, Table Store, Table Store Stream, Object Storage Service (OSS), FTP, HBase, LogHub, Hadoop Distributed File System (HDFS), and Stream. For more information about the supported connections, see Supported data sources.

1. Create a workflow.
   i. Log on to the DataWorks console.
   ii. On the left-side navigation submenu, click **Manually Triggered Workflows** to go to the **Manually Triggered Workflows** tab.
   iii. On the Manually Triggered Workflows tab, move the pointer over the **Create** icon and select **Workflow**.
   iv. In the **Create Workflow** dialog box that appears, set **Workflow Name** and **Description**. Then, click **Create**.
2. Create a sync node.

   In the left-side navigation pane, click the created workflow. Then, right-click **Data Integration** and choose **Create Data Integration Node > Sync**.

In the **Create Node** dialog box that appears, set **Node Name** and click **Commit**.

3. Configure the sync node. For more information, see Configure a data synchronization node by using the codeless UI.
4. Configure the node properties.

   Click the **General** tab in the right-side navigation pane. On the **General** tab that appears, set the parameters. For more information, see Schedule.
5. Commit the node.

   After the node properties are configured, click the **Save** icon in the upper-left corner. Then, commit or commit and unlock the node to the development environment.
6. Deploy the node.

   For more information, see Deploy.
7. Test the node in the production environment.

   For more information, see Recurring tasks.

2.4.9.4. ODPS MR node

MaxCompute supports the MapReduce API. You can call the Java API operations of MapReduce to develop MapReduce programs for processing data in MaxCompute. You can also create and run ODPS MR nodes in DataWorks.

Before creating ODPS MR nodes, you must upload, commit, and then deploy required resources.

Create a resource

1. Create a manually triggered workflow.
   i. Log on to the DataWorks console.
   ii. On the left-side navigation submenu, click **Manually Triggered Workflows** to go to the **Manually Triggered Workflows** tab.
   iii. On the Manually Triggered Workflows tab, move the pointer over the **Create** icon and select **Workflow**.
   iv. In the **Create Workflow** dialog box that appears, set **Workflow Name** and **Description**. Then, click **Create**.
2. In the left-side navigation pane, click the created workflow. Then, right-click **Resource** and choose **Create Resource > JAR**.
3. In the **Create Resource** dialog box that appears, set a resource name based on the naming convention, make sure that the resource type is set to **JAR**, select a local JAR package to upload, and then click **OK**.

> Note
>
> - If the selected JAR package has been uploaded from the MaxCompute client, clear **Upload to MaxCompute**. If you do not clear it, an error will occur during the upload process.
> - The resource name can be different from the name of the uploaded file.
> - Convention for naming resources: A resource name can contain letters (case-insensitive), digits, underscores (_), and periods (.). It must be 1 to 128 characters in length. A JAR resource name must end with .jar. A Python resource name must end with .py.

4. On the configuration tab of the created resource, click the **Submit** icon to commit the resource to the development environment.
5. Deploy the resource.

   For more information, see Deploy.

Create an ODPS MR node

1. In the left-side navigation pane, click the created workflow. Then, right-click **Data Analytics** and choose **Create Data Analytics Node > ODPS MR**.
2. In the **Create Node** dialog box that appears, set **Node Name** and click **Commit**.
3. Edit the code of the ODPS MR node. Double-click the created ODPS MR node. The node configuration tab appears.

   Use the following sample code:

   ```
   jar -resources base_test.jar -classpath ./base_test.jar com.taobao.edp.odps.brandnormalize.Word.NormalizeWordAll
   ```

   The code is described as follows:

   - `-resources base_test.jar` : the name of the JAR resource.
   - `-classpath` : the path of the JAR resource. You can right-click the resource in the left-side navigation pane and select **Insert Resource Path** to insert the path of the resource into the code.

     > Note Make sure that the configuration tab of the ODPS MR node is active when you attempt to insert the path of a JAR resource.

   - `com.taobao.edp.odps.brandnormalize.Word.NormalizeWordAll` : the main class in the JAR resource.

   If you use multiple JAR resources in a single ODPS MR node, separate the resource paths with commas (,), for example, `-classpath ./xxxx1.jar,./xxxx2.jar` .
4. Configure the node properties.

   Click the **General** tab in the right-side navigation pane. On the **General** tab that appears, set the parameters. For more information, see Schedule.
5. Commit the node.

After the node properties are configured, click the **Save** icon in the upper-left corner. Then, commit or commit and unlock the node to the development environment.

6. Deploy the node.

   For more information, see Deploy.

7. Test the node in the production environment.

   For more information, see Recurring tasks.

2.4.9.5. SQL script template

This topic describes how to create and configure SQL script templates in a manually triggered workflow.

Procedure

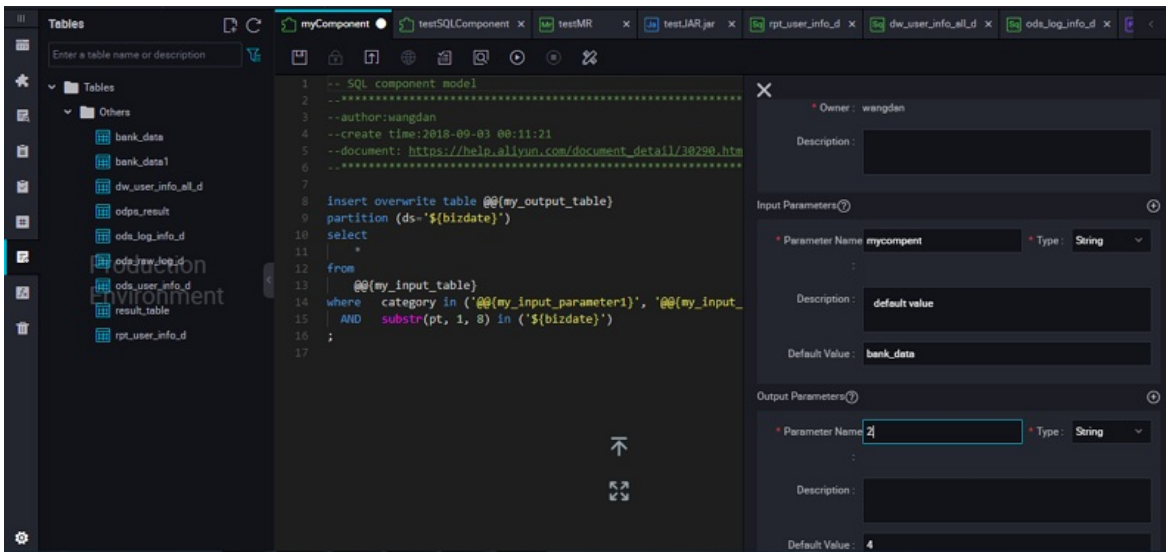
1. Create a manually triggered workflow.
   i. Log on to the DataWorks console.
   ii. On the left-side navigation submenu, click **Manually Triggered Workflows** to go to the **Manually Triggered Workflows** tab.
   iii. On the Manually Triggered Workflows tab, move the pointer over the **Create** icon and select **Workflow**.
   iv. In the **Create Workflow** dialog box that appears, set **Workflow Name** and **Description**. Then, click **Create**.
2. Create an SQL script template.
   i. In the left-side navigation pane, click the created workflow. Then, right-click **Data Analytics** and choose **Create Data Analytics Node > SQL Snippet**.
   ii. In the **Create Node** dialog box that appears, set **Node Name** and click **Commit**.

   To improve development efficiency, you can also create data analytics nodes by using the script templates provided by workspace members and tenants.

   - The script templates provided by members of the current workspace are available on the **Workspace-Specific** tab.
   - The script templates provided by tenants are available on the **Public** tab.

   On the left-side navigation submenu, click **Snippets**. On the **Workspace-Specific** tab, right-click **Components** and choose **Create Node > Snippet** to create an SQL script template.

On the configuration tab of the created SQL script template, set **Snippet**. Then, click the **Parameters** tab in the right-side navigation pane to set parameters for the selected script template.



3. Configure the node properties.

   Click the **General** tab in the right-side navigation pane. On the **General** tab that appears, set the parameters. For more information, see Schedule.

4. Commit the node.

   After the node properties are configured, click the **Save** icon in the upper-left corner. Then, commit or commit and unlock the node to the development environment.

5. Deploy the node.

   For more information, see Deploy.

6. Test the node in the production environment.

   For more information, see Recurring tasks.

Upgrade the version of an SQL script template

When a new version is released for a script template, you can decide whether to upgrade the version of the script template used in your nodes to the latest version.

The script template upgrade mechanism allows developers to continuously upgrade script template versions. This mechanism enhances the process execution efficiency and optimizes the business performance.

For example, User A uses V1.0 of a script template that belongs to User B. Then, User B releases V2.0 for the script template. User A receives a notification of the new version. After comparing the code of the two versions, User A can decide whether to upgrade the script template to the latest version.

SQL script templates are easy to upgrade because they are developed based on a template. To upgrade the version of an SQL script template, properly set parameters for the SQL script template of the new version according to the version description. Then, save the node and commit it for deployment.

GUI elements

The following table describes the graphical user interface (GUI) elements on the configuration tab of an SQL script template.

No.	GUI element	Description
1	Save icon	Click the icon to save the settings of the current script template.
2	Submit icon	Click the icon to commit the current script template to the development environment.
3	Commit and Unlock icon	Click the icon to commit the current script template and unlock the script template to edit it.
4	Steal Lock icon	Click the icon to steal the lock of the current script template and then edit it if you are not the owner of the script template.
5	Run icon	Click the icon to run the current script template in the development environment.
6	Run with Arguments icon	Click the icon to run the code of the current script template with the configured parameters. **Note** This feature is unavailable for Shell nodes.
7	Stop icon	Click the icon to stop running the current script template.
8	Reload icon	Click the icon to reload the code of the current script template. The code will be restored to the version last saved. Unsaved changes will be lost. **Note** If Auto Save is selected on the Configuration Center page, you are notified of the code that is cached but not saved after the page is refreshed. In this case, select the version that you need.
9	Run Smoke Test icon	Click the icon to test the code of the current script template.
10	View Smoke Test Log icon	Click the icon to view the runtime logs of the current script template.
11	Parameters tab	Click the tab to view the basic information and set input and output parameters for the current script template.
12	General tab	Click the tab to set the owner, description, parameters, and resource group of the current script template.
13	Lineage tab	Click the tab to view the lineage and dependencies between the current script template and other nodes.
14	Versions tab	Click the tab to view the committed and deployed versions of the current script template.

2.4.9.6. Zero-load node

A zero-load node is a control node, which only supports dry-run scheduling and does not generate any data. It usually serves as the root node of a workflow.

Create a zero-load node

1. Create a manually triggered workflow.
   i. Log on to the DataWorks console.
   ii. On the left-side navigation submenu, click **Manually Triggered Workflows** to go to the **Manually Triggered Workflows** tab.
   iii. On the Manually Triggered Workflows tab, move the pointer over the **Create** icon and select **Workflow**.
   iv. In the **Create Workflow** dialog box that appears, set **Workflow Name** and **Description**. Then, click **Create**.
2. In the left-side navigation pane, click the created workflow. Then, right-click **Data Analytics** and choose **Create Data Analytics Node > Zero-Load Node**.
3. In the **Create Node** dialog box that appears, set the parameters and click **Commit**.
4. Configure the node properties.

   You do not need to edit the code for the zero-load node. Click the **General** tab in the right-side navigation pane. On the **General** tab that appears, set the parameters. For more information, see Schedule.
5. Commit the node.

   After the node properties are configured, click the **Save** icon in the upper-left corner. Then, commit or commit and unlock the node to the development environment.
6. Deploy the node.

   For more information, see Deploy.
7. Test the node in the production environment.

   For more information, see Recurring tasks.

2.4.9.7. Shell node

Shell nodes support standard shell syntax but not interactive syntax.

Procedure

1. Create a manually triggered workflow.
   i. Log on to the DataWorks console.
   ii. On the left-side navigation submenu, click **Manually Triggered Workflows** to go to the **Manually Triggered Workflows** tab.
   iii. On the Manually Triggered Workflows tab, move the pointer over the **Create** icon and select **Workflow**.
   iv. In the **Create Workflow** dialog box that appears, set **Workflow Name** and **Description**. Then, click **Create**.

2. Create a Shell node.

   In the left-side navigation pane, click the created workflow. Then, right-click **Data Analytics** and choose **Create Data Analytics Node > Shell**.

3. In the **Create Node** dialog box that appears, set **Node Name** and **Location**, and then click **Commit**.

4. Edit the code of the Shell node.

   Edit the code on the configuration tab of the Shell node.

   To call the system scheduling parameters for the Shell node, run the following statement:

   ```
   echo "$1 $2 $3"
   ```

   > **Note** Separate multiple parameters with spaces. For more information about the system scheduling parameters, see Parameter configuration.

5. Configure the node properties.

   Click the **General** tab in the right-side navigation pane. On the **General** tab that appears, set the parameters. For more information, see Schedule.

6. Commit the node.

   After the node properties are configured, click the **Save** icon in the upper-left corner. Then, commit or commit and unlock the node to the development environment.

7. Deploy the node.

   For more information, see Deploy.

8. Test the node in the production environment.

   For more information, see Recurring tasks.

2.4.10. Configure parameters for ad-hoc tasks

2.4.10.1. Basic properties

Log on to the DataWorks console. On the **DataStudio** page that appears, click **Manually Triggered Workflows** on the left-side navigation submenu. On the Manually Triggered Workflows tab that appears, create a manually triggered node. Then, double-click the node. The node configuration tab appears.

Click the **General** tab in the right-side navigation pane. On the General tab that appears, set the parameters in the **General** section.

Parameter	Description
Node Name	The name of the node that you set when creating the node. To modify the name, right-click the node in the left-side navigation pane and select **Rename**.
Node ID	The unique ID of the node. The node ID is generated when the node is committed at the first time. The node ID cannot be modified.

Parameter	Description
Node Type	The type of the node that you set when creating the node. The node type cannot be modified.
Owner	The owner of the node. By default, the owner of a newly created node is the current logon user. You can change the owner. **Note** Only a member in the workspace where the node resides can be selected as the owner.
Description	The description of the node, such as the business and usage.
Arguments	The parameter used to assign a value to a variable in the code during node scheduling. You can enter multiple parameters. Separate multiple parameters with spaces.

Parameter value assignment formats for various node types

- Format for ODPS SQL and ODPS MR nodes: `Variable name 1=Parameter 1 Variable name 2=Parameter 2`. Separate multiple parameters with spaces.
- Format for Shell nodes: `Parameter 1 Parameter 2`. Separate multiple parameters with spaces.

For more information about the built-in scheduling parameters, see Parameter configuration.

2.4.10.2. Parameter configuration

DataWorks provides the parameter configuration feature to make sure that manually triggered nodes can adapt to environment changes.

Note the following issues when configuring parameters:

- Do not add spaces on either side of the equal sign (=) for a parameter. For example, enter `bizdate=$bizdate`.
- Separate multiple parameters (if any) with spaces. For example, enter `bizdate=$bizdate datetime=${yyyymmdd}`.

System parameters

DataWorks provides the following system parameters:

- ${bdp.system.cyctime}: the scheduled time to run an instance. Default format: yyyymmddhh24miss.
- ${bdp.system.bizdate}: the timestamp of data to be analyzed by an instance. Default format: yyyymmdd. The default data timestamp is one day before the scheduled time.

The formula for calculating the running time and data timestamp is as follows: `Running time = Data timestamp + 1`.

To use the system parameters, you can directly reference them in the code, instead of configuring them in the Arguments field. The system can automatically replace the values of the parameters that reference the system parameters in the code.

> **Note** The scheduling properties of an auto triggered node are configured to define the scheduling rules of the running time. Therefore, you can calculate the data timestamp based on the scheduled time to run an instance and obtain the values of system parameters for the instance.

Example

For example, to set an ODPS SQL node to run once per hour from 00:00 to 23:59 every day, follow these steps if you want to use system parameters in the code:

Run an ODPS SQL node once per hour from 00:00 to 23:59 every day. Run the following statements to use system parameters in the code:

```
insert overwrite table tb1 partition(ds ='20180606') select
c1,c2,c3
from (
select * from tb2
where ds ='${bizdate}');
```

Configure parameters for non-Shell nodes

> **Note** The name of a variable in the SQL code can contain only lowercase letters (a-z), uppercase letters (A-Z), digits, and underscores (_). If the variable name is date, the value of $bizdate is automatically assigned to this variable. You do not need to assign a value in the Arguments field. Even if another value is assigned, it is not used in the code because the value of $bizdate is automatically assigned in the code by default.

To configure scheduling variables for a non-Shell node, add ${Variable name} in the code to reference the function and assign a value to the scheduling variable.

For example, for an ODPS SQL node, add ${Variable name} in the code and configure the following parameter for the node: Variable name=Built-in scheduling parameter.

For a parameter referenced in the code, you must assign a value to be parsed during scheduling.

Configure parameters for Shell nodes

The parameter configuration procedure of a Shell node is similar to that of a non-Shell node, except that the variable naming rules are different. Variable names for a Shell node cannot be customized, but must follow the $1,$2,$3... format.

For example, add $1 in the code of a Shell node and enter the built-in scheduling parameter $xxx in the Arguments field. Then, the value of $xxx can replace that of $1 in the code.

For a parameter referenced in the code, you must assign a value to be parsed during scheduling.

> **Note** If the number of parameters in a Shell node reaches 10, use ${10} to declare the tenth variable.

Configure a variable with a fixed value

For example, for an SQL node, add ${Variable name} in the code and configure the following parameter for the node: `Variable name=Fixed value`. Use the following code: `select xxxxxx type='${type}'`. If the value assigned to the scheduling variable is `type='aaa'`, the variable in the code is replaced as follows when the node is run: `type='aaa'`.

Configure a variable as a built-in scheduling parameter

For example, for an SQL node, add ${Variable name} in the code and configure the following parameter for the node: `Variable name=Scheduling parameter`. Use the following code: `select xxxxxx dt=${datetime}`. If the value assigned to the scheduling variable is `datetime=$bizdate` and the node is run on July 22, 2017, the variable in the code is replaced as follows: `dt=20170721`.

Built-in scheduling parameters

- $bizdate
  - Parameter description: the data timestamp in the format of yyyymmdd. By default, the value of this parameter is one day before the scheduled time to run a node.
  - Example 1: The code of an ODPS SQL node includes pt=${datetime}, and the parameter configured for the node is datetime=$bizdate. If the node is run on July 22, 2017, $bizdate is replaced as follows: pt=20170721.
  - Example 2: The code of an ODPS SQL node includes pt=${datetime}, and the parameter configured for the node is datetime=$gmtdate. If the node is run on July 22, 2017, $gmtdate is replaced as follows: pt=20170722.
- $cyctime

- Parameter description: the scheduled time to run a node. If no scheduled time is configured for a node scheduled by day, $cyctime is set to 00:00 of the day. The time is accurate to seconds. This parameter is usually used for nodes scheduled by hour or minute.

  > **Note**
  > - Pay attention to the difference between the time parameters configured by using $[] and ${}. $bizdate specifies the data timestamp, which is one day before the current day by default.
  > - $cyctime specifies the scheduled time to run a node. If no scheduled time is configured for a node scheduled by day, $cyctime is set to 00:00 of the day. The time is accurate to seconds. This parameter is usually used for nodes scheduled by hour or minute.
  >
  >   For example, if a node is scheduled to run at 00:30 on the current day, $cyctime is set to `yyyy-mm-dd 00:30:00`.
  > - If a time parameter is configured by using ${}, $bizdate is used as the benchmark for running nodes. The time parameter is replaced with the data timestamp selected for retroactive data generation.
  > - If a time parameter is configured by using $[], $cyctime is used as the benchmark for running nodes. The time is calculated in the same way as the time in Oracle. The time parameter is replaced with the data timestamp selected for retroactive data generation plus one day.
  >
  >   For example, if the data timestamp is set to 20140510 for retroactive data generation, $cyctime is replaced with 20140511.

- Examples: assume that $cyctime=20140515103000
  - $[yyyy] = 2014, $[yy] = 14, $[mm] = 05, $[dd] = 15, $[yyyy-mm-dd] = 2014-05-15, $[hh24:mi:ss] = 10:30:00, $[yyyy-mm-dd hh24:mi:ss] = 2014-05-1510:30:00
  - $[hh24:mi:ss - 1/24] = 09:30:00
  - $[yyyy-mm-dd hh24:mi:ss -1/24/60] = 2014-05-1510:29:00
  - $[yyyy-mm-dd hh24:mi:ss -1/24] = 2014-05-15 09:30:00
  - $[add_months(yyyymmdd,-1)] = 20140415
  - $[add_months(yyyymmdd,-12*1)] = 20130515
  - $[hh24] =10
  - $[mi] =30
- Method for testing the $cyctime parameter:

  After an instance starts to run, right-click the instance in the directed acyclic graph (DAG) and select **More**. Check whether the scheduled time is the time at which the instance is run.

  The value of the Schedule parameter is replaced with the scheduled time minus 1 hour.

- $jobid
  - Parameter description: the ID of the workflow to which a node belongs.
  - Example: jobid=$jobid.
- $nodeid
  - Parameter description: the ID of a node.

  - Example: nodeid=$nodeid.

- $taskid
  - Parameter description: the instance ID of a node.
  - Example: taskid=$taskid.

- $bizmonth
  - Parameter description: the month of the data timestamp in the format of yyyymm. If the month of a data timestamp is the current month, the value of $bizmonth is the month of the data timestamp minus 1. Otherwise, the value of $bizmonth is the month of the data timestamp.
  - For example, the code of an ODPS SQL node includes pt=${datetime}, and the parameter configured for the node is datetime=$bizmonth.

    Assume that the current day is July 22, 2017. If the node is run on July 22, 2017, $bizmonth is replaced as follows: pt=201706.

- ${...} custom parameter
  - You can customize a time format based on the value of $bizdate, where yyyy indicates the four-digit year, yy indicates the two-digit year, mm indicates the month, and dd indicates the day. You can use any combination of these parameters, for example, ${yyyy}, ${yyyymm}, ${yyyymmdd}, and ${yyyy-mm-dd}.
  - $bizdate is accurate to the day. Therefore, ${...} can only specify the year, month, or day.
  - The following table describes how to specify other intervals based on $bizdate.

Interval	Expression
N years later	${yyyy+N}
N years before	${yyyy-N}
N months later	${yyyymm+N}
N months before	${yyyymm-N}
N weeks later	${yyyymmdd+7*N}
N weeks before	${yyyymmdd-7*N}
N days later	${yyyymmdd+N}
N days before	${yyyymmdd-N}

- $gmtdate
  - Parameter description: the current date in the format of yyyymmdd. By default, the value of this parameter is the current date. During retroactive data generation, the input value is the data timestamp plus one day.
  - For example, the code of an ODPS SQL node includes pt=${datetime}, and the parameter configured for the node is datetime=$gmtdate. Assume that the current day is July 22, 2017. If the node is run on July 22, 2017, $gmtdate is replaced as follows: pt=20170722.

- ${yyyymmdd}

- Parameter description: the data timestamp in the format of yyyymmdd. The value of this parameter is the same as that of $bizdate. This parameter supports delimiters, for example, yyyy-mm-dd.

  By default, the value of this parameter is one day before the scheduled time to run a node. You can customize a time format for this parameter, for example, yyyy-mm-dd for ${yyyy-mm-dd}.

- Examples:
  - The code of an ODPS SQL node includes pt=${datetime}, and the parameter configured for the node is datetime=${yyyy-mm-dd}. If the node is run on July 22, 2018, ${yyyy-mm-dd} is replaced as follows: pt=2018-07-21.
  - The code of an ODPS SQL node includes pt=${datetime}, and the parameter configured for the node is datetime=${yyyymmdd-2}. If the node is run on July 22, 2018, ${yyyymmdd-2} is replaced as follows: pt=20180719.
  - The code of an ODPS SQL node includes pt=${datetime}, and the parameter configured for the node is datetime=${yyyymm-2}. If the node is run on July 22, 2018, ${yyyymm-2} is replaced as follows: pt=201805.
  - The code of an ODPS SQL node includes pt=${datetime}, and the parameter configured for the node is datetime=${yyyy-2}. If the node is run on July 22, 2018, ${yyyy-2} is replaced as follows: pt=2016.
  - You can assign values to multiple parameters when configuring an ODPS SQL node. For example, set startdatetime=$bizdate enddatetime=${yyyymmdd+1} starttime=${yyyy-mm-dd} endtime=${yyyy-mm-dd+1}.

2.4.11. Components

2.4.11.1. Create a script template

This topic describes the definition and composition of script templates and how to create a script template.

Definition

A script template defines an SQL code process that involves multiple input and output parameters. Each SQL code process references one or more source tables. You can filter source table data, join source tables, and aggregate them to generate a result table required for new business.

Value

In actual business, many SQL code processes are similar. The input and output tables in these processes may have the same or compatible schema but different names. In this case, developers can abstract an SQL code process as a script template to reuse the SQL code. The script template extracts input parameters from input tables and generates output parameters in output tables.

To create SQL script templates, you can select script templates from the script template list according to your business process and configure specific input and output tables in your business for the selected script templates, without repeatedly copying the code. This greatly improves the development efficiency and avoids repeated development. You can deploy and run the created SQL script templates in the same way as other SQL nodes.

Composition

Similar to a function, a script template consists of input parameters, output parameters, and an SQL code process.

Input parameters

The input parameters of a script template have the properties such as the parameter name, parameter type, parameter description, and parameter definition. The parameter type can be table or string.

- A table-type parameter specifies the table to be referenced in an SQL code process. When using a script template, you can specify the input table required for the specific business.
- A string-type parameter specifies the variable control parameter in an SQL code process. For example, to export only the sales amount of the top N cities in each region in a result table of an SQL code process, you can use a string-type parameter to specify the value of N.

  To export the total sales amount of a province in a result table of an SQL code process, you can set a string-type parameter to specify the province and obtain the sales data of the specified province.
- The parameter description specifies the role of a parameter in an SQL code process.
- The parameter definition is a text definition of the table schema, which is required only for table-type parameters. When specifying the parameter definition for a table-type parameter, you must provide an input table that contains the same field names and compatible types defined by the table-type parameter so that the SQL code process can run properly. Otherwise, an error is returned when the SQL code process runs because the specified field name cannot be found in the input table. The input table must contain the field names and types defined by the table-type parameter. The input table can contain other fields. The field names and types in the input table can be in any order. The parameter definition is for reference only and provides guidance for users.
- We recommend that you enter the parameter definition in the following format:

  ```
  Name of field 1 Type of field 1 Description of field 1
  Name of field 2 Type of field 2 Description of field 2
  Name of field n Type of field n Description of field n
  ```

  Example:

  ```
  area_id string 'Region ID'
  city_id string 'City ID'
  order_amt double 'Order amount'
  ```

Output parameters

- The output parameters of a script template have the properties such as the parameter name, parameter type, parameter description, and parameter definition. The parameter type must be table. A string-type output parameter has no logical meaning.
- A table-type parameter specifies the table to be generated in an SQL code process. When using a script template, you can specify the result table that the SQL code process generates for the specific business.
- The parameter description specifies the role of a parameter in an SQL code process.
- The parameter definition is a text definition of the table schema. When specifying the parameter definition for a table-type parameter, you must provide an output table that contains the same number of fields and compatible types defined by the table-type parameter so that the SQL code process can run properly. Otherwise, an error is returned when the SQL code process runs because the

number of fields does not match or the field type is incompatible. The field names of the output table do not need to be consistent with those defined by the table-type parameter. The parameter definition is for reference only and provides guidance for users.

- We recommend that you enter the parameter definition in the following format:

```
Name of field 1 Type of field 1 Description of field 1
Name of field 2 Type of field 2 Description of field 2
Name of field n Type of field n Description of field n
```

Example:

```
area_id string 'Region ID'
city_id string 'City ID'
order_amt double 'Order amount'
rank bigint 'Ranking'
```

SQL code process

The parameters in an SQL code process are referenced in the following format: `@@{Parameter name}`.

By containing an abstract SQL code process, a script template controls and processes an input table based on input parameters to generate an output table with business value.

To develop an SQL code process, you must use input and output parameters in the code properly to make sure that they can be set as needed and correct SQL code can be generated and run during the process.

Create a script template

1. Log on to the DataWorks console.
2. On the left-side navigation submenu, click **Snippets**.
3. On the Workspace-Specific tab, right-click **Components** or a folder under Components and choose **Create Node > Snippet**.
4. In the **Create Snippet** dialog box that appears, set **Snippet Name**, **Description**, and **Location**.

   > **Note** The script template name can contain letters, digits, underscores (_), and periods (.).

5. After the configuration is completed, click **Commit**.

Source table schema

The following table describes the schema of a source MySQL table that contains sales data.

Field	Type	Description
order_id	Varchar	The ID of the order.
report_date	Datetime	The date of the order.

Field	Type	Description
customer_name	Varchar	The name of the customer.
order_level	Varchar	The priority of the order.
order_number	Double	The number of orders.
order_amt	Double	The amount of the order.
back_point	Double	The discount.
shipping_type	Varchar	The method of transportation.
profit_amt	Double	The amount of the profit.
price	Double	The unit price.
shipping_cost	Double	The cost of transportation.
area	Varchar	The region.
province	Varchar	The province.
city	Varchar	The city.
product_type	Varchar	The type of the product.
product_sub_type	Varchar	The subtype of the product.
product_name	Varchar	The name of the product.
product_box	Varchar	The packaging of the product.
shipping_date	Datetime	The date of transportation.

Business implication

Script template name: get_top_n

Script template description: This script template uses the specified sales data table as the table-type input parameter, the number of the top cities as the string-type input parameter, and the total sales amount of the cities for ranking. Using this SQL code process, you can easily obtain the rankings of the specified top cities in each region.

Script template parameters

Input parameter 1:

Parameter name: myinputtable, type: table

Input parameter 2:

Parameter name: topn, type: string

Output parameter 3:

Parameter name: myoutput, type: table

Parameter definition:

area_id string

city_id string

order_amt double

rank bigint

Table creation statement:

```
CREATE TABLE IF NOT EXISTS company_sales_top_n
(
area STRING COMMENT 'Region',
city STRING COMMENT 'City',
sales_amount DOUBLE COMMENT 'Sales amount',
rank BIGINT COMMENT 'Ranking'
)
COMMENT 'Company sales rankings'
PARTITIONED BY (pt STRING COMMENT '')
LIFECYCLE 365;
```

Example of defining an SQL code process

```
INSERT OVERWRITE TABLE @@{myoutput} PARTITION (pt='${bizdate}')
  SELECT r3.area_id,
  r3.city_id,
  r3.order_amt,
  r3.rank
from (
SELECT
  area_id,
  city_id,
  rank,
  order_amt_1505468133993_sum as order_amt,
  order_number_1505468133991_sum,
  profit_amt_1505468134000_sum
FROM
  (SELECT
  area_id,
  city_id,
  ROW_NUMBER() OVER (PARTITION BY r1.area_id ORDER BY r1.order_amt_1505468133993_sum DESC)
AS rank,
  order_amt_1505468133993_sum
```

```
  order_amt_1505468133993_sum,
  order_number_1505468133991_sum,
  profit_amt_1505468134000_sum
FROM
  (SELECT area AS area_id,
   city AS city_id,
   SUM(order_amt) AS order_amt_1505468133993_sum,
   SUM(order_number) AS order_number_1505468133991_sum,
   SUM(profit_amt) AS profit_amt_1505468134000_sum
FROM
  @@{myinputtable}
WHERE
  SUBSTR(pt, 1, 8) IN ( '${bizdate}' )
GROUP BY
  area,
  city )
  r1 ) r2
WHERE
  r2.rank >= 1 AND r2.rank <= @@{topn}
ORDER BY
  area_id,
  rank limit 10000) r3;
```

Sharing scope

Script templates can be shared within a workspace or made public.

By default, a deployed script template is visible and available to users within the current workspace. The developer of a script template can click the **Publish Snippet** icon to make the general-purpose script template public to the current Apsara Stack tenant account so that all users under the account can view and use the script template.

You can view the **Publish Snippet** icon on the configuration tab of a script template. If the icon is clickable, the script template is made public.

Use of script templates

For more information about how to use a developed script template, see Use components.

Reference records

In the script template list, double-click a script template. On the configuration tab that appears, click the **Snippet Nodes** tab in the right-side navigation pane to view the reference records of the script template.

2.4.11.2. Use components

To improve development efficiency, you can create data analytics nodes based on components that are created by workspace and organization members.

- The Workspace-Specific tab lists the components created by workspace members.
- The Public tab lists the components created by organization members.

For more information, see SQL component nodes.

Component configuration wizard

The component configuration wizard is described as follows:

No.	Icon or Tab	Description
1	Save	Save the settings of the component.
2	Steal Lock	Change a component that is not owned by you.
3	Submit	Submit the component to the development environment.
4	Publish Component	Publish a component to the entire organization so that all members in the organization can view and use the component.
5	Parse I/O Parameters	Parse input and output parameters from the code.
6	Precompile	Edit custom and system parameters for the component.
7	Run	Run the component in the development environment.
8	Stop	Stop running the component.
9	Format	Format the code based on keywords.
10	Parameters	View and configure the component information, input parameters, and output parameters.
11	Version	View the published versions of the component.
12	Reference Records	View the use records of the component.

2.4.12. Ad-hoc query

The Ad-Hoc Query tab allows you to test your code in the development environment. You can check for errors and check whether your code works as expected. You do not need to commit and deploy ad-hoc query nodes or set scheduling parameters for ad-hoc query nodes.

To use the scheduling parameters, create a data analytics node or create a node in a workflow.

Create a folder

1. Log on to the DataWorks console. On the left-side navigation submenu, click **Ad-Hoc Query** to go to the **Ad-Hoc Query** tab.
2. On the Ad-Hoc Query tab, move the pointer over the **Create** icon and select **Folder**.
3. In the **Create Folder** dialog box that appears, set **Folder Name** and **Location**, and then click

Commit.

> **Note**
> - The folder name can contain letters, digits, underscores (_), and periods (.).
> - Multi-level folders are supported. You can create a folder in an existing folder.

Create a node

You can only create Shell and ODPS SQL nodes for ad-hoc query.

For example, to create an ODPS SQL node, right-click the target folder and choose **Create Node > ODPS SQL**.

No.	GUI element	Description
1	Save icon	Click the icon to save the entered code for the current node.
2	Steal Lock icon	Click the icon to steal the lock of the current node and then edit it if you are not the owner of the node.
3	Run icon	Click the icon to run the current node in the development environment.
4	Run with Arguments icon	Click the icon to run the code of the current node with the configured parameters. **Note** This feature is unavailable for Shell nodes.
5	Stop icon	Click the icon to stop running the current node.
6	Reload icon	Click the icon to reload the code of the current node. The code will be restored to the version last saved. Unsaved changes will be lost. **Note** If Auto Save is selected on the Configuration Center page, you are notified of the code that is cached but not saved after the page is refreshed. In this case, select the version that you need.
7	Format Code icon	Click the icon to format the code based on keywords to avoid excessively long code in a single line.

2.4.13. Runtime logs

The Runtime Logs tab displays the records of all nodes that are run in the development environment in the last three days. You can view the node history and filter the records by node status.

> **Note** The runtime logs are retained for only three days.

View runtime logs

1. Log on to the DataWorks console. On the left-side navigation submenu, click **Runtime Logs**. By default, the nodes in all states appear.
2. Select the target node state from the drop-down list.
3. On the **Runtime Logs** tab, click the target record. The runtime log appears in the right pane.

Save the code as an ad-hoc query node

To save the SQL statements in the runtime log, click the **Save as Ad-Hoc Query Node** icon.

In the Create Node dialog box that appears, set **Node Name** and **Location**, and then click **Commit**.

2.4.14. Public tables

Log on to the DataWorks console. On the left-side navigation submenu, click **Tenant Tables** to go to the **Tenant Tables** tab.

On the Tenant Tables tab, you can view tables created in all workspaces under the current Apsara Stack tenant account.

- **Project**: the name of the workspace. A prefix of odps is added to each workspace name. For example, if a workspace name is test, the value in the Project column is odps.test.
- **Table Name**: the name of the table in the workspace.

After you click a table name, the column information, partition information, and data preview of the table appear in the lower part of the left-side navigation pane.

- **Columns**: displays the name, data type, and description for each column.
- **Partitions**: displays the partition information. A maximum of 60,000 partitions are supported. If you have specified the time-to-live for partitions, the number of partitions depends on the time-to-live.
- **Preview**: displays the preview of data.

Switch between the environments

Public tables are available either in the development or production environment. You can click the Filter icon next to the search box. In the dialog box that appears, a rectangular in blue indicates the current environment. If you click the other rectangular, you can view public tables in the other environment.

2.4.15. Table management

This topic describes how to create, commit, and query a table.

Create a table

1. Log on to the DataWorks console.
2. On the left-side navigation submenu, click **Workspace Tables**.
3. On the Workspace Tables tab that appears, click the **Create** icon.
4. In the Create Table dialog box that appears, enter the table name and click **Commit**.

> **Note** Currently, only MaxCompute tables are supported.

5. Configure the basic properties of the table.

Parameter or button	Description
Display Name	The alias of the table.
Level 1 Folder	The name of the level-1 folder where the table is located. **Note** Level-1 and level-2 folders only show the table locations in DataWorks so that you can better manage tables.
Level 2 Folder	The name of the level-2 folder where the table is located.
Create Folder	Click **Create Folder** to go to the **Theme Management** page. On this page, you can create level-1 and level-2 folders for tables.
Description	The description of the table.

6. Create a table.

   Use one of the following methods to create a table:

   - Create a table in DDL mode.

     Click **DDL Statement** in the top navigation bar. In the dialog box that appears, enter standard statements for creating a table.

     After you finish editing the statements, click **Generate Table Schema**. Information is automatically entered in the General, Physical Model, and Schema sections.

   - Create a table on the graphical user interface (GUI).

     If the DDL mode is inappropriate for you to create a table, try using the GUI.

- Physical Model section

Parameter	Description
Partitioning	Specifies whether the table is partitioned. Valid values: Partitioned Table and Non-Partitioned Table.
Time-to-Live	The time-to-live of data in MaxCompute. If you enter a number to specify the number of days, data in the table (or partition) that has not been updated for the specified number of days is cleared.
Table Level	The level of the table. Generally, tables are divided into DW, ODS, and RPT to indicate the data warehouse level, operational data store level, and data product level, respectively.
Categories	The category of the table. Tables are categorized into basic services, advanced services, and other services. If you want to create a table category or level, click **Create Level** to go to the Hierarchical Management page.
Table Type	The type of the table. Default value: Internal Table.

- Schema section

- Create a field

Parameter or button	Description
Field Name	The name of the field. The name can contain letters, digits, and underscores (_).
Display Name	The alias of the field.
Data Type	The data type of the field.
Definition or Maximum Value Length	The length of the field.
Description	The description of the field.
Primary Key Field	Specifies whether the field serves as the primary key or part of a composite primary key.
Actions	The operations that you can perform on the field. ■ After editing a field, click the **Save** icon to save the field. ■ Click the **Delete** icon to delete the field. **Note** If you delete a field from an existing table, DataWorks requests you to delete the table and create another table with the same name. This operation is forbidden in the production environment.
Move Up	Click **Move Up** to adjust the field sequence of a table that has not been created. If you adjust the sequence of fields in an existing table, DataWorks requests you to delete the table and create another table with the same name. This operation is forbidden in the production environment.

Parameter or button	Description
Move Down	Click **Move Down** to adjust the field sequence of a table that has not been created.

- **Add a partition**

  You can click **Add** to add a partition to the current table. If you add a partition to an existing table, DataWorks requests you to delete the table and create another table with the same name. This operation is forbidden in the production environment.

  > **Note** This parameter is available only when the Partitioning parameter in the Physical Model section is set to Partitioned Table.

Parameter or button	Description
Field Name	The name of the partition field.
Data Type	The data type of the partition field. We recommend that you use the STRING type for all partition fields.
Length	The length of the partition field.
Description	The description of the partition field.
Partition Column Date Format	The format of the date partition. If the partition field is a date, select or enter a date format, such as yyyymmdd or yyyy-mm-dd.
Partition Column Date Granularity	The granularity of the date partition. Valid values: Second, Minute, Hour, Day, Month, Quarter, and Year. You can enter a partition granularity as required. If you need to specify multiple partition granularities, note that a greater granularity corresponds to a higher partition level by default. For example, three partitions whose granularities are day, hour, and month, respectively, are available. The multi-level partition hierarchy is as follows: level-1 partition (month), level-2 partition (day), and level-3 partition (hour).
Actions	■ After editing a partition field, click the **Save** icon to save the partition field. ■ Click the **Delete** icon to delete the partition field. > **Note** If you delete a partition from an existing table, DataWorks requests you to delete the table and create another table with the same name. This operation is forbidden in the production environment.

Commit a table

After editing the schema of a table, you can commit the table to the development environment and production environment.

Button	Description
Load from Development Environment	If the table is committed to the development environment, the button is clickable. After you click the button, the information about the table that is committed in the development environment overwrites the table information on the current page.
Commit in Development Environment	After you click the button, DataWorks first checks whether you have configured all the required items on the current page. If any item is missing, an alert is triggered and the table cannot be committed.
Load from Production Environment	After you click the button, the information about the table that is committed to the production environment overwrites the table information on the current page.
Commit to Production Environment	After you click the button, the table is committed to and created in the production environment.

Query a table

You can filter tables in the development environment and production environment. The query results appear by folder.

- **Development Environment**: queries tables in the development environment only.
- **Production Environment**: queries tables in the production environment only. Exercise caution when performing operations on tables in the production environment.

2.4.16. Functions

The Built-In Functions tab displays all available built-in functions by category. It also provides instructions for each function.

1. Log on to the DataWorks console.
2. On the left-side navigation submenu, click **Built-In Functions**. A list of functions appears.

   Available functions include aggregate functions, analytic functions, date functions, mathematical functions, string functions, and other functions. The functions are provided by DataWorks. You can click a function to view its description.

2.4.17. Recycle bin

The Recycle Bin pane appears if you click **Recycle Bin** in the left-side navigation pane.

The Recycle Bin tab displays a list of nodes that have been deleted from the current workspace. After you right-click a node, you can select to restore or destroy the node.

Click the **My Files** icon in the tool bar of the Recycle Bin pane to view all your nodes that have been deleted.

> **Note** A node cannot be restored after it is deleted from the recycle bin.

2.4.18. Editor keyboard shortcuts

This section describes keyboard shortcuts available for the code editor.

Google Chrome in Windows OS

`Ctrl + S` : Save changes to a node.

`Ctrl + Z` : Undo an action.

`Ctrl + Y` : Redo an action.

`Ctrl + D` : Select occurrences.

`Ctrl + X` : Cut a line.

`Ctrl + Shift + K` : Delete a line.

`Ctrl + C` : Copy a line.

`Ctrl + I` : Select a line.

`Alt + Shift + Drag` : Select a block.

`Alt + Click` : Insert an additional cursor.

`Ctrl + Shift + L` : Select all occurrences.

`Ctrl + F` : Search for text in a node.

`Ctrl + H` : Replace text in a node.

`Ctrl + G` : Locate a line.

`Alt + Enter` : Select all matched strings.

`Alt + Up or down arrow` : Move a line up or down.

`Alt + Shift + Up or down arrow` : Duplicate a line.

`Ctrl + Shift + K` : Delete a line.

`Ctrl + Enter or Ctrl + Shift + Enter` : Insert a line break downwards or upwards.

`Ctrl + Shift + Back slash (\)` : Jump to the parenthesis, bracket, or brace that matches the adjacent one.

`Ctrl + Left bracket (]) or right bracket ([)` : Increase or decrease the indent of a line.

`Home or End` : Move the cursor to the beginning or end of a line.

`Ctrl + Home or End` : Move the cursor to the top or bottom of a node.

`Ctrl + Left or Right arrow` : Move the cursor one word to left or right.

`Ctrl + Shift + Left bracket (]) or right bracket ([)` : Hide or show a block.

`Ctrl + K + Left bracket (]) or right bracket ([)` : Hide or show sub-blocks in a block.

Ctrl + K + 0 or J : Hide or show all blocks.

Ctrl + Slash (/) : Comment out or uncomment the selected lines or blocks.

Google Chrome in Mac OS

Command-S : Save changes to a node.

Command-Z : Undo an action.

Command-Y : Redo an action.

Command-D : Select occurrences.

Command-X : Cut a line.

Shift-Command-K : Delete a line.

Command-C : Copy a line.

Command-I : Select a line.

Command-F : Search for text in a node.

Option-Command-F : Replace text in a node.

Option-Up or down arrow : Move a line up or down.

Option-Shift-Up or down arrow : Duplicate a line.

Shift-Command-K : Delete a line.

Command-Enter or Shift-Command-Enter : Insert a line break downwards or upwards.

Shift-Command-Back slash (\) : Jump to the parenthesis, bracket, or brace that matches the adjacent one.

Command-Left bracket (]) or right bracket ([) : Increase or decrease the indent of a line.

Command-Left or right arrow : Move the cursor to the beginning or end of a line.

Command-Up or down arrow : Move the cursor to the top or bottom of a node.

Option-Left or right arrow : Move the cursor one word to left or right.

Option-Command-Left bracket (]) or right bracket ([) : Hide or show a block.

Command-K-Left bracket (]) or right bracket ([) : Hide or show sub-blocks in a block.

Command-K-0 or J : Hide or show all blocks.

Command-Slash (/) : Comment out or uncomment the selected lines or blocks.

Insert multiple cursors and select multiple occurrences or lines

Option-Click : Insert an additional cursor.

Option-Command-Up or down arrow : Insert an additional cursor to the previous or next line.

`Command-U` : Undo a cursor-related operation.

`Option-Shift-I` : Insert a cursor at the end of each selected line.

`Command-G or Shift-Command-G` : Select the next or previous matched string.

`Command-F2` : Select the nearest character of each cursor.

`Shift-Command-L` : Select the nearest word of each cursor.

`Option-Enter` : Select all the matched strings.

`Option-Shift-Drag` : Multi-select lines

`Option-Shift-Command-Up or down arrow` : Extend a selection one line up or down.

`Option-Shift-Command-Left or right arrow` : Extend a selection one character to the left or right.

2.4.19. E-MapReduce in DataWorks

Bind an E-MapReduce project to a DataWorks workspace

> **Note** Before binding an E-MapReduce project to a DataWorks workspace, you must obtain the information about the E-MapReduce project.

1. Log on to the DataWorks console.
2. On the DataStudio page that appears, click the **Workspace Manage** icon in the upper-right corner. The **Project Management** page appears.
3. On the **Project Management** page, find the **Compute Engine** section and choose **Add Compute Engine** > **Add EMR Cluster**.
4. In the **Add EMR Cluster** dialog box that appears, set relevant parameters

Parameter	Description
Cluster Name	The name of the E-MapReduce cluster. The name must be globally unique.
Access ID and Access Key	The AccessKey ID and AccessKey secret of the account authorized to access the E-MapReduce cluster.
EmrClusterID	The ID of the E-MapReduce cluster. You can obtain the ID from the E-MapReduce console.
EmrUserID	The ID of the user who created the E-MapReduce cluster. You can obtain the ID from the E-MapReduce console.
EmrProjectID	The ID of the project in the E-MapReduce cluster. You can obtain the ID from the E-MapReduce console.

Parameter	Description
EmrResource QueueName	The name of the resource queue in the E-MapReduce cluster. You can obtain the name from the E-MapReduce console.
EmrEndpoint	The endpoint of the E-MapReduce cluster. You can obtain the endpoint from the E-MapReduce console.

5. Click **OK** to complete the binding. Then, you can go to the **DataStudio** page to create an E-MapReduce node.

> **Note** If the binding fails, check whether the failure is caused by one of the following reasons:
>
> - The E-MapReduce user ID is bound to another tenant account.
> - The specified cluster name already exists.

Create an E-MapReduce node

E-MapReduce nodes are categorized into four types: EMR HIVE, EMR SPARK SQL, EMR SPARK, and EMR MR.

1. Log on to the DataWorks console.
2. Create a workflow.
   i. On the **Data Analytics** tab, move the pointer over the **Create** icon and select **Workflow**.
   ii. In the **Create Workflow** dialog box that appears, set **Workflow Name** and **Description**.
   iii. Click **Create**.
3. Create an E-MapReduce node.
   i. In the left-side navigation pane, click the created workflow. Then, right-click **Data Analytics** and choose **Create Data Analytics Node > EMR HIVE**.
   ii. In the **Create Node** dialog box that appears, set **Node Name** and click **Commit**.
4. Edit the code on the node configuration tab.
5. Commit the node.

   After the node properties are configured, click the **Save** icon in the upper-left corner. Then, commit or commit and unlock the node to the development environment.
6. Deploy the node.

   For more information, see Publish nodes.
7. Test the node in the production environment.

   For more information, see Recurring tasks.

Reference resource files

E-MapReduce resource files are categorized into two resource types: EMR JAR and EMR File.

To reference E-MapReduce resource files, do as follows:

- For EMR HIVE and EMR MR nodes, add `--@resource_reference{"Resource name"}` at the first line of the code.
- For EMR SPARK nodes, add `##@resource_reference{"Resource name"}` at the first line of the code.

Manage data

DataWorks allows you to query E-MapReduce metadata and synchronize the data for data development.

2.5. HoloStudio

2.5.1. Overview

HoloStudio provides Interactive Analytics users with standardized and easy-to-use development management services and one-stop real-time data warehouse construction services through a visualized user interface and a wizard. In addition to standard management available in PostgreSQL, HoloStudio provides more interactive analytics features.

Features

- **Foreign table management**

  HoloStudio allows you to create a foreign table sourced from MaxCompute through one-click schema synchronization, and preview and analyze MaxCompute data.

- **Table management**

  HoloStudio allows you to create a PostgreSQL table on a visualized user interface or by using SQL statements.

- **Data analytics**

  Based on the scheduling framework of DataWorks, HoloStudio can periodically build the mappings between offline MaxCompute data and Interactive Analytics index data.

- **SQL Console**

  The SQL Console of HoloStudio allows you to use an SQL editor to obtain the query result in seconds.

- **Web Console**

  The Web Console of HoloStudio provides the web-based PostgreSQL service to facilitate terminal-based development.

2.5.2. Interactive Analytics instance configuration

Before using HoloStudio, make sure that you have been added to an Interactive Analytics instance. If your company or organization does not have an Interactive Analytics instance, you can use an Apsara Stack tenant account to request one for your company or organization. This topic describes how to bind the current workspace to an Interactive Analytics instance in HoloStudio as a superuser.

> **Note**
>
> - The user who requests an Interactive Analytics instance is the superuser of the instance. Other users can access the Interactive Analytics instance only after relevant permissions are granted to them by the superuser.
> - It is optional for common users to request an Interactive Analytics instance. To enable a common user to use Interactive Analytics, the superuser only needs to make sure that the user is authorized to access a database on the instance. To obtain more permissions, a common user must submit a request to the superuser. For more information, see Role management.

1. **Log on to HoloStudio.**

   Log on to DataWorks console as a workspace administrator. On the DataStudio page that appears, click the DataWorks icon in the upper-left corner and choose **All Products > HoloStudio**. The HoloStudio page appears.

2. **Bind the current workspace to an Interactive Analytics instance.**

   Log on to HoloStudio as a superuser. On HoloStudio homepage, click **Create Database**. In the dialog box that appears, set parameters to bind the current workspace to an Interactive Analytics instance.

   After an Interactive Analytics instance is created, a database named postgres is created and an endpoint of the Interactive Analytics instance is generated by default. You must set the Database Name parameter to postgres when you configure the binding. To obtain the endpoint, contact an O&M engineer. After the workspace is bound to the Interactive Analytics instance, the superuser can use the postgres database for data analytics in HoloStudio and grant permissions to other users.

Parameter	Description	Note
Connect To	The type of the data store.	The value is generated automatically and cannot be changed.
Server	The endpoint of the Interactive Analytics instance.	The value is generated automatically after the Interactive Analytics instance is created.
Port	The port number of the Interactive Analytics instance.	The value is generated automatically after the Interactive Analytics instance is created.
Database Name	The name of the database to be bound to. Default value: postgres.	A database named postgres is created by default after an Interactive Analytics instance is created. You must set this parameter to postgres when you bind the workspace to the Interactive Analytics instance for the first time.

Parameter	Description	Note
Account Type	Alicloud Integrated Account	The value is generated automatically and cannot be changed.
User name	The AccessKey ID of the account that you use to connect to Interactive Analytics.	You can click the username in the upper-right corner to view the AccessKey ID.
Password	The AccessKey secret of the account that you use to connect to Interactive Analytics.	You can click the username in the upper-right corner to view the AccessKey secret.
Test connectivity	Tests whether the database is connected.	None

Note The administrator of a workspace can contact an Interactive Analytics O&M engineer and ask the engineer to directly create an Interactive Analytics instance and bind the workspace to the Interactive Analytics instance. Then, the administrator can directly use HoloStudio to perform data analytics without requesting an instance.

2.5.3. RAM user management

This topic describes how the superuser adds and deletes a Resource Access Management (RAM) user in HoloStudio.

Add a RAM user

1. **Create a RAM user.**

   If you have created a RAM user, go to step 2 to directly add the RAM user to the workspace.

   If you do not have any RAM users, create one first by following these steps:

   i. Log on to the Apsara Stack console as a superuser. In the left-side navigation pane, choose **User Center > User Management**. On the page that appears, click **Create** in the upper-right corner. In the dialog box that appears, set the required parameters and click **OK** to create a RAM user. Note that you must select the department where the current Apsara Stack tenant account resides from the Department drop-down list.

   ii. After the RAM user is created, you can reset and obtain the password of it. Click the username of the created RAM user. On the User Information page that appears, click **Reset Password**. In the dialog box that appears, click **Reset and Download** to obtain the password of this RAM user.

2. **Add the RAM user to the workspace.**

   In the upper-left corner of the Apsara Stack console, click the **Products** icon and click **DataWorks** in the Big Data section.

   In the DataWorks console, click **Workspace Manage** in the upper-right corner. On the page that appears, click **User Management** in the left-side navigation pane. On the User Management page, click **Add Member** in the upper-right corner.

Select the target RAM user, click > to move the selected RAM user to the **Add Member** section, and select one or more roles to grant relevant permissions to the RAM user. Only authorized RAM users are allowed to access the workspace.

3. **Grant permissions to the RAM user in HoloStudio.**

   Log on to DataWorks as the created RAM user. Click the username in the upper-right corner to view the UID of the current RAM user. The corresponding user ID is the UID without the first digit. For example, if the UID of a RAM user is 52801453680211755xx, the user ID is 2801453680211755xx. We recommend that you save the user ID of the RAM user because it is required for permission granting.

   Log on to DataWorks as a superuser. On the page for running an ad hoc query in HoloStudio, create a role in Interactive Analytics for a RAM user and grant permissions to the role.

   i. Run either of the following SQL statements to create a role in Interactive Analytics for the RAM user:

   ```
   create user "p4_account ID";//Replace the account ID with the user ID of the RAM user.
   create user "p4_account ID" superuser;//Grant the superuser permissions to the RAM user.
   ```

   ii. After a role is created for the RAM user, you can grant permissions to the RAM user. For example, run the following SQL statement: (If the RAM user has been configured as a superuser, you do not need to run the following SQL statement.)

   ```
   GRANT SELECT,INSERT,UPDATE ON ALL TABLES IN SCHEMA public TO "p4_account ID"; // Grant the RAM user the add, delete, modify, and query permissions on tables.
   ```

   > **Note** Pay attention to the following:
   >
   > - With the preceding authorization, the RAM user can delete only the tables created by the RAM user.
   > - In the SQL statements, `p4_` is required, `p` must be in lowercase, and p4_account ID must be enclosed in a pair of double quotation marks (").

Delete a RAM user

```
DROP USER "p4_account ID";
```

Currently, Interactive Analytics supports only the DROP statement to delete RAM users. After the preceding statement is run, the RAM user is deleted from the Interactive Analytics instance, but is still retained in the workspace. This means that the RAM user can still access other objects except the Interactive Analytics instance in the workspace.

2.5.4. PostgreSQL management

2.5.4.1. Database management

The PostgreSQL (PG) management module of HoloStudio allows you to manage databases in a visualized manner. You can quickly create, view, or delete a database. In addition, HoloStudio supports interactive queries within seconds. This topic describes how to use the PG management module of HoloStudio to manage databases. Currently, you can only create a database in HoloStudio.

Create a database

1. **Create an ad hoc query.**

   Log on to DataWorks as a superuser. On the HoloStudio page, run the following SQL statement:

   ```
   create database dbname;
   ```

2. **Bind the database to the workspace.**

   The database is created after you run the preceding SQL statement, but you must bind the database to the current workspace to use the database for data analytics. On the HoloStudio page, click **PG management** in the left-side navigation pane. On the PG management tab, move the pointer over the Create icon and click **Create Database**.

3. **Configure the database.**

   In the Create Database dialog box, set the parameters marked with a red asterisk (*****) to configure the database.

Parameter	Description	Note
Connect To	The type of the data stor	The value is generated automatically and cannot be changed.
Server	The endpoint of the Interactive Analytics instance.	You can obtain the endpoint of the postgres database from the database details.
Port	The port number of the Interactive Analytics instance.	You can obtain the port number of the postgres database from the database details.
Database Name	The name of the database to be bound to.	The value must be the same as the database name in the CREATE DATABASE statement.
Account Type	Alicloud Integrated Account	The value is generated automatically and cannot be changed.
User name	The AccessKey ID of the account that you use to connect to Interactive Analytics.	You can click the username in the upper-right corner to view the AccessKey secret
Password	The AccessKey secret of the account that you use to connect to Interactive Analytics.	You can click the username in the upper-right corner to view the AccessKey secret.
Test connectivity	Tests whether the database is connected.	None

Delete a database

The PG management module of HoloStudio allows you to quickly delete databases. In the left-side navigation pane, click **PG management**. Right-click the database you want to delete, and select **Delete Database** to delete the database.

In the dialog box that appears, click **OK** to delete the database.

> **Note** Only the superuser of a database or the database owner configured by the superuser can delete the database.

2.5.4.2. Table management

Similar to PostgreSQL, all the operations in Interactive Analytics are performed on tables. The PostgreSQL (PG) management module of HoloStudio allows you to manage tables in a visualized manner. You can quickly create, check, or delete a table. This topic describes how to use the PG management module of HoloStudio to manage tables.

Create a table

1. On the homepage of HoloStudio, click PG management in the left-side navigation pane. Move the pointer over the Create icon and click **Table**.
2. On the page that appears, edit the table content and attributes, and click **Commit** to create a table. This example describes how to create an air temperature table.

Type	Parameter	Description
Field	Field Name	The name of the field in the table.
	Data Type	The data type of the fie
	Primary Key Field	Specifies whether to use the field as the primary key for the table.
	Optional	Specifies whether the field can be null.
	Array	Specifies whether the field is an ordered array of elements.
	Actions	Moves up or down the position of the field in the table.
Properties	Storage Mode	The storage mode of the table. Valid values: Row Store and Column Store. Default value: Column Store.
	Lifecycle (Seconds)	The lifecycle of the table. HoloStudio automatically recycles a table if the table is not changed within a specified period since the last update.

Type	Parameter	Description
	Clustered Index	The index used for sorting.
	Dictionary Code Columns	The column based on whose values a dictionary mapping is built.
	Bitmap Column	The column on which bit code is built.
Partitioned Table	PARTITION BY LIST	The partition field.
Commit	Commit	You can click this button to commit the table that you create.

Check a table

In the left-side navigation pane, click **PG management**. Double-click the table you want to check, and click **Data Preview** to check the content of the table.

In the left-side navigation pane, click **PG management**. Double-click the table you want to check, and click **Generate DDL Statement** to check the SQL statement used to create the table.

Button	Description
Generate DDL Statement	You can click this button to check the SQL statement used to create the table.
Data Preview	You can click this button to check the content of the table.

Delete a table

In the left-side navigation pane, click **PG management**. Right-click the table you want to delete, and select **Delete Table** to delete the table.

In the dialog box that appears, click **OK**.

2.5.4.3. Foreign table management

Foreign tables are the tables that are not stored in Interactive Analytics. Interactive Analytics integrates seamlessly with the big data ecosystem. You can directly query foreign tables through Interactive Analytics in an accelerated manner or import data of foreign tables to Interactive Analytics for processing. The PostgreSQL (PG) management module of HoloStudio allows you to create, query, or delete foreign tables. Currently, you can only analyze foreign tables sourced from MaxCompute. This helps you quickly obtain the query results.

This topic describes how to use the PG management module of HoloStudio to manage foreign tables.

Create a foreign table

In the left-side navigation pane, click **PG management**. Move the pointer over the Create icon and click **Foreign Table**. Set parameters for creating a foreign table and click **Commit**. This example creates an air temperature table.

Interactive Analytics can read data from MaxCompute tables across workspaces. That is, if your account can access MaxCompute tables in another workspace, you can create foreign tables in HoloStudio to directly read data from the MaxCompute tables.

> **Note**
>
> 1. Before creating a foreign table in Interactive Analytics, make sure that its source table exists in a MaxCompute project.
> 2. The fields of a foreign table in Interactive Analytics have a one-to-one mapping with those of the source table in MaxCompute. After you search for a table name in MaxCompute, HoloStudio automatically generates a foreign table based on the fields and partitions.

Type	Parameter	Description
General	Interactive Analytics Database	The database where the foreign table to be created resides.
	Table Name	The name of the foreign table.
External Service	Types	The service type of the foreign table. Currently, you can only set this parameter to MaxCompute.
Table	Table	The source table in MaxCompute to be mapped.
Commit	Commit	You can click this button to commit the foreign table that you create.

Check a foreign table

In the left-side navigation pane, click **PG management**. Double-click the foreign table you want to check, and click **Data Preview** to check the content of the foreign table.

In the left-side navigation pane, click **PG management**. Double-click the foreign table you want to check, and click **Generate DDL Statement** to check the SQL statement used to create the foreign table.

Delete a foreign table

In the left-side navigation pane, click **PG management**. Right-click the foreign table you want to delete and select **Delete Table** to delete the table.

2.5.5. SQL Console

The SQL Console in HoloStudio is an editor for running SQL statements. In the SQL Console, you can run SQL statements to analyze data in Interactive Analytics and quickly obtain the query results. This topic describes the basic features and usage of the SQL Console in HoloStudio.

Folder

The Folder module stores new ad hoc queries, which helps you manage ad hoc queries.

In the left-side navigation pane, click **SQL Console**. Move the pointer over the Create icon and click **Folder**. In the dialog box that appears, create a folder. You can create an ad hoc query in the folder and run standard SQL statements on tables. You can also right-click a table in the folder and select the relevant menus to move, rename, or delete the table.

SQL Console

The SQL Console module can generate an SQL editor, in which you can run standard SQL statements.

1. In the left-side navigation pane, click **SQL Console**. Move the pointer over the Create icon and click SQL Console. In the dialog box that appears, set parameters for creating an ad hoc query.

Parameter	Description
Node Name	The name of the ad hoc query. A query name can contain letters, digits, underscores, and periods (.) .
Location	The folder where the ad hoc query is stored
Database management	The target database in which the ad hoc query is r

2. Write the SQL statements used in the ad hoc query and click **Run** to run the query. Then, you can check the query result. The following example shows how to create a table, import data to the table, and then query the table:

```
BEGIN;
CREATE TABLE supplier (
 s_suppkey bigint NOT NULL,
 s_name text NOT NULL,
 s_address text NOT NULL,
 s_nationkey bigint NOT NULL,
 s_phone text NOT NULL,
 s_acctbal bigint NOT NULL,
 s_comment text NOT NULL,
PRIMARY KEY (s_suppkey)
);
CALL SET_TABLE_PROPERTY('supplier', 'bitmap_columns', 's_suppkey,s_nationkey,s_acctbal,s_name')
;
CALL SET_TABLE_PROPERTY('supplier', 'dictionary_encoding_columns', 's_name,s_address');
CALL SET_TABLE_PROPERTY('supplier', 'time_to_live_in_seconds', '31536000');
COMMIT;
INSERT INTO supplier VALUES
(1, 'Supplier01', 'New York', 17, '27-918-335-1736',  575594, 'careful'),
(6, 'Supplier06', 'London', 14, '24-696-997-4969',  136579, 'final accounts '),
(10, 'Supplier03', 'Beijing', 24, '34-852-489-8585', 389191, 'ing waters'),
(18, 'Supplier04', 'Paris', 16, '26-729-551-1115', 704082, 'accounts snooze'),
(39, 'Supplier05', 'Shanghai',  8, '18-851-856-5633 611565', 88990, 'special packages'),
(48, 'Supplier06',  'Canada', 14, '24-722-551-9498',563062, 'xpress instructions affix');
SELECT * FROM supplier;
```

Item	Description
SQL editor	You can write SQL statements in the SQL editor.
Save	You can click this icon to save all statements in the SQL editor.
Run	You can click this icon to run all statements in the SQL editor. The result appears at the bottom. You can also select an SQL statement to run it. The system only runs this statement by default.
Refresh	You can click this icon to refresh the content in the SQL editor. The system retains only the saved content after the refresh.
Stop	You can click this icon to stop running SQL statements.

Item	Description
Runtime Log	You can check the running results and, if any, error messages.
Result	You can check the table content after the SQL statements are run.

HoloStudio also allows you to directly perform operations on the queried data. For example, you can hide columns, copy data, and search for data.

> **Note** For statements without results returned, such as the `CREATE TABLE` statement, only operational logs are generated after the statements are run.

2.5.6. Data Analytics

The Data Analytics module of HoloStudio is used to create data analytics nodes. This module integrates seamlessly with DataWorks for node scheduling and provides one-stop stable and efficient extract-transform-load (ETL) services. This topic describes the Data Analytics module of HoloStudio

Folder

The Folder module stores new data analytics nodes, which helps you manage data analytics nodes of each database.

In the left-side navigation pane, click **Data Analytics**. Move the pointer over the Create icon and click **Folder**. In the dialog box that appears, create a folder.

Interactive Analytics Development

The Interactive Analytics Development module allows you to create data analytics nodes. It integrates with DataWorks to allow you to schedule nodes in DataWorks.

1. In the left-side navigation pane, click **Data Analytics**. Move the pointer over the Create icon and click **Interactive Analytics Development**. In the dialog box that appears, enter the node information and click **Commit** to create a data analytics node for scheduling.

Parameter	Description
Node Name	The name of the data analytics node.
Location	The folder where the data analytics node is stored.
Database	The target database in which the data analytics node is run.

2. **Schedule a node in DataWorks.**

   Enter SQL statements and click **Go to DataStudio for Scheduling** in the upper-right corner to schedule the node in DataStudio. For more information about the scheduling procedure, see Example: Use HoloStudio for periodic scheduling.

Item	Description
SQL editor	You can write SQL statements in the SQL editor.
Save	You can click this icon to save all statements in the SQL editor.
Run	You can click this icon to run all statements in the SQL editor. The result appears at the bottom. You can also select an SQL statement to run it. The system only runs this statement by default.
Refresh	You can click this icon to refresh the content in the SQL editor. The system retains only the saved content after the refresh.
Stop	You can click this icon to stop running SQL statements.
Runtime Log	You can check the running results and, if any, error messages.
Result	You can check the table content after the SQL statements are run.

Note After you create and save a data analytics node in DataStudio, you directly open the created node when you click **Go to DataStudio for Scheduling** in HoloStudio the next time.

2.5.7. Example: Use HoloStudio for periodic scheduling

This topic describes how to use HoloStudio to map the source data stored in a MaxCompute table to Interactive Analytics for periodic scheduling.

1. **Prepare a MaxCompute table.**

   Prepare a MaxCompute table that stores source data. You can create a table and import data, or directly select a table from Data Map. For more information, see MaxCompute Quick Start. In this example, an existing table from Data Map is used. The DDL statement for creating the table is as follows:

```
CREATE TABLE IF NOT EXISTS sale_detail(
(
 age          BIGINT COMMENT 'age',
 job          STRING COMMENT 'job type',
 marital      STRING COMMENT 'marital status',
 education    STRING COMMENT 'education level',
 card         STRING COMMENT 'credit card available or not',
 housing      STRING COMMENT 'mortgage',
 loan         STRING COMMENT 'loan',
 contact      STRING COMMENT 'contact',
 month        STRING COMMENT 'month',
 day_of_week  STRING COMMENT 'day of the week',
 duration     STRING COMMENT 'duration',
 campaign     BIGINT COMMENT 'contact times during the campaign',
 pdays        DOUBLE COMMENT 'interval from the last contact',
 previous     DOUBLE COMMENT 'contact times with the customer',
 poutcome     STRING COMMENT 'result of the marketing campaign',
 emp_var_rate DOUBLE COMMENT 'employment change rate',
 cons_price_idx DOUBLE COMMENT 'consumer price index',
 cons_conf_idx DOUBLE COMMENT 'consumer confidence index',
 euribor3m    DOUBLE COMMENT 'Euro deposit rate',
 nr_employed  DOUBLE COMMENT 'number of employees',
 y            BIGINT COMMENT 'fixed time deposit available or not'
);
```

2. **Create a foreign table in HoloStudio for data analytics.**

   Log on to the DataWorks console. On the DataStudio page that appears, click the DataWorks icon in the upper-left corner and choose **All Products > HoloStudio**. On the homepage of HoloStudio, click **PG management** in the left-side navigation pane. Move the pointer over the Create icon and click **Foreign Table**. On the page that appears, set parameters and click **Commit** to create a foreign table in Interactive Analytics for mapping the source table in MaxCompute projects.

   Enter the following sample SQL statements and click **Save**. These SQL statements create a foreign table sourced from the MaxCompute table. In the upper-right corner, click **Go to DataStudio for Scheduling**.

```
BEGIN;
CREATE FOREIGN TABLE if not EXISTS bank_data_foreign_holo (
 age int8,
 job text,
 marital text,
 education text,
 card text,
 housing text,
 loan text,
 contact text,
 month text,
 day_of_week text,
 duration text,
 campaign int8,
 pdays float8,
 previous float8,
 poutcome text,
 emp_var_rate float8,
 cons_price_idx float8,
 cons_conf_idx float8,
 euribor3m float8,
 nr_employed float8,
 y int8
)
SERVER odps_server
OPTIONS (project_name 'hologresdemo4rh_dev', table_name 'bank_data_odps');
GRANT SELECT ON bank_data_foreign_holo TO PUBLIC;
COMMIT;
```

3. **Schedule the foreign table.**

   In DataStudio, configure scheduling information.

   Create an **Interactive Analytics Development** node and click **Update Code** to synchronize the node created in HoloStudio to DataWorks. Click the **Properties** tab on the right. In the **Dependencies** section, make sure that Parent Node Output Name is set to the source MaxCompute table. After the scheduling configuration is complete, click **Save**, **Submit**, and **Deploy** in sequence. After deploying the node, click **Operation Center** to go to the production environment to deploy the node.

   In the production environment, select the node and click **Deploy** in the Actions column.

   After the node is deployed, click **Operation Center** in the upper-right corner to configure data. In the left-side navigation pane, click **Cycle Task**. Right-click the node that is deployed and choose **Run > Current Node Retroactively** to run the node.

4. **Create a partitioned table in HoloStudio for data analytics.**

   After the node for inserting data to the foreign table is deployed, go to HoloStudio to create a partitioned table and write partition data to the table.

   Go to **HoloStudio** and click **Data Analytics** in the left-side navigation pane. Click **Create Data Analytics Node**. On the page that appears, enter the following SQL statements and click **Run**. Specify a custom value for the ${bizdate} parameter. After the SQL statements are run, click **Save**. In the upper-left corner, click **Go to DataStudio for Scheduling**.

```
BEGIN;
CREATE TABLE if not EXISTS bank_data_holo (
 age int8,
 job text,
 marital text,
 education text,
 card text,
 housing text,
 loan text,
 contact text,
 month text,
 day_of_week text,
 duration text,
 campaign int8,
 pdays float8,
 previous float8,
 poutcome text,
 emp_var_rate float8,
 cons_price_idx float8,
 cons_conf_idx float8,
 euribor3m float8,
 nr_employed float8,
 y int8,
 ds text NOT NULL
)
PARTITION  BY LIST(ds);
CALL SET_TABLE_PROPERTY('bank_data_holo', 'orientation', 'column');
CALL SET_TABLE_PROPERTY('bank_data_holo', 'time_to_live_in_seconds', '700000');
COMMIT;
create table if not exists bank_data_holo_1_${bizdate} partition of bank_data_holo
 for values in ('${bizdate}');
insert into bank_data_holo_1_${bizdate}
select
  age as age,
```

```
    job as job,
    marital as marital,
    education as education,
    card as card,
     housing as housing,
    loan as loan,
    contact as contact,
    month as month,
    day_of_week as day_of_week,
     duration as duration,
    campaign as campaign,
     pdays as pdays,
    previous as previous,
    poutcome as poutcome,
     emp_var_rate as emp_var_rate,
    cons_price_idx as cons_price_idx,
    cons_conf_idx as cons_conf_idx,
    euribor3m as euribor3m,
    nr_employed as nr_employed,
    y as y,
    '${bizdate}' as ds
from bank_data_foreign_holo;
```

5. **Schedule the partitioned table.**

   In DataStudio, create a **data analytics** node and click **Update Code** to synchronize the partitioned table information to the node. Click the **Properties** tab on the right, and specify a date as the value of **Parameter** in the **General** section. In the **Dependencies** section, specify the newly deployed foreign table as the output of the parent node. Then, click **Save**, **Submit**, and **Deploy** in sequence, and go to **Operation Center** to deploy the node in the production environment.

6. **View data in HoloStudio.**

   After the node for inserting data to the partitioned table is deployed, create a retroactive instance for the node.

   Go to HoloStudio. In the left-side navigation pane, choose **PG management > Table**. Double-click the partitioned table that is scheduled and click **Data Preview** to view the data.

2.6. DataAnalysis

2.6.1. Overview

Integrated with DataWorks, DataAnalysis supports creating MaxCompute tables in tabular mode, collaboratively editing workbooks and performing statistical analysis, and generating and sharing visual reports. These features enable data developers and business staff to quickly analyze data.

Go to DataAnalysis

1. Log on to the DataWorks console.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > DataAnalysis**.
3. On the **Home** page of DataAnalysis, click **Experience now** to go to the Web Excel page.

Features

- **Workbook**

  You can create and edit workbooks. Workbooks support basic operations such as addition, subtraction, multiplication, and division, and multiple data processing methods, including functions, classification, and aggregation. In addition, you can edit workbooks collaboratively with other users online and create pivot tables for further analysis.

- **Visual report**

  You can create and design visual reports by dragging, dropping, and configuring controls without running SQL statements.

- **Dimension table**

  You can create MaxCompute tables in tabular mode by one click without running SQL statements and edit MaxCompute tables collaboratively with other users online.

  - You can create a MaxCompute table in tabular mode.
  - You can import data into a MaxCompute table by one click.

2.6.2. Workbook

Create a workbook or report

On the **Web Excel** page, you can click **New spreadsheet** or **New Report** to create a workbook or report, respectively.

- **Create a workbook**
  i. On the Web Excel page, click **New spreadsheet**.
  ii. In the **New spreadsheet** dialog box that appears, enter a name in **File name**.
  iii. Click **OK**.
- **Create a report**
  i. On the Report page, click **New Report**.
  ii. In the **New Report** dialog box that appears, enter a name in **Report name** and a description in **Report Description**.
  iii. Click **OK**.

Manage workbooks or reports

In the **Files** section, you can view the workbooks or reports that you created and perform operations such as **Rename**, **Change Owner**, **Clone**, and **Delete** on them.

- Find the workbook that you want to rename, and click **Rename** in the Operation column. In the **Rename** dialog box that appears, enter a new name and click **OK**.
- Find the workbook whose owner you want to change, and click **Change Owner**. In the **Change**

Owner dialog box that appears, select a new owner to whom you want to transfer the ownership of the workbook, and then click **OK**.

- Find the workbook that you want to clone, and click **Clone**. The cloned workbook appears in the workbook list, with its name suffixed by _copy.
- Find the workbook that you want to delete, and click **Delete**. In the **Delete** dialog box that appears, click **OK**.

To manage reports, click **Report** under **Files**.

2.6.2.1. Operate workbooks

In the **All Spreadsheets** section on the **Web Excel** page, click a workbook in the **File name** column. On the page that appears, you can operate the workbook as needed.

Import

Click **Import** in the menu bar. In the dialog box that appears, select a local file you want to import, and click **Open**. The data in the local file is imported into the workbook.

> **Note** You can only import data from Excel files.

Export

Move the pointer over **Export** in the menu bar and click **Generate MaxCompute Build Table Statement**.

To make the workbook easy to use in data development modules of DataWorks or other scenarios, you can generate MaxCompute table creation statements based on the workbook. You can choose whether to include MaxCompute table creation statements in the **Export as MaxCompute Table** dialog box.

Pivot

1. On the workbook editing page, select the data for which you want to create a pivot table, and click **Pivot** in the upper-right corner.
2. In the **Create Pivot Table** dialog box that appears, specify the data to be analyzed. You can set the Choose Data parameter to **Select Range** or **Use External Data Store** as needed.
   - **Select Range**: You can select cells in an editable worksheet of the current workbook as the data store.

     Select the cells in the workbook for which you want to create a pivot table. The value of the **Range** field changes based on the selected cells.
   - **Use External Data Store**: You can select a MySQL data store or an API of DataService Studio. If you use an external data store, make sure that the connection to the data store has been configured.
3. Click **OK**. The pivot table editing page appears. The following figure shows the pivot table for a selected range of data.
   - **Data Store**: the range that you specified in the previous step.
   - **Pivot Table Fields**: the names of the fields that you selected in the previous step.
   - **Rows**: Drag and drop fields from the Pivot Table Fields section to the **Rows** section. Each value of the field added to the **Rows** section occupies a row in the pivot table.

- **Columns**: Drag and drop fields from the Pivot Table Fields section to the **Columns** section. Each value of the field added to the **Columns** section occupies a column in the pivot table.
- **Values**: Click the property setting icon for a field in the **Values** section. In the Property settings dialog box that appears, set the **Summary method** and **Data Display mode** parameters. By default, the **Field Name** parameter cannot be modified.

Parameter	Description
Source Field	The name of the selected source field.
Field Name	The name of the field displayed in the pivot table. The name is in the format of **Aggregation method:Source field name**.
Summary method	The aggregation method. You can select **SUM**, **COUNT**, **MAX**, **MIN**, or **AVG** from the drop-down list.
Data Display mode	The mode for displaying the data. Select **No calculation** or **Percentage of Total** from the drop-down list.

- **Filters**: Drag and drop fields from the Pivot Table Fields section to the Filters section. In the right-side pane that appears, you can select values to filter data.

Share

You can share workbooks with specified users or all users. The shared workbooks can be set to read-only or editable. For example, if user A shares the editing permission of a workbook to user B, both user A and user B can steal the lock of the workbook and edit its content collaboratively.

Create

Move the pointer over **New** in the upper-right corner and click **New Spreadsheet** or **New Dimension Table**.

- **Create a workbook**

  After you click **New Spreadsheet**, the **Web Excel** page appears. On this page, you can create a workbook.

- **Create a dimension table**

  i. Click **New Dimension Table**.

  ii. In the **New Dimension Table** dialog box that appears, specify a workspace for **Target Workspace** and set the parameters **Table Name**, **Table description**, and **Field**. Select **I have known this risk and confirmed that as owner of this table, I am responsible for the subsequent changes to this table**.

  iii. Click **OK**.

Menu bar

- **Font**

No.	Feature	Description
1	**Bold**	Set text in bold.

No.	Feature	Description
2	**Italic**	Set text in italic.
3	**Underline**	Underline text.
4	**Strikethrough**	Add a strikethrough to text.
5	**Borders**	Add borders to cells.
6	**Background Color**	Specify the background color of cells.
7	**Text Color**	Change the text color.

- **Text Alignment**

No.	Feature	Description
1	**Top Align**	Align text vertically to the top.
2	**Middle Align**	Align text vertically to the center.
3	**Bottom Align**	Align text vertically to the bottom.
4	**Wrap Text**	Display long text in multiple lines in a cell.
5	**Align Left**	Align text horizontally to the left.
6	**Center**	Align text horizontally to the center.
7	**Align Right**	Align text horizontally to the right.
8	**Merge and Center**	Merge multiple cells to one cell and center the content in the cell.

- **Number**

No.	Feature	Description
1	**Data Type**	Specify the type of data held in cells. You can select General, Number, Currency, Short Date, Long Date, Time, Percentage, Fraction, Scientific, and Text from the drop-down list.

No.	Feature	Description
2	**Percentage**	Apply the percentage format to numbers.
3	**Two Decimal Places**	Round numbers to two decimal places.
4	**1000 Separator**	Display numbers with thousands separators, for example, **1,005**.
5	**Currency**	Add a currency sign to numbers. The following currency signs are supported: yuan sign (¥), dollar sign ($), pound sign (£), euro sign (€), and franc sign (Fr).

- **Rows and Columns**

No.	Feature	Description
1	**Insert Row**	Insert a row to the workbook.
2	**Insert Column**	Insert a column to the workbook.
3	**Delete Row**	Delete rows from the workbook.
4	**Delete Column**	Delete columns from the workbook.
5	**Lock Row**	Lock the rows before the selected row in the workbook.
6	**Lock Column**	Lock the columns before the selected column in the workbook.
7	**Hide Row**	Hide rows in the workbook.
8	**Hide Column**	Hide columns in the workbook.

- **Conditional Formatting**

No.	Feature
1	Specify the rules for highlighting cells.
2	Format cells by using data bars and color scales.
3	Format cells by using icon sets. The icon sets include directional icons, shapes, indicators, and rating icons.

No.	Feature
4	Clear the formatting. You can select **Clear Rules from Selected Cells** or **Clear Rules from Entire Sheet** from the drop-down list.

- **Edit**

No.	Feature	Description
1	**AutoSum**	Select an aggregation method. You can select **Sum**, **Average**, **Count Numbers**, **Max**, or **Min** from the drop-down list.
2	**Search**	Click **Search** or press **Ctrl+F**. The search box appears.
3	**Sort and Filter**	Filter data and sort data in ascending or descending order.
4	**Clear**	Clear the content in cells.

- **Charts**

  You can select different charts based on the characteristics and visualization requirements of data in the selected range. Currently, DataWorks supports three types of bar charts, six types of line charts, two types of pie charts, and other 16 types of charts in four categories, such as area charts and scatter charts.

Editing area

The editing area is below the menu bar. The editing area is the main operation area for editing a workbook and consists of cells.

At the top of the editing area, the Fx field displays the formula entered in a cell.

You can directly enter content in a cell in the editing area. You can also enter a formula that references values in other cells. The column headers increase from left to right and start from A. The row headers increase from top to bottom and start from 1. You can right-click selected rows or columns and select **Hide**, **Unhide**, or **Delete** to hide, unhide, or delete the selected rows or columns.

Worksheet bar

The worksheet bar is at the bottom of the workbook editing area. You can create multiple worksheets in a workbook. On each worksheet, you can edit data or create pivot tables.

Click **+** to create a worksheet and then edit the worksheet.

2.6.3. Reports

Create a report

1. Go to the **DataAnalysis** page. For more information, see Go to DataAnalysis.
2. On the Report page, click the **New Report** icon.
3. In the **New Report** dialog box that appears, enter a name in **Report Name** and a description in

Report Description.

4. Click **OK**.

Manage reports

You can click a report in the **Report** column in the **All Reports** section to view its content. You can also perform operations such as **Rename** and **Delete** on the report.

- Find the report that you want to rename, and click **Rename** in the Operation column. In the **Rename** dialog box that appears, enter a new name and click **OK**.
- Find the report that you want to delete, and click **Delete** in the Operation column. In the **Delete** dialog box that appears, click **OK**.

Edit a report

You can click a report in the **File Name** column in the **All Reports** section to go to the report editing page.

- Title bar

  The title bar is below the top navigation bar and displays the file information and operations that you can perform. For example, the title bar displays the name of the report and allows you to import, preview, save, share, and release the report.

  - **Return**: Click this button to return to the Report page. On the Report page, you can view other reports and go to their respective editing page.
  - **Preview**: Click this button to preview the report.
  - **Save**: Click this button to save the report so that you can open and edit the saved report next time.
  - **Share & Release**: Click this button to share and release the report. You can share the report with specified users or all users.

- Menu bar

  The menu bar is located in the upper-left corner of the Report page. DataAnalysis provides 22 controls, which are categorized into seven types. You can drag and drop a control from the menu bar to the canvas to use the control.

- Canvas and configuration section

  The canvas is below the menu bar and is the main operation area for editing a report. You can drag and drop a control from the menu bar to the canvas to add this control as a component of the report. You can move a chart control to any location and resize the chart control on the canvas as needed.

  The configuration section is next to the canvas. When you click a chart control on the canvas, the configuration section on the right side displays the configuration items of the chart control. On the Data Config tab of the configuration section, you can select a data store and configure fields for the control. For example, you can specify the X-axis, Y-axis, split, and filter fields for a column chart.

  After you add a column chart to a report, follow these steps to configure the chart:

  i. Select a data store.

     You can add a new data store or select an existing one. To add a data store, click Add in the configuration section. The Create Pivot Table dialog box appears. You can set the Choose Data parameter to Select a spreadsheet or Use External Data Store.

- **Select a spreadsheet**: You can select an editable worksheet in a workbook of the current user as the data store.
- **Use External Data Store**: You can select a MySQL data store or an API of DataService Studio.

ii. Select fields as statistical items.

The fields that need to be specified vary with the chart type. For example, you must specify the X-axis, Y-axis, split, and filter fields for a column chart.

Multiple charts can use the same data store. They can use the data store in different ways without affecting each other. A chart can use only one data store. When you click a chart and drag fields from the Pivot Table Fields section to the Data Config section, the chart is associated with the data store.

iii. Set other items

You can adjust the settings such as title, arrangement, and label display to show chart information more clearly.

2.6.4. Report center

Go to DataAnalysisIn the top navigation bar of the DataAnalysis page, click **Report center** to go to the **Data analysis report center** page.

On this page, you can view the visualized report solution that DataAnalysis provides.

2.6.5. Learning center

Go to DataAnalysis. In the top navigation bar of the DataAnalysis page, click **Learn** to go to the **Data analytics Learning Center** page.

On this page, you can view relevant materials and learn about DataAnalysis.

2.7. Administration

2.7.1. Overview

Generally, developers need to test workflows and nodes on the Operation Center page.

As a key tool for routine O&M, Operation Center enables you to manage and maintain the workflows and nodes that you have committed. The Operation Center service consists of four modules: Dashboard, Nodes, Node Instances, and Monitor.

- **Dashboard**: enables you to view and manage all global nodes of DataWorks. It displays various information, including **Instances**, **Instances Run Today**, **Node Runtime**, **Instances Run in the Last Month**, **Nodes with Errors in the Last Month**, and **Node Types** of the current workspace.
- **Nodes**: provides **Recurring** and **Manually Triggered**.
- **Node Instances**: provides **Recurring**, **Manually Triggered**, **Smoke Test** and **Retroactive**. You can manage them in a list view or DAG.
  - The list view displays the running status of nodes in a list. You can add multiple alerts at a time, change owners, and add nodes to baselines.
  - In the DAG, you can maintain and manage the running status of nodes and their dependencies on ancestor and descendant nodes. You can also perform operations, such as retroactive data generation and rerun, for a single node.

- **Monitor**: provides **Baseline Instances**, **Baselines**, **Events**, **Alert Triggers**, and **Alerts**.

2.7.2. Permissions

2.7.2.1. Role permissions

The Administration service is only available to workspace administrators, developers, and administration experts.

The following table lists the permissions of workspace administrators, developers, and administration experts.

Parent permission	Permission	Workspace administrator	Developer	Administration expert
Task administration	View the DAG of a recurring task	Supported	Supported	Supported
	Jump to the DataStudio page to edit code for a recurring task	Supported	Supported	Not supported
	View the DAG of an instance	Supported	Supported	Supported
	View ancestor and descendant tasks in the DAG of a recurring task	Supported	Supported	Supported
	View the list of tasks	Supported	Supported	Supported
	View operational logs of the business flow where a recurring task resides	Supported	Supported	Supported
	Perform smoke tests on a recurring task	Supported	Supported	Supported
	Retroactively run a recurring task	Supported	Supported	Supported
	Change the owner of a recurring task	Supported	Supported	Supported
	View details of a recurring task	Supported	Supported	Supported

administration Parent permission	Permission	Workspace administrator	Developer	Administration expert
	View ancestor and descendant instances in the DAG of an instance	Supported	Supported	Supported
	Pause an instance	Supported	Supported	Supported
	Restore an instance	Supported	Supported	Supported
	Terminate a single instance	Supported	Supported	Supported
	Terminate multiple instances at a time	Supported	Not supported	Supported
	View the list of instances	Supported	Supported	Supported
	View runtime logs	Supported	Supported	Supported
	Rerun a single instance	Supported	Supported	Supported
	Rerun multiple instances at a time	Supported	Not supported	Supported
	Search for an instance	Supported	Supported	Supported
	Set the status of an instance to Successful	Supported	Supported	Supported
	Modify the baseline for a single recurring task	Supported	Supported	Supported
	Modify the baseline for multiple recurring tasks at a time	Supported	Not supported	Supported
	View the code of a recurring task	Supported	Supported	Supported

Parent permission	Permission	Workspace administrator	Developer	Administration expert
Node administration	Change the owner of a single recurring task	Supported	Supported	Supported
	Change the owner of multiple recurring tasks at a time	Supported	Not supported	Supported
	Change the resource group for a single recurring task	Supported	Supported	Supported
	Change the resource group for multiple recurring tasks at a time	Supported	Not supported	Supported
	Perform smoke tests on a recurring task	Supported	Supported	Supported
	Retroactively run a recurring task	Supported	Supported	Supported
	Delete a dependency from an instance	Supported	Not supported	Supported
	Pause an instance	Supported	Supported	Supported
	Restore an instance	Supported	Supported	Supported
	Terminate a single instance	Supported	Supported	Supported
	Terminate multiple instance at a time	Supported	Not supported	Supported
	Modify the priority of an instance	Supported	Supported	Supported
	Refresh the dependencies of an instance	Supported	Supported	Supported
	Rerun a single instance	Supported	Supported	Supported

Parent permission	Permission	Workspace administrator	Developer	Administration expert
	Rerun multiple instances at a time	Supported	Not supported	Supported
	Set the status of an instance to Successful	Supported	Supported	Supported
Administration overview	View the number of overtime task instances	Supported	Supported	Supported
	Remove a record from the overview page	Supported	Supported	Supported
	View the sorting of tasks by errors within 30 days	Supported	Supported	Supported
	View the trend of task instances run each day	Supported	Supported	Supported
	View the distribution of tasks by status	Supported	Supported	Supported
	View the trend of task instances run today	Supported	Supported	Supported
	View the sorting of tasks by duration	Supported	Supported	Supported
	View the distribution of tasks by type	Supported	Supported	Supported
	View the list of notification messages	Supported	Supported	Supported
	Disable a single alert	Supported	Supported	Supported
	Disable multiple alerts at a time	Supported	Not supported	Supported

Parent permission	Permission	Workspace administrator	Developer	Administration expert
Monitoring	Enable or disable notification by phone	Supported	Supported	Supported
	Create custom notification rules	Supported	Supported	Supported
	Delete custom notification rules	Supported	Supported	Supported
	Edit custom notification rules	Supported	Supported	Supported
	View custom notification rules	Supported	Supported	Supported
	View the list of events	Supported	Supported	Supported
	View details of an event	Supported	Supported	Supported
	View details of a personal event	Supported	Supported	Supported

2.7.2.2. Developers

Common scenarios

Test run and manage the workflows submitted in the DataStudio service.

Perform operations only on workflow tasks and node tasks of workspaces in the development environment. Access to the production environment through authorization is not allowed.

Permissions in the development environment

- Test, pause, rerun, and perform retroactive executions on a workflow or node task.
- Modify the attributes of multiple workflows or node tasks. Terminate and rerun multiple tasks. Configure alerts.

2.7.2.3. Administration expert

Scenarios

- Create tasks to publish nodes.
- Handle task exceptions.

  Perform administration for tasks in development and production environments after being authorized by an administrator.

For example, test or pause a business flow or node task, rerun a task, retroactively run a task, modify the attributes of multiple business flows or node tasks, terminate or rerun multiple tasks, and configure the alerts.

2.7.2.4. Workspace administrator

You are authorize to use the Administration service to manage the workspace.

2.7.3. Dashboard

1. Log on to the DataWorks console.
2. On the DataStudio page that appears, click the DataWorks icon in the upper-left corner and choose **All Products > Operation Center**. By default, the **Dashboard** page appears.

   On this page, you can view relevant information in charts and tables, including instance running status, node running status, node running time, and nodes with errors in the last month.

2.7.4. Task List

2.7.4.1. Auto triggered nodes

Auto triggered nodes are automatically run as scheduled after being committed to the scheduling system.

1. Log on to the DataWorks console.
2. On the DataStudio page that appears, click the DataWorks icon in the upper-left corner and choose **All Products > Operation Center**.
3. On the Operation Center page, choose **Nodes > Recurring** in the left-side navigation pane. The **Recurring** page appears.
4. Click the >> icon to show the node list. Find the target node and click **DAG** in the Actions column. The directed acyclic graph (DAG) of the node appears.
5. In the DAG section on the right, right-click the target node and then click a button on the menu that appears to perform the corresponding operation. You can also view the node running details on the Recurring page.

Button	Description
Show Ancestor Nodes and Show Descendent Nodes	Click a button to show ancestor or descendent nodes at one or more levels. More levels indicate that more ancestor or descendent nodes are displayed. If a workflow contains three or more nodes, the DAG only displays the current node and hides its ancestor and descendent nodes.
View Node Details	Click the button to go to the **Node Information** page. You can view the information about the current node, including the input table, output table, ancestor node list, and descendent node list.
View Code	Click the button to view the code of the current node.
Edit Node	Click the button to go to the DataStudio page and modify the current node.
View Instances	Click the button to view the instances of the current node.

Button	Description
View Lineage	Click the button to view the lineage of the current node.
Test	Click the button. In the **Smoke Test** dialog box that appears, set **Smoke Test Instance Name** and **Data Timestamp**, and then click **OK** to run a smoke test on the current node.
Run	Click the button to create a retroactive instance for the current node. You can select **Current Node Retroactively**, **Current and Descendent Nodes Retroactively**, or **Mass Nodes Retroactively**. If you select **Mass Nodes Retroactively**, you can create a retroactive instance separately in multiple workspaces.
Freeze	Click the button to pause the scheduling of the current node. After you click Freeze, a confirmation dialog box appears. Click Freeze to pause the node.
Unfreeze	Click the button to resume the scheduling of the paused node.
Configure Data Quality Rules	Click the button to configure data quality monitoring rules to verify data of the current node.

2.7.4.2. Manually triggered nodes

Manually triggered nodes are created in manually triggered workflows. They are manually run after being committed to the scheduling system.

> **Note** Manually triggered nodes can only be manually run, but cannot be automatically run.

1. Log on to the DataWorks console.
2. On the DataStudio page that appears, click the DataWorks icon in the upper-left corner and choose **All Products > Operation Center**.
3. On the Operation Center page, choose **Nodes > Manually Triggered** in the left-side navigation pane. The **Manually Triggered** page appears.
4. Find the target node and click **Run** in the Actions column. In the dialog box that appears, confirm the data timestamp and click Run. Then, choose Node Instances > **Manually Triggered** to view the manually triggered node instance that is generated.

2.7.5. Node instances

Auto triggered node instances

An auto triggered node instance is a snapshot of a node taken when the node is scheduled to run at a specified time. DataWorks generates an instance every time a node is run. Node instances include auto triggered node instances, test instances, and retroactive instances. You can manage node instances, such as terminating, rerunning, and restoring nodes.

> **Note** DataWorks automatically generates node instances before 22:30 every day based on the scheduling properties of each auto triggered node. If you commit newly created nodes or modify node dependencies after 22:30, the new nodes are run or the modified node dependencies take effect from the next day.

Test instances

A test instance is generated from a selected node when a test run is performed on the node as scheduled. Each test instance processes data based on the data timestamp you select. The default data timestamp is one day before the system time.

You can test an entire workflow with one test instance. That is, a test instance is a snapshot of all nodes in a workflow.

You can also test one or more selected nodes with one test instance.

> **Note** Exercise caution when you run a smoke test on a node. Smoke testing can modify tables and files involved in the node.

Manually triggered node instances

DataWorks generates manually triggered node instances from manually triggered nodes. Manually triggered nodes do not have node dependencies. They must be run manually.

Retroactive instances

If auto triggered nodes fail to run, you can create and run retroactive instances for substitution. This guarantees the completion of business data. When you create a retroactive instance for an auto triggered node, you can select **Current Node Retroactively**, **Current and Descendent Nodes Retroactively**, or **Mass Nodes Retroactively**.

The following table lists the node running status.

No.	Status	Icon
1	Successful	
2	Frozen	
3	Failed	
4	Running	
5	Pending	

The following table describes the buttons available on the menu that appears if you right-click an instance in a directed acyclic graph (DAG).

Button	Description
Show Ancestor Nodes and Show Descendent Nodes	Click a button to show ancestor or descendent nodes at one or more levels. If a workflow contains three or more nodes, the DAG only displays the current node and hides its ancestor and descendent nodes.
View Runtime Log	Click the button to view the runtime logs of the current instance if it is in the running, successful, or failed state.
View Code	Click the button to view the code of the current instance.
Edit Node	Click the button to go to the DataStudio page and modify the current node.
View Lineage	Click the button to view the lineage of the current instance.
Stop	Click the button to stop running the current instance.
Rerun	Click the button to rerun the current instance if it is in the failed or abnormal state.
Rerun Descendent Nodes	Click the button to rerun all the descendent instances of the current instance.
Set Status to Successful	Click the button to change the status of the current instance to successful. **Note** The original status of the instance must be failed.
Freeze	Click the button to pause the scheduling of the current instance.
Unfreeze	Click the button to resume the scheduling of the paused instance.

2.7.6. Monitor

2.7.6.1. Overview

The Monitor module is a node monitoring and analysis system of DataWorks. Based on monitoring rules and node running status, the Monitor module determines whether, when, and how to trigger an alert, and whom an alert is sent to. It automatically selects the most appropriate alerting time, notification methods, and recipients.

The Monitor module provides you with the following benefits:

- Improves your efficiency on configuring monitoring rules.
- Prevents invalid alerts from bothering you.
- Automatically covers all important nodes for you.

General monitoring systems cannot meet the requirement of DataWorks. The reasons are as follows:

- DataWorks has numerous nodes, so it is difficult for you to find out the nodes to be monitored. Some DataWorks businesses have a large number of nodes, and dependencies between the nodes are

complex. Even if you know the most important node, it is difficult to find all ancestor nodes of the node and monitor them all. In this case, if you simply monitor all nodes, a large number of invalid alerts may be generated. In consequence, you may miss those useful alerts.

- The alerting method varies with nodes. For example, some monitoring tasks require the relevant nodes to run for more than one hour before triggering alerts, while other monitoring tasks require the relevant nodes to run for more than two hours. It is extremely complex to set a monitoring node for each node, and it is difficult to predict the alert threshold value for each node.
- The alerting time varies with nodes. For example, an alert for an unimportant node can be sent after you start working in the morning. An alert for an important node needs to be sent immediately when an error occurs. General monitoring systems cannot tell the importance of each node.
- Different alerts require different operations to turn off.

The Monitor module provides comprehensive monitoring and alerting logic. You only need to provide the node name of your business. Then, the Monitor module automatically monitors the entire process of your node and creates standard alert triggers for the node. In addition, you can customize alerting triggers by completing basic settings.

Currently, the Monitor module has been used for monitoring all important businesses of Alibaba Group. Its full-path monitoring function guarantees the overall data output of all important businesses of Alibaba Group. In addition, it supports analyzing ancestor and descendant node paths to promptly detect risks and provide O&M advice for business departments. These functions of the Monitor module have guaranteed the long-term high stability of businesses in Alibaba Group.

2.7.6.2. Feature description

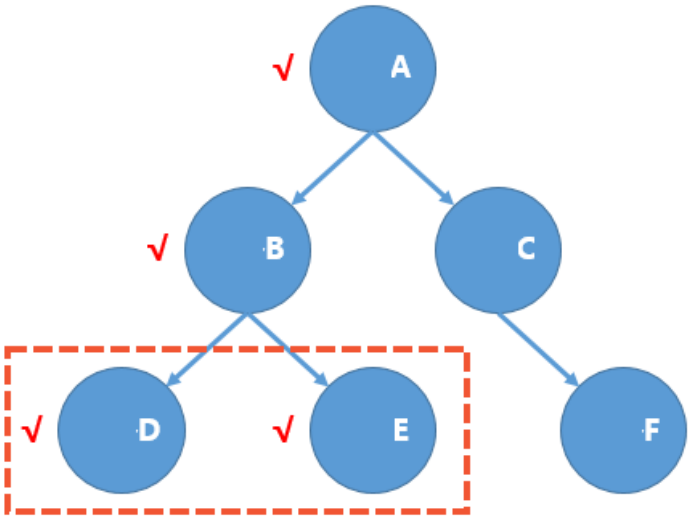
2.7.6.2.1. Baseline alert and event alert

This topic describes the functional logic of baseline alerts and event alerts from the aspects of monitoring scope, node capturing, alert object judgment, alerting time judgment, notification methods, and alert escalation.

Monitoring scope

A baseline is a management unit of a group of nodes, that is, a node group. You can specify nodes to monitor in a baseline.

After a baseline is monitored, all nodes of the baseline and its ancestor nodes are monitored. The Monitor module does not monitor all nodes by default. A node is monitored only when it has descendant nodes that are added to a monitoring baseline. If no descendant nodes are added to a monitoring baseline, the Monitor module does not report any alert even if the node fails.



As shown in the preceding figure, assume that DataWorks has only six nodes, and nodes D and E belong to a monitoring baseline. Nodes D and E and all their ancestor nodes are monitored by the Monitor module. That is, any error or slowdown on node A, B, D, or E will be detected by the Monitor module. However, nodes C and F are not monitored by the Monitor module.

Node capturing

After the nodes to be monitored are specified, if a monitored node incurs an exception, the Monitor module generates an event. All alert decisions are based on the analysis of this event. Two types of node exceptions are available. You can choose **Events > Event Type** to view them.

- **Error**: indicates that a node fails to run.
- **Slow**: indicates that the running time of a node is significantly longer than the average running time of the node in the past periods.

> **Note** If a node times out and then encounters an error, two events are generated.

Alerting time judgment

Buffer, an important concept in the Monitor module, refers to the maximum time period that a node can be delayed. The latest start time of a node is obtained by subtracting the average uptime from the baseline time.

The baseline time of baseline A is 05:00, you must set the latest start time of node E to 04:10. This time is calculated by subtracting the average uptime of node F (20 minutes) and node E (30 minutes) from the baseline time 05:00. This time is also the latest completion time of node B in baseline A.

To ensure that the baseline time of baseline B is 06:00, you must set the latest completion time of node B to 04:00. This time, which is earlier than 04:10, is calculated by subtracting the average uptime of node D (2 hours) from the baseline time 06:00. To meet the baseline time of both baseline A and baseline B, you must set the latest completion time of node B to 04:00.

The latest completion time of node A is 02:00, which is calculated by subtracting the average uptime of node B (2 hours) from 04:00. The latest start time of node A is 01:50, which is calculated by subtracting the average uptime of node A (10 minutes) from 02:00. If node A fails to run before 01:50, it is probable that baseline A is broken.

If node A fails to run at 01:00, its buffer is 50 minutes, which is the difference between 01:00 and 01:50. As demonstrated in this example, buffer reflects the degree of caution for a node exception.

Baseline alert

Baseline alerting is an additional feature developed for baselines that are enabled. Each baseline must provide an alert buffer and committed time. Baseline alerting is the action of notifying the preset alert recipient three times at the interval of 30 minutes when the baseline completion time estimated by the Monitor module exceeds the alert buffer.

Notification method

Currently, baseline alerts are sent to the baseline owner by default. On the **Alert Triggers** page, you can find **Global Baseline Alert Trigger**, click **View Details**, and change the alert trigger method and the alerting action.

Gantt chart function

The Gantt chart function reflects the key path of a node. The function is provided by the **Baseline Instances** module of Monitor.

> **Note** The key path is the slowest upstream link that causes the node to be completed at this time point.

2.7.6.2.2. Custom alert trigger

Alert trigger customization is a lightweight monitoring function of the Monitor module.

You can customize all monitoring alert triggers by setting the following parameters:

- Objects: You can specify nodes, baselines, and workspaces as objects.
- Trigger Condition: Valid values include Completed, Uncompleted, Error, Uncompleted Cycle, and Overtime.
- Notification Method: Valid values include SMS and Email.
- Maximum Alerts: This parameter indicates the maximum number of alert reporting times. If the number of alerting times exceeds the preset threshold, no alerts are generated.
- Minimum Alert Interval: This parameter indicates the minimum time interval at which DataWorks reports alerts.
- Quiet Hours: This parameter indicates the specified period during which no alerts are reported.
- Recipient: This parameter indicates the person who receives alerts. You can set this parameter to the node owner or another recipient.

A monitoring rule uses the following five alert trigger conditions: Completed, Uncompleted, Error, Uncompleted Cycle, and Overtime.

- **Completed**

A completion alert can be set for nodes, baselines, and workspaces. Once all nodes of the preset objects are completed, the completion alert is reported. If you set a completion alert for a baseline, the alert is reported when all nodes of the baseline are completed.

- **Uncompleted**

  You can set alerts for nodes, baselines, or workspaces that are not completed at a certain time point. For example, if you require that a baseline be completed at 10:00, an alert containing a list of uncompleted nodes is reported once a node in the baseline is not completed at the specified time.

- **Error**

  An error alert can be set for nodes, baselines, and workspaces. Once a node has an error, an alert containing detailed node error information is sent to the recipient.

- **Uncompleted Cycle**

  For the monitoring rules of hourly scheduled nodes, you can separately specify the uncompleted time points in different periods.

- **Overtime**

  An overtime alert can be set for nodes, baselines, and workspaces. Once a monitored node of the preset object is not completed within the specified time, an alert is reported.

2.7.6.3. Instructions

2.7.6.3.1. Baseline instances

On the Baseline Instances page, you can view the information about a baseline.

1. Log on to the DataWorks console.
2. On the DataStudio page that appears, click the DataWorks icon in the upper-left corner and choose **All Products > Operation Center**. The **Operation Center** page appears.
3. On the Operation Center page, choose **Monitor > Baselines** in the left-side navigation pane. On the **Baselines** page, create a baseline. For more information abut how to create a baseline, see Create a baseline.

   > **Note** If you have created a baseline, skip this step and directly go to the **Baseline Instances** page to perform subsequent operations.

4. In the left-side navigation pane, choose **Monitor > Baseline Instances**. The **Baseline Instances** page appears. On this page, you can search for baseline instances by condition, such as the data timestamp, owner name or ID, event ID, workspace, and baseline name. You can also click **View Details**, **Handle**, and **View Gantt Chart** in the Actions column to perform corresponding operations on a baseline.

   > **Note** After creating a baseline, you must enable the baseline so that a baseline instance can be generated.

   A baseline can be in the one of the following four states:

   - **Normal**: All nodes in the baseline are completed before the alerting time.
   - **Alerting**: One or more nodes in the baseline are not completed at the alerting time but the committed completion time has not arrived.

- **Overtime**: One or more nodes in the baseline are not completed at the committed completion time.
- **Others**: All nodes in the baseline are paused or the baseline is not associated with any node.

You can click **View Details**, **Handle**, and **View Gantt Chart** in the Actions column to perform corresponding operations on a baseline.

- **View Details**: Click **View Details** to go to the **Baseline Instance Details** page.

  On the **Baseline Instance Details** page, you can view the general information, critical path, baseline instance information, history graph, and relevant events.

  > Note
  >
  > - In the preceding figure, the data timestamp is `one day before the system time` .
  > - When you create a baseline, you can select **By the Day Interval** or **By the Hour Interval**. The **Cycle** parameter appears as the advanced settings of the **Committed Time** parameter only when you select By the Hour Interval.

- **Handle**: Click Handle to pause the alert generated by the baseline when the baseline is being handled.
- **View Gantt Chart**: Click **View Gantt Chart** to view the critical paths of nodes.

2.7.6.3.2. Baselines

You can create and define baselines on the Baselines page.

Create a baseline

1. Log on to the DataWorks console.
2. On the DataStudio page that appears, click the DataWorks icon in the upper-left corner and choose **All Products > Operation Center**. The **Operation Center** page appears.
3. On the Operation Center page, choose **Monitor > Baselines** in the left-side navigation pane.
4. On the **Baselines** page, click **Create Baseline** in the upper-right corner.

   > Note Currently, only workspace administrators can create baselines.

5. In the **Create Baseline** dialog box that appears, set the parameters and click **OK**.

Parameter	Description
Baseline Name	The name of the baseline.
Workspace	The workspace of the node associated with the baseline.
Owner	The name or ID of the owner.

Parameter	Description
Recurrence	Specifies whether the baseline detects nodes by day or hour. ○ **By the Day Interval**: Select this option for nodes scheduled by day. ○ **By the Hour Interval**: Select this option for nodes scheduled by hour.
Nodes	○ **Node**: the node associated with the baseline. Enter the name or ID of a node, and then click the icon on the right to add the node. You can add multiple nodes. ○ **Workflow**: the workflow associated with the baseline. Enter the name or ID of a workflow, and then click the icon on the right to add the workflow. We recommend that you only add the last node of a workflow instead of all nodes.
Priority	The priority of the baseline. A baseline with a higher priority is scheduled first. Currently, the only available priority value is 1.
Estimated Completion Time	The completion time of the node estimated based on the average running time of the node during previous scheduling. If no historical data is available, the message **The completion time cannot be estimated due to a lack of historical data** appears.
Committed Time	The time point when a node should be completed. An alert is triggered if the node is not completed until the time point obtained by subtracting the alert margin threshold from the committed completion time.
Margin Threshold	The interval before an alert is triggered. For example, set Committed Time to 3:30 and Margin Threshold to 10 minutes. An alert is triggered if the node is not completed at 3:20. Assume that the average running time of the node is 30 minutes. If the node is not started at 2:50, an alert is triggered. **Note** The average running time of a node can be calculated based on the data of the last 15 days.

6. After a baseline is created, click **Enable** in the Actions column to enable the baseline.

   You can click **View Details**, **Change**, **Enable**, Disable, or **Delete** in the Actions column to perform the corresponding operation on a baseline.

   - **View Details**: Click **View Details** to view the basic information about the baseline.
   - **Change**: Click **Change** to modify the baseline.
   - **Enable** or Disable: Click Enable or Disable to enable or disable the baseline. A baseline instance can be generated only when the corresponding baseline is enabled.
   - **Delete**: Click **Delete** to delete the baseline.

Add a node to a baseline

By default, all nodes in the production environment are in the default baseline of each workspace. When you create a baseline, you actually move nodes from the default baseline to the baseline that you create.

> **Note** A node must belong to a baseline, so you cannot directly remove nodes from the default baseline. Instead, you can create a baseline to move nodes from the default baseline to the new baseline. When you delete a baseline that you create, you actually move the nodes in the baseline to the default baseline.

To change the baseline of a node, perform one of the following operations:

- On the **Baselines** page, click **Create Baseline** in the upper-right corner. Then, create a baseline by following the instructions in the Create a baseline section.
- In the left-side navigation pane, choose Nodes > **Recurring**. On the page that appears, find the node and choose **More > Add to Baseline** in the Actions column.

2.7.6.3.3. Events

On the Events page, you can view all events related to slowdown or errors.

1. Log on to the DataWorks console.
2. On the DataStudio page that appears, click the DataWorks icon in the upper-left corner and choose **All Products > Operation Center**.
3. On the Operation Center page, choose **Monitor > Events** in the left-side navigation pane. The **Events** page appears.

   You can search for events by condition, such as the event owner, time when an event was detected, event status, event type, and name or ID of a node or node instance.

   In the search results, each event is displayed in a row and associated with a node that encounters errors. The worst baseline indicates a baseline with the minimum margin among the baselines affected by an event.

   - Click **View Details** in the Actions column of an event. You can view the event occurrence time, alert time, clearance time, historical runtime logs of the node, and detailed node logs.

     You can assign an alert recipient. After you click **View Alerts**, the alert details page corresponding to the event appears. Affected baselines are all descendant baselines affected by the node associated with the event. You can observe descendant baselines and the impact on these baselines and analyze node logs to identify the causes of the event.
   - If you click **Handle**, DataWorks records the event handling operation and pauses the alert for the event when the event is being handled.
   - If you click **Ignore**, DataWorks keeps the event ignorance record and permanently stops the alert for the event.

2.7.6.3.4. Alert triggers

This topic describes how to customize alert triggers on the Alert Triggers page.

1. Log on to the DataWorks console.
2. On the DataStudio page that appears, click the DataWorks icon in the upper-left corner and choose **All Products > Operation Center**.

3. On the Operation Center page, choose **Monitor > Alert Triggers** in the left-side navigation pane. The **Alert Triggers** page appears.
4. On the Alert Triggers page, click **Create Custom Trigger** in the upper-right corner.
5. In the **Create Custom Trigger** dialog box that appears, set relevant parameters.

Parameter	Description
Trigger Name	The name of the custom alert trigger.
Object Type	The granularity of monitored objects. Valid values: **Node** and **Workflow**.
Objects	The monitored object. Enter the name or ID of a node or workflow and click the icon on the right to add the object.
Trigger Condition	The condition for triggering an alert. Valid values: **Completed**, **Uncompleted**, **Error**, **Uncompleted Cycle**, and **Overtime**.
Maximum Alerts	The maximum number of alert reporting times. If the number of alert reporting times exceeds the preset threshold, no alerts are reported.
Minimum Alert Interval	The minimum time interval at which DataWorks reports an alert.
Quiet Hours	The specified period during which no alerts are reported.
Notification Method	The method of reporting alerts. Valid values: **Email** and **SMS**.
Recipient	The person who receives alerts. You can set this parameter to the node owner or another recipient.
DingTalk Chatbot	The DingTalk chatbot to receive alerts.

6. Click **OK** to create the alert trigger.

   On the **Alert Triggers** page, you can click **View Details** in the Actions column of an alert trigger to view the details of the alert trigger.

2.7.6.3.5. Alert information

You can view all alerts on the Alerts page.

1. Log on to the DataWorks console.
2. On the DataStudio page that appears, click the DataWorks icon in the upper-left corner and choose **All Products > Operation Center**.
3. On the Operation Center page, choose **Monitor > Alerts** in the left-side navigation pane. The **Alerts** page appears.

   You can search for alerts by condition, such as the alert trigger ID or name, recipient, alert time, notification method, and alert trigger type.

   You can also view alert details such as the notification method and status. To view more alert details, find the target alert and click **View Details** in the Actions column.

2.7.6.4. FAQ related to the Monitor module

2.7.6.4.1. Why was my alert reported to someone else?

- For custom alerts, confirm the alert triggers with their creators.
- For alerts generated for a baseline after the baseline is enabled, you can choose **Monitor > Alerts** in the left-side navigation pane of Operation Center, find the target alert, and then click **View Details** in the Actions column to view the alert cause.

2.7.6.4.2. What can I do if I do not want to receive unimportant alerts for a node?

1. Log on to the DataWorks console.
2. On the DataStudio page that appears, click the DataWorks icon in the upper-left corner and choose **All Products > Operation Center**.
3. On the Operation Center page, choose **Monitor > Events** in the left-side navigation pane. The **Events** page appears.
4. On the Events page, find the target event and click **View Details** in the Actions column to view the descendant baselines affected by the node associated with the event.

   If you do not want to receive unimportant alerts for a node, request the node owner to contact the baseline owner and ask the baseline owner to move the node from the baseline to another baseline.

2.7.6.4.3. Why is no alert reported for a baseline break?

Baseline monitoring is controlled by the baseline switch and enabled for nodes. If all nodes are running normally, no alert will be triggered even in case of a baseline break. This is because all the nodes are running normally and DataWorks cannot determine which node has an error. Baseline break is a baseline status, indicating that a node is still not completed after the committed time.

The reasons why the baseline is still broken when all nodes are normal are as follows:

- The baseline time is set improperly.
- The node dependency is incorrect.

2.7.6.4.4. Can I disable DataWorks from reporting an alert for a node that slows down?

DataWorks reports a node slowdown alert only when a node meets both the following conditions:

- The node is an ancestor node of an important baseline.
- Compared with its historical performance, the node does become slowdown.

If the node slowdown has a minor impact, you can ignore the alert. Confirm the impact with the party whose monitoring baseline uses your node as an ancestor node. You can go to the **Events** page to view the descendant baseline information. If you are responsible for the party, maintain the node properly.

2.7.6.4.5. Why did I fail to receive an alert for an error node?

DataWorks reports an alert only for specified nodes when an error occurs. An alert is reported for an error node only when the node meets any of the following conditions:

- The node is an ancestor node of a baseline that has been enabled.
- An alert trigger has been customized.

2.7.6.4.6. What can I do if I receive an alert at night?

If you receive an alert at night, go to the event page to disable the event alert. However, the alert can only be disabled for a period of time. After receiving an alert, you need to handle it in a timely manner.

2.8. Security Center

2.8.1. Overview

Security Center provides flexible permission management features. It allows you to request permissions and handle permission requests on the graphical user interface (GUI), and view and manage permissions. Security Center not only improves data security but also facilitates data permission management.

Log on to the DataWorks console. On the DataStudio page that appears, click the DataWorks icon in the upper-left corner and choose **All Products > Security Center**. The **Security Center** page appears.

Security Center consists of the following modules: **My Permissions**, **Authorizations**, and **Approval Center**.

Currently, Security Center provides the following features:

- Self-service permission request: Users can select the required tables to quickly initiate a permission request online. This online request mode is more efficient than the original mode in which users need to contact administrators offline.
- Permission management: Administrators can view the users who have permissions on database tables and revoke permissions as required. Users can also revoke unnecessary permissions themselves.
- Permission request approval: Before granting permissions to users, administrators approve permission requests initiated by users. This implements a visual and process-based permission management system, and supports reviewing the approval process.

In Security Center, you can view permissions on all the tables in an organization, request and revoke table permissions, and approve or reject permission requests.

Each operation in Security Center applies to all the workspaces of a tenant in standard mode and basic mode.

2.8.2. My Permissions

On the My Permissions page, you can view your table and field permissions in a workspace, and request or revoke table and field permissions.

View table and field permissions

1. Move the pointer over the DataWorks icon in the upper-left corner, and click **Security Center**. In

the left-side navigation pane, click **My Permissions**. The **Table** tab appears.

2. On this tab, you can select a workspace and specify the environment (for a workspace in standard mode) to view all the tables of the workspace in the specified environment. You can also enter a table name in the search box to search for required tables in fuzzy match mode.

   You can view the names and owners of tables in the workspace, view your permissions on the tables, and request or revoke table and field permissions.

Request table and field permissions

1. Select the tables and fields on which you want to request permissions.
   - Request permissions on a table or some fields in the table

     Select the required fields on which you have no permissions in a table and choose **More > Request Permission** in the Actions column.

     Alternatively, choose **More > Request Permission** in the Actions column for a table without selecting any fields to request permissions on all the fields in the table.

     > **Note** You can request permissions on fields only in a workspace with LabelSecurity enabled. If LabelSecurity is disabled for a workspace, you can request permissions only on tables in this workspace.

   - Request permissions on multiple tables and fields

     Select all the required tables and fields and click **Request Permission**.

     > **Note** You can also click **Request Permission** without selecting any tables or fields, and then select the required tables and fields in the **Table Permission Request** dialog box.

2. Set the parameters in the **Table Permission Request** dialog box.

Parameter	Description
Workspace	The name of the workspace, which is automatically entered based on the information you specified on the My Permissions page. You can change the workspace as required.
Environment	The environment of the workspace.
MaxCompute Project	The name of the MaxCompute project.
Grant To	The account for which you request permissions. You can request permissions for the current account or a production account of another workspace you joined.
Reason for Request	The reason why you request permissions.
Objects Requested	The tables on which you request permissions. The tables that you select on the previous page are displayed. You can add tables or delete existing tables as required.

3. After the configuration is completed, click **Submit**. If you do not want to request the permissions, click **Cancel**.

Revoke permissions

You can revoke table and field permissions.

- Revoke field permissions

  > Note
  > - You can revoke permissions on fields only in a workspace with LabelSecurity enabled.
  > - To revoke permissions on all the fields in a table, you can directly revoke the permissions on the table.

  i. Choose **More > Revoke Field Permission** in the **Actions** column for the table on which you want to revoke permissions.
  ii. In the **Revoke Field Permission** dialog box, select the fields on which you want to revoke permissions.
  iii. Click **OK**.
- Revoke table permissions
  i. Choose **More > Revoke Permission** in the **Actions** column for the table on which you want to revoke permissions.
  ii. In the **Revoke Permission** dialog box, select the permissions you want to revoke.
  iii. Click **OK**.

2.8.3. Authorizations

On the Authorizations page, a workspace administrator can view the accounts that have permissions on tables and fields in each workspace, and revoke unnecessary table and field permissions.

You can move the pointer over the DataWorks icon in the upper-left corner, and click **Security Center**. In the left-side navigation pane, click **Authorizations**. On the **Table** tab that appears, you can view and search for tables in workspaces of the current organization.

On the Table tab, you can select a workspace and specify the environment (for a workspace in standard mode) to view all the tables of the workspace in the specified environment. You can also enter a table name in the search box to search for required tables in fuzzy match mode.

View accounts that have permissions on a table

On the **Table** tab of the **Authorizations** page, click the plus sign (+) in front of a table to view all the accounts that have permissions on the table.

Revoke table permissions

Click **Revoke Permission** in the Actions column for an account to revoke the permissions of the account on the current table.

View field permissions

Click **View Field Permissions** in the Actions column for an account to view the permissions of the account on the fields in the current table.

Revoke field permissions

If LabelSecurity is enabled for the workspace, select fields on the Field Permissions page and click **Revoke Field Permissions** to revoke the permissions on the fields.

2.8.4. Approval Center

On the Approval Center page, you can view your requests and their status, view and handle the requests pending your approval, and view the requests that you have handled.

My Requests

1. Move the pointer over the DataWorks icon in the upper-left corner, and click **Security Center**. In the left-side navigation pane, click **Approval Center**. On the Approval Center page, click the **My Requests** tab.

   On this tab, you can view the information about each of your requests, including **Object Type**, **Workspace**, **Status**, **MaxCompute Project**, **Request Time**, and **Table**.

   > **Note** If a request contains permission requests for tables that belong to different owners, Security Center automatically splits the request into multiple requests by table owner.

2. Click **View** in the Actions column to view the details about a request.

Pending My Approval

1. On the **Approval Center** page, click the **Pending My Approval** tab.

   On this tab, you can view the requests pending your approval. If a request is pending your approval, a red dot appears next to Approval Center and Pending My Approval to remind you.

   You can view the information about each of requests pending your approval, including **Object Type**, **Grant To**, **Request Time**, **Workspace**, **MaxCompute Project**, and **Table**.

2. Click **Handle** in the Actions column to view the details about a request and handle it on the Request Details page. The request details include the progress and objects requested.
3. Enter your comments and click Approve or Reject as required.

Handled by Me

1. On the **Approval Center** page, click the **Handled by Me** tab.

   On this tab, you can view the information about each request that you have handled, including **Object Type**, **Grant To**, **Result**, **Workspace**, **MaxCompute Project**, **Table**, and **Request Time**.

2. Click **View** in the Actions column to view the details about a request. The request details include the progress and objects requested.

2.8.5. FAQ

This topic describes the frequently asked questions (FAQs) about the Security Center service of DataWorks.

- Q: What permissions can I request in Security Center?

A: In Security Center, you can request permissions on tables in DataWorks workspaces in the development environment and production environment.

- Q: What is the relationship between Data Management and Security Center?

  A: Security Center is a product that upgrades and replaces the permission and security features in Data Management. You can choose **Security Center > My Permissions** to view the permissions requested or granted by using the `odpscmd grant` command in **Data Management**.

  If you want to request other permissions and handle permission requests on the GUI, go to **Security Center** and perform operations as required. The **Data Management** service does not support permission request and approval any more.

- Q: Why cannot I select fields when I request permissions?

  A: If LabelSecurity is enabled for a workspace, you can request permissions on fields in this workspace. If LabelSecurity is disabled for a workspace, you can request permissions only on tables in this workspace.

- Q: Who will handle my request?

  A: Your request is handled by a workspace administrator or a table owner. After either of them approves or rejects your request, the request is closed.

- Q: Why do I find two requests on the **My Requests** page after I submit only one request?

  A: The tables in your request belong to two owners. In this case, Security Center automatically splits your request into two by table owner.

- Q: I request permissions on a field for one month only. Why does the validity period of the permissions become permanent after my request is approved?

  A: The security level of this field is zero or not higher than the security level of your account.

- Q: Why do I obtain permissions on some tables and fields on which I have not requested any permissions?

  A: The possible causes are as follows:

  - An administrator has granted the permissions to you by running commands in the DataWorks console.
  - After your request is approved in Security Center, Security Center also grants you the permissions on fields whose security level is zero or not higher than the security level of your account, even though you have not requested the permissions.

- Q: Why does a request disappear from the **Pending My Approval** tab before I handle it?

  A: Another workspace administrator or the table owner has approved or rejected the request. The request is closed and no longer needs to be handled.

- Q: What can I do if the message "An error occurred in the MaxCompute project" appears when I specify the workspace and environment?

  A: Send the error message and error code to a workspace administrator for troubleshooting.

- Q: Why do I fail to revoke permissions on a field?

  A: You can revoke permissions only on the fields whose security level is higher than the security level of your account.

- Q: Why do I fail to request permissions by using my tenant account?

A: By default, a tenant account has all permissions. Therefore, you do not need to request permissions for your tenant account. The tenant account hides unnecessary operations such as permission request. This does not affect the use of the tenant account.

- Q: In **Security Center**, can I view the permission request and approval records of **Data Management**?

  A: Security Center and Data Management have not synchronized permission request and approval records yet. You need to go to **Data Management** to view the permission request and approval records of Data Management.

- Q: Can I revoke permissions based on the request records in Security Center?

  A: Currently, Security Center is not the only service that provides authorization. To facilitate permission revocation, the Authorizations page in Security Center provides an access control list (ACL) of all users, regardless of the authorization channel. You can revoke any granted permissions without using the request records.

- Q: A permission request submitted in **Data Management** has not been approved yet. Do I need to submit it again in Security Center?

  A: Security Center and Data Management have not synchronized permission request and approval records yet. You need to submit the permission request again in Security Center.

- Q: How do I specify the LabelSecurity parameter for fields?

  A: You need to go to **Data Map** to set the LabelSecurity parameter for fields.

2.9. Data Quality

2.9.1. Overview

DataWorks provides a Data Quality service for you to control the data quality of disparate connections. In Data Quality, you can check data quality, configure alert notifications, and manage connections.

Relying on DataWorks, Data Quality provides a comprehensive data quality solution that has various features. For example, you can detect data, compare data, monitor data quality, and use intelligent alerting.

Data Quality monitors data in datasets. Currently, it allows you to monitor MaxCompute tables and DataHub topics. When offline MaxCompute data changes, Data Quality checks data and blocks nodes if it detects exceptions. This prevents nodes from being affected. In addition, Data Quality allows you to manage the check result history so that you can analyze and evaluate the data quality.

For streaming data, Data Quality uses DataHub to monitor data streams and sends alert notifications to subscribers if it detects stream discontinuity. You can also set the alert severity such as warning and error alerts, and the alert frequency to minimize repeated alerts.

The following figure shows the monitoring flowchart in Data Quality.

> **Note** Data Quality monitors the quality of data from MaxCompute and DataHub datasets. To use Data Quality features, you need to create tables and write data to the tables.
>
> You can create MaxCompute tables and write data to the tables in the MaxCompute console or in the DataWorks console.

Log on to the DataWorks console. Click the DataWorks icon in the upper-left corner and choose **All Products > Data Quality** to go to the **Data Quality** page.

2.9.2. Features

2.9.2.1. Dashboard

As the homepage of Data Quality, the Dashboard page displays an overview of alerts and blocks for subscribed nodes. You can set filter conditions to view the required alerts and blocks.

Card	Description
My MaxCompute Partition Subscriptions	Displays the number of MaxCompute partitions with alerts or blocks and the number of normal MaxCompute partitions on the current day. You can click this card to go to the Search by Node page for the MaxCompute connection and view alert details.
My DataHub Topic Subscriptions	Displays the number of DataHub topics with alerts and the number of normal DataHub topics on the current day. You can click this card to go to the Search by Node page for the DataHub connection and view alert details.
Current task alarm condition	Displays alerts for MaxCompute and DataHub connections of the current workspace on the current day.
Current task blocking situation	Displays blocks for the MaxCompute connection of the current workspace on the current day.
Task Alarm Situation Trend	Displays the trend chart of alerts for MaxCompute and DataHub connections. You can view the alert trend in the past 7 or 30 days, or a custom time period within the past three months.
Task Blocking Situation Trend Graph	Displays the trend chart of blocks for MaxCompute and DataHub connections. You can view the block trend in the past 7 or 30 days, or a custom time period within the past three months.

2.9.2.2. My Subscriptions

The My Subscriptions page displays all nodes subscribed by your account.

Go to the My Subscriptions page

Currently, Data Quality allows you to monitor MaxCompute tables and DataHub topics. You can select a connection on the **My Subscriptions** page and search for subscribed nodes of the connection.

1. Log on to the DataWorks console.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > Data Quality**.
3. In the left-side navigation pane, click **My Subscriptions**. The **My Subscriptions** page appears.

Subscribed MaxCompute connections

On the **My Subscriptions** page, select **MaxCompute** from the connection drop-down list in the upper-left corner. All the subscribed MaxCompute connections appear.

- You can click a partition expression on the right to go to the **Rules** page. For more information, see MaxCompute monitoring.
- You can click **View Check Results** in the Actions column for a partition expression to go to the Search by Node page.
- Data Quality supports the following four notification methods: **Email**, **Email and SMS**, **DingTalk Chatbot**, and **DingTalk Chatbot @ALL**.
- You can click **Cancel Subscription** to unsubscribe from the connection.

Subscribed DataHub connections

On the **My Subscriptions** page, select **DataHub** from the connection drop-down list in the upper-left corner. All the subscribed DataHub connections appear.

- After you click **Alerts** for a topic, the **Alerts** page appears, allowing you to view detailed information about the rule alert.
- You can click **Notification Method** for a topic to change the notification method of the rule alert.
- You can click **Cancel Subscription** in the Actions column for a topic to unsubscribe from the topic.

2.9.2.3. Rules

Currently, Data Quality allows you to monitor MaxCompute tables and DataHub topics. This topic describes how to configure rules for MaxCompute monitoring.

Create rules

1. Log on to the DataWorks console.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > Data Quality**.
3. In the left-side navigation pane, click **Rules** and select a connection as required. On the **Rules** page that appears, you can select a MaxCompute connection or a DataHub connection.
   - On the Rules page, select MaxCompute from the drop-down list in the upper-left corner. All tables of the MaxCompute connection are listed on the right. You can also search for tables in the search box.
   - On the Rules page, select DataHub from the drop-down list in the upper-left corner. All topics of the DataHub connection are listed on the right. You can also search for topics in the search box.
4. Click **View Monitoring Rules** of the corresponding connection. The **Rules** page appears.
5. Select the partition expression that has been added, and click **Create Rule**.

   > **Note** Before configuring a template rule for a table, you need to configure a partition expression. For more information, see Configure partition expressions.

6. In the dialog box that appears, configure the rule as required (see the following section for more information), and click **Save**.

   Currently, Data Quality allows you to configure template rules and custom rules for a table.

Template rules

You can click **Create Monitoring Rule** or **Quick Create** to create a template rule.

- In the **Template Rules** dialog box that appears, click **Create Monitoring Rule** and perform related

configurations.

Configuration item	Description
Rule Name	The name of the rule.
Rule Type	The type of the rule. Valid values: Strong or Weak. ◦ If you select Strong, error alerts are reported and descendant nodes are blocked, whereas warning alerts are reported but descendant nodes are not blocked. ◦ If you select Weak, error alerts are reported but descendant nodes are not blocked, whereas warning alerts are not reported and descendant nodes are not blocked.
Field	The fields to be monitored. You can select **All Fields in Table** or specify fields. If you specify fields, you can specify fields of a numeric type or non-numeric type.
Template	The template to apply to the rule. Currently, Data Quality supports 37 rule templates. **Note** You can set field-specific rules of the average value, accumulated value, minimum value, and maximum value only for numeric fields.
Comparison Method	The comparison method of the rule. Valid values: **Absolute Value**, **Raise**, and **Drop**.

Configuration item	Description
Thresholds	○ You can calculate the fluctuation by using the following formula: Fluctuation = (Sample - Baseline)/Baseline ○ You can calculate the fluctuation variance only for numeric fields such as Bigint and Double fields. The formula is as follows: Fluctuation variance = (Sample - Baseline)/Standard deviation **Note** The sample and baseline are defined as follows: ○ Sample: the sample value for the current N days. For example, if you want to check the fluctuation of table rows on an SQL node in a day, the sample is the number of table rows on that day. ○ Baseline: the comparison value from the previous N days. For example: ■ If you want to check the fluctuation of table rows on an SQL node in a day, the baseline is the number of table rows on the previous day. ■ If you want to check the fluctuation of the average number of table rows on an SQL node in seven days, the baseline is the average number of table rows in the previous seven days. You can set **Warning Threshold** and **Error Threshold** to monitor data at different severities: ○ If the fluctuation does not exceed the warning threshold, Data Quality determines that data is normal. ○ If the fluctuation exceeds the warning threshold but does not exceed the error threshold, Data Quality reports a warning alert. ○ If the fluctuation exceeds the error threshold, Data Quality reports an error alert. ○ If you do not specify the warning threshold, Data Quality reports error alerts or normal based on the check result. ○ If you do not specify the error threshold, Data Quality reports warning alerts or normal based on the check result. ○ If you specify neither the warning threshold nor the error threshold, Data Quality reports error alerts if it detects exceptions. However, you must specify at least one of the two thresholds. If you specify neither of them, Data Quality applies default values, that is, 10% for the warning threshold and 50% for the error threshold.
Description	The description of the new rule.

- In the **Template Rules** dialog box that appears, click **Quick Create** and perform related configurations.

Configuration item	Description
Rule Name	The name of the rule.

Configuration item	Description
Field	The fields to be monitored. You can select **All Fields in Table** or specify fields. If you specify fields, you can specify fields of a numeric type or non-numeric type.
Trigger	The trigger condition of the rule. If you select All Fields in Table for Field, you can select only **The number of rows is greater than 0**.

Custom rules

If template rules do not meet your requirements for monitoring the data quality, you can create custom rules.

Click **Custom Rules**. In the Custom Rules dialog box that appears, you can click **Create Monitoring Rule** or **Quick Create** to create a custom rule.

- In the **Custom Rules** dialog box that appears, click **Create Monitoring Rule** and perform related configurations.

Configuration item	Description
Rule Name	The name of the rule.
Field	The fields to be monitored. Valid values: **All Fields in Table**, **SQL Statement**, and specific fields. ○ If you select All Fields in Table or specify fields, you can specify the WHERE clause to customize filter conditions based on business requirements. ○ If you select SQL Statement, you can customize the SQL logic to set a rule. The return value is the value in a row of a column.
Rule Type	The type of the rule. Valid values: Strong or Weak. ○ If you select Strong, error alerts are reported and descendant nodes are blocked, whereas warning alerts are reported but descendant nodes are not blocked. ○ If you select Weak, error alerts are reported but descendant nodes are not blocked, whereas warning alerts are not reported and descendant nodes are not blocked.
Sampling Method	The sampling method of the rule. Valid values: **sum**, **max**, **min**, and **avg**.
Filter	The filter condition of the rule. For example, if you want to query partitions of the table based on a specific data timestamp, you can specify the WHERE clause as follows: `pt=$[yyyymmdd-1]`.
Threshold Type	The threshold type of the rule. Valid values: **Value** and **Fluctuation**.
Comparison Type	The comparison method of the rule. Valid values: **Greater Than**, **Greater Than or Equal To**, **Equal To**, **Unequal To**, **Less Than**, and **Less Than or Equal To**.

Configuration item	Description
Compare To	The comparison value of the rule. Currently, the comparison value must be a constant.
Expected Value	The expected value of the rule.
Description	The description of the rule.

- In the **Custom Rules** dialog box that appears, click **Quick Create** and perform related configurations.

Configuration item	Description
Rule Name	The name of the rule.
Rule Type	The type of the rule. You can select only **Values Duplicated in Multiple Fields**.
Field	The fields to be monitored.

2.9.2.4. Search by Node

The Search by Node page displays the monitoring results of MaxCompute partitions and DataHub topics. After monitoring rules are run, you can view monitoring results on this page.

Go to Search by Node

1. Log on to the DataWorks console.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > Data Quality**.
3. Click **Search by Node** in the left-side navigation pane. The **Search by Node** page appears.

View MaxCompute monitoring results

On the **Search by Node** page, you can search for MaxCompute monitoring results by metrics such as **Connection**, **Status**, **Table Name**, and **Node ID**. You can click an action in the Actions column to go to the corresponding page and perform operations as required.

- **Node ID**: the ID of the node that triggers rules.
- **Run At**: the runtime of rules.
- **Status**: the monitoring result of rules.
- **Actions**:
  - **Details**: Click **Details** of a rule. The **Instance Details** page appears.
    - **More**: Click it to view more information about the node instance, such as the connection, workspace name, node ID, and owner.
    - **View History Check Results**: Click it for a rule to view the check result history of the rule.
  - **Rules**: Click it for a rule to go to the **Rules** page. On this page, you can view and modify existing partition expressions and rules. For more information, see MaxCompute monitoring.
  - **Logs**: Click it for a rule to view the runtime logs of the rule.

- **Data Distribution**: Click it for a rule to view each runtime status of the rule since it was created.

View DataHub monitoring results

On the **Search by Node** page, you can search for DataHub monitoring results by metrics such as **Connection Type**, **Status**, **Connection**, and **Topic**. You can click an action in the Actions column to go to the corresponding page and perform operations as required.

Actions:

- **Logs**: Click it for a topic to view the runtime logs of the rules under the topic.
- **Alerts**: Click it for a topic to view alert details. You can cancel alerts for the topic on the Alerts page.

2.9.3. User guide

2.9.3.1. MaxCompute monitoring

The Rules page is the most important part of Data Quality, where you can configure monitoring rules. Currently, Data Quality allows you to monitor MaxCompute tables and DataHub topics. This topic describes how to configure rules for MaxCompute monitoring.

Add a connection

Before configuring monitoring rules, you need to go to the **Data Integration** page to add a connection. For more information, see Add MaxCompute data sources. After the connection is added, you can go to the **Data Quality** page to configure monitoring rules.

Select a connection

1. Log on to the DataWorks console. Click the DataWorks icon in the upper-left corner and choose **All Products > Data Quality**.
2. In the left-side navigation pane, click **Rule Configuration**.
3. On the Rules page, select **MaxCompute** from the drop-down list in the upper-left corner. All tables of the MaxCompute connection are listed on the right.

   On the Tables page, you can search for a table by table name. Fuzzy search based on the initial letter is supported.
4. Find the target table and click **View Monitoring Rules** in the Actions column.

Configure partition expressions

In Data Quality, you need to configure rules based on a partition expression.

> **Note**
> - To configure rules for a non-partitioned table, you can specify NOTAPARTITIONTABLE as the partition expression.
> - To configure rules for a partitioned table, you can specify a data timestamp expression, such as $[yyyymmdd], or a regular expression as the partition expression.

On the Rules page of the target table, click **+** in the upper-left corner to add a partition expression.

- Add partition expressions: Click **+** in the upper-left corner. In the Add Partition dialog box that

appears, specify a partition expression as needed. For a non-partitioned table, select **NOTAPARTITIONTABLE** from the recommended partition expressions.

- For a table with only one partition, follow the format: Partition key=Partition value. The partition value can be either a constant or a system parameter. You must configure partition expressions through the last partition.
- For a table with multiple partitions, follow the format: Partition key 1=Partition value/Partition key 2=Partition value/Partition key N=Partition value. Each partition value can be either a constant or a system parameter. You must use brackets ([ ]) to indicate a parameter, such as $[yyyymmdd-N].

The data timestamp configured in a partition expression also determines the recurrence of the partition expression. For example, if the data timestamp is the date of five days ago, the partition expression is triggered every five days. The following table lists supported partition expressions.

Partition expression	Description
dt=$[yyyymmdd-N]	Indicates N days before the date specified by the data timestamp.
dt=$[yyyymm01-1]	Indicates the first day of each month.
dt=$[yyyymm01-Nm]	Indicates the first day of the month that is N months before the month specified by the data timestamp.
dt=$[yyyymmld-1]	Indicates the last day of each month.
dt=$[yyyymmld-1m]	Indicates the last day of the month that is N months before the month specified by the data timestamp.
dt=$[hh24miss-1/24]	Indicates one hour before the hour specified by the data timestamp.
dt=$[hh24miss-30/24/60]	Indicates half an hour before the hour specified by the data timestamp.
$[yyyymmdd]	Indicates the data timestamp of recurrence.
$[yyyymmdd-1]	Indicates one day before the data timestamp of the current instance.
$[yyyymmddhh24miss]	Indicates the data timestamp of the current instance. The format `yyyymmddhh24miss` is described as follows: ◦ yyyy indicates a four-digit year. ◦ mm indicates a two-digit month. ◦ dd indicates a two-digit day. ◦ hh24 indicates a two-digit hour (24-hour clock). ◦ mi indicates two-digit minutes. ◦ ss indicates two-digit seconds.
NOTAPARTITIONTABLE	Indicates the partition expression of a non-partitioned table.

- Select recommended partition expressions: For example, the following procedure describes how to

select a recommended partition expression for the partition key dt. We recommend that you do not specify a regular expression as the partition expression for a dynamic partitioned table.

i. In the **Add Partition** dialog box, click the **Partition Expression** field. A drop-down list appears to show you the partition expressions recommended by Data Quality.
   - Select a recommended partition expression if it meets your expectation.
   - Customize a partition expression if no recommended partition expressions meet your expectation.

ii. After you enter a partition expression, click **Verify**. Data Quality uses the current time, that is, the data timestamp, to calculate data and verify the partition expression.

iii. Click **OK**.

- Delete partition expressions: You can delete a partition expression as required. When you delete a partition expression, all rules configured based on the partition expression are also deleted.

  Move the point over the partition expression that you want to delete, and click **Delete**. In the dialog box that appears, click **Delete**.

Manage linked nodes

To monitor the quality of offline data involved in a node, you need to link a partition expression to the node by clicking **Manage Linked Nodes**.

> **Note**
> - The Manage Linked Nodes dialog box lists all committed nodes. Data Quality allows you to link a partition expression to a node in another workspace.
> - Before linking a partition expression to a node in another workspace, make sure that you are an administrator, a developer, or an administration expert in two workspaces.

You can link a partition expression to one or more nodes. After nodes are linked, Data Quality can automatically monitor linked nodes.

> **Note** Data Quality allows you to flexibly link a partition expression to a node. You can select a node that is not related to your table.

Create rules

The Rules page is the most important part of Data Quality, where you can create rules for your tables.

Currently, Data Quality allows you to create template rules and custom rules as needed. To create a template rule or a custom rule, you can click **Create Monitoring Rule** or **Quick Create**. For more information about how to create a rule, see Rules.

After rules are configured, you can click **Save** to save all the configured rules for the current partition expression.

Test rules

After the rules are configured, you can click **Test** on the **Rules** page to test all the rules under a partition expression and view the test results.

> **Note** By testing monitoring rules, you can manually run these rules to test their configuration and notification methods. We recommend that you test rules as required.

1. In the left-side navigation pane, click **Rules**. The **Rules** page appears.
2. On the Rules page, click **Test** in the upper-right corner.
3. In the **Test** dialog box that appears, specify the time to test rules, and click **Test**.

Configuration item	Description
Partition	The partition expression for which rules are run. The actual partition key varies with the data timestamp. For a non-partitioned table, use NOPARTITIONTABLE as the partition expression.
Data Timestamp	The time to test rules. The default value is the current time.

4. Click **The test run is complete. Click to view the result.** to view the test results on the Search by Node page.

Manage subscriptions

After the rules are configured, you can click **Manage Subscriptions** on the **Rules** page. In the **Manage Subscriptions** dialog box that appears, specify **Notification Method** and **Recipient**, and then click **Save**.

By default, Data Quality sends notifications to the user who created a partition expression. You can add other users so that Data Quality sends notifications to them. Currently, Data Quality supports four notification methods: Email, Email and SMS, DingTalk Chatbot, and DingTalk Chatbot @ALL.

Change the owner

As the owner of a partition expression, you can change the owner to another member in the same workspace before you resign or are transferred. The default owner is the user who created the partition expression.

Move the pointer over the owner of a partition expression, and wait until a button appears. Click the button, enter the name of the new owner, and then click **OK**.

More actions

Action	Description
View Operation Log	Click it to view the records of all rules configured for the current partition expression.
View Check Results	Click it to view the last check result and the check result history of rules for the current partition expression on the Search by Node page.
Clone Rules	Click it to duplicate configured rules and subscribers to another partition expression.

2.9.3.2. DataHub monitoring

The Rules page is the most important part of Data Quality, where you can configure monitoring rules. Currently, Data Quality allows you to monitor MaxCompute tables and DataHub topics. This topic describes how to configure rules for DataHub monitoring.

DataHub monitoring supports the following features:

- Templates for monitoring stream discontinuity and data latency
- Stream processing features, such as custom Flink SQL, dimension table join, multi-stream join, and analytic functions

Add a connection

Before configuring monitoring rules, you need to go to the Data Integration page to add a connection. For more information, see Add a DataHub connection. After the connection is added, you can go to the Data Quality page to configure monitoring rules.

Select a connection

1. Log on to the DataWorks console.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > Data Quality**.
3. In the left-side navigation pane, click **Rules**.
4. On the Rules page, select **DataHub** from the drop-down list in the upper-left corner. All topics of the DataHub connection are listed on the right.

   You can also search for topics in the search box.

Configuration item	Description
Configure Flink Resources	After you add a connection, click Configure Flink Resources to configure Flink and Log Service resources related to the connection.
Topics	The Topics tab lists all topics of the DataHub connection. You can click the following actions in the Actions column for a topic: ○ **View Monitoring Rules**: Click it to create rules for the topic. You can create template rules and custom rules as needed. ○ **Manage Subscriptions**: Click it to view and modify subscribers to the current topic, and change the notification method. You can configure DingTalk Chatbot notification methods. The changed notification method takes effect for all subscribers to the topic.

Configuration item	Description
Dimension Tables	When you create custom rules for a topic, you can create dimension tables and use the JOIN clause to join dimension tables. If the collected data streams lack some fields for a dimension table, you need to supplement fields to data streams before data analysis and declare the dimension table in Data Quality. DataHub supports the dimension tables of ApsaraDB for HBase, Lindorm, ApsaraDB for RDS, Table Store, Taobao Distributed Data Layer (TDDL), and MaxCompute. Flink SQL does not design the data definition language (DDL) syntax for dimension tables. You can use the standard CREATE TABLE statement. However, you need to add `period for system_time` to specify the period of a dimension table and declare that the dimension table stores time-varying data. **Note** When you declare a dimension table, you must specify the unique key. When you use the JOIN clause to join dimension tables, the ON clause must contain the equivalent conditions of all unique keys.

5. On the Topics tab, click **View Monitoring Rules** in the Actions column for a topic.

Configure monitoring rules

1. On the Monitoring Rules page, click **Create Rule** in the upper-right corner. Data Quality allows you to create template rules and custom rules.
   - Click **Create Template Rule**. Two templates are available: **Data Delay** and **Stream Discontinuity**.

     For example, you can select **Data Delay** for Template Type.

Configuration item	Description
Rule Name	The name of the rule. The name can be up to 255 characters in length.
Field Type	The fields to be monitored. By default, the field type is All Fields in Table.

Configuration item	Description
Template Type	■ The template to apply to the rule. Valid values: Data Delay and Stream Discontinuity. **Data Delay**: monitors the interval between the time when data is generated and the time when data is written to DataHub based on the data timestamp field. If the interval exceeds a specified threshold, an alert is generated. **Note** The data timestamp field supports two data types: Timestamp and String (YYYY-MM-DD hh:mm:ss). ■ **Stream Discontinuity**: monitors the period during which no data is written to DataHub. If the period exceeds a specified threshold, an alert is generated. **Note** Before configuring a stream discontinuity rule, you need to activate Alibaba Cloud Realtime Compute in Flink and create a project.
Alerts Threshold	The maximum number of alerts generated for data latency. Data Quality reports an alert when the number of alerts generated for data latency exceeds this threshold. This parameter takes effect only when you select Data Delay for Template Type.
Data Timestamp Field	The data timestamp field of the topic for which the rule is created. This field supports two data types: Timestamp and String (YYYY-MM-DD hh:mm:ss). This parameter takes effect only when you select Data Delay for Template Type.
Alert Frequency	The interval for reporting an alert. You can set the alert interval to 10 minutes, 30 minutes, 1 hour, or 2 hours.
Warning Threshold	The warning threshold, in seconds. The value must be an integer and less than the error threshold.
Error Threshold	The error threshold, in seconds. The value must be an integer and greater than the warning threshold.

- If template rules do not meet your requirements for monitoring the data quality of DataHub topics, you can click **Create Custom Rule** to create a rule as required.

  Note
  - The field in the SELECT clause must be a column. Ensure that you can compare the field values with the warning and error thresholds.
  - The FROM clause must include the current topic and all its columns.

Configuration item	Description

Configuration item	Description
Rule Name	The name of the rule. The name must be unique in the topic and can be up to 20 characters in length.
Script	The custom SQL script, which is used to set a rule. The return value of the SELECT clause must be unique. ■ Example 1: Use a simple SQL statement `select id as a from zmr_tst02;` ■ Example 2: Join the topic and a dimension table named test_dim `select e.id as eid` `from zmr_test02 as e` `join test_dim for system_time as of proctime() as w` `on e.id=w.id` ■ Example 3: Join the topic and another topic named dp1test_zmr01 `select count(newtab.biz_date) as aa` `from (select o.*` `from zmr_test02 as o` `join dp1test_zmr01 as p` `on o.id=p.id)newtab` `group by id.biz_date,biz_date_str,total_price,'timestamp'`
Warning Threshold	The warning threshold, in minutes. The value must be an integer and less than the error threshold.
Error Threshold	The error threshold, in minutes. The value must be an integer and greater than the warning threshold.
Minimum Alert Interval	The minimum interval for reporting an alert, in minutes.
Description	The description of the rule.

2. After the configuration is completed, click **Save** to apply the rule to the topic.

More actions

- **View Log**: Click it to view the runtime logs of rules.
- **Enable Monitoring**: Click it to enable monitoring rules.
- **Manage Subscriptions**: Click it to view and modify subscribers to the current rule, and change the notification method. The changed notification method takes effect for all subscribers to the rule.

You can configure DingTalk Chatbot and DingTalk Chatbot @ALL notification methods to send notifications to DingTalk groups.

If you select **DingTalk Chatbot**, you need to add a DingTalk Chatbot to a DingTalk group, and then copy the webhook URL of the DingTalk Chatbot to the Manage Subscriptions dialog box. In this way, you can use the DingTalk Chatbot to send notifications for the rule.

2.10. Data Map

2.10.1. Overview

Data Map allows you to search for data globally, use a personal account to manage data, or manage configurations as an administrator.

Log on to the DataWorks console. On the DataStudio page that appears, click the DataWorks icon in the upper-left corner and choose **All Products > Data Map**. The **Data Map** page appears.

- If you prefer a powerful search engine, go to the homepage to search for data. The homepage appears by default when you access **Data Map**. To return to the homepage from other pages, click **Data Map** in the upper-left corner.

  Currently, if you enter keywords to search for data, the search results are more accurate. Data Map also supports other search approaches. For example, if you use Data Map frequently, you can directly select tables in the **Recently Viewed Tables** and **Recently Read Tables** sections. You can also select tables in the **Most Read Tables** and **Most Viewed Tables** sections. These tables are recommended based on your access records.
- If you would like to search for tables by category, click **All Categories**. Tables are displayed by category. The number of tables in each category is also displayed.
- If you want to handle personal data, such as modifying your tables or using tools, click **My Tables**.
- If you are a category administrator or workspace administrator and want to modify the workspace configuration or global categories, click **Settings**.

2.10.2. View the overall information

This topic describes how to view the overall information about a workspace on the Overview page.

Log on to the DataWorks console. On the DataStudio page, click the DataWorks icon in the upper-left corner and choose **All Products > Data Map (Data Management)**. The **Data Map** page appears.

In the top navigation bar, click **Overview** to go to the **Overview** page. Data Map collects data of the previous day for the entire organization and generates data on the Overview page offline.

Item	Description
Projects	The total number of projects in the organization.
Tables	The total number of tables in the organization.
Table Storage	The total storage occupied by all tables in the organization.
CPU Usage	The number of compute units (CUs) consumed in one day in the organization. One CU is equivalent to the computing resources consumed by one fully loaded CPU core in one day.

Item	Description
Project Lineage	The chart that shows the relationships between projects in the organization. An arc in the chart represents a project. Two projects are connected if they have the lineage relationship.
Details	The lineage relationship between projects in the organization. The first column indicates a project in which the ancestor table is located, the second column indicates a project in which the descendant table is located, and the third column indicates the number of lineage relationships between the two projects.
Top Projects by Table Storage	The top 10 projects that occupy the most storage space in the organization.
Top Tables by Occupied Storage	The top 10 data tables that occupy the most storage space in the organization. You can click a table name to go to the details page of the table. **Note** The logical storage space occupied by projects and tables is collected in a T+1 manner. The numbers next to the project and table names indicate the sizes of the occupied logical storage space. Besides the table storage volume, the project storage volume includes the storage volumes of resources, data in the recycle bin, and other system files. Therefore, the project storage volume is larger than the table storage volume. The table storage volume is charged based on the logical storage rather than the physical storage.
Most Frequently Used Tables	The top 10 most frequently referenced tables in the organization. You can click a table name to go to the details page of the table.

2.10.3. Manage data

This topic describes how to manage data on the My Tables page of Data Map.

Log on to the DataWorks console. On the DataStudio page, click the DataWorks icon in the upper-left corner and choose **All Products > Data Map (Data Management)**. The **Data Map** page appears.

In the top navigation bar, click **My Tables**. Then, you can view data on the **Owned by Me**, **Managed by Me as Workspace Administrator**, **Managed by Tenant Account**, and **My Favorites** pages. You can also manage the permissions on the relevant data.

Owned by Me

In the left-side navigation pane, click **Owned by Me**. On the page that appears, you can search for data based on the **table name**, **environment**, **project or data store**, and **visibility**. You can also view the details about the desired table or perform relevant operations on the table.

Parameter	Description

Parameter	Description
Table Name	The name of the table. You can click a table name to go to the table details page.
Display Name	The display name of the table. You can click the icon next to a display name to change it.
Project/Data Store	The project or data store of the table. Tables have different suffixes when they are deployed in different environments. For example, **_dev** indicates the development environment. You can click the project or data store of a table to view the details.
Environment	The environment type. Two environment types are available: **development environment** and **production environment**.
Storage	The amount of data that is stored.
TTL (Days)	The time to live (TTL) of the table. It is the same as that you set when creating the table. You can click the **Edit** icon to change the value.
Actions	The operations that you can perform. In the Actions column for a table, click the buttons to perform the corresponding operations, such as **deleting the table**, **changing the category**, and **hiding the table**. **Note** If you hide a table, the **Request Permission** button does not appear on the details page of the table.
Edit	Select the tables to be edited and click **Edit** in the lower part of the page. In the **Edit** dialog box that appears, enter the display name, select the TTL in days, specify whether to hide or show the tables, and click **OK**.
Change Owner	Select the tables whose owners are to be changed and click **Change Owner** in the lower part of the page. In the **Change Owner** dialog box that appears, select a new owner from the drop-down list and click **OK**.
Delete	Select the tables to be deleted and click **Delete** in the lower part of the page. In the **Delete** dialog box that appears, click **OK**.
Change Category	Select the tables whose categories are to be changed and click **Change Category** in the lower part of the page. In the **Change Category** dialog box that appears, select a new category from the drop-down list and click **OK**.

Managed by Me as Workspace Administrator

In the left-side navigation pane, click **Managed by Me as Workspace Administrator**. On the page that appears, you can search for data based on the **table name**, **environment**, and **project or data store**. You can also view the details about the desired table or perform relevant operations on the table.

Parameter	Description
Table Name	The name of the table. You can click a table name to go to the table details page.
Display Name	The display name of the table. You can click the icon next to a display name to change it.
Project/Data Store	The project or data store of the table. Tables have different suffixes when they are deployed in different environments. For example, **_dev** indicates the development environment. You can click the project or data store of a table to view the details.
Environment	The environment type. Two environment types are available: **development environment** and **production environment**.
Storage	The amount of data that is stored.
TTL (Days)	The TTL of the table. It is the same as that you set when creating the table.
Actions	The operations that you can perform. In the Actions column for a table, click the buttons to perform the corresponding operations, such as **deleting the table** and **changing the category**.
Edit	Select the tables to be edited and click **Edit** in the lower part of the page. In the **Edit** dialog box that appears, enter the display name, select the TTL in days, and click **OK**.
Change Owner	Select the tables whose owners are to be changed and click **Change Owner** in the lower part of the page. In the **Change Owner** dialog box that appears, select a new owner from the drop-down list and click **OK**.
Change Category	Select the tables whose categories are to be changed and click **Change Category** in the lower part of the page. In the **Change Category** dialog box that appears, select a new category from the drop-down list and click **OK**.

Managed by Tenant Account

In the left-side navigation pane, click **Managed by Tenant Account**. On the page that appears, you can search for data based on the **table name**, **environment**, and **project or data store**. You can also view the details about the desired table.

Parameter	Description

Parameter	Description
Table Name	The name of the table. You can click a table name to go to the table details page.
Display Name	The display name of the table. You can click the icon next to a display name to change it.
Project/Data Store	The project or data store of the table. Tables have different suffixes when they are deployed in different environments. For example, **_dev** indicates the development environment. You can click the project or data store of a table to view the details.
Environment	The environment type. Two environment types are available: **development environment** and **production environment**.
Storage	The amount of data that is stored.
TTL (Days)	The TTL of the table. It is the same as that you set when creating the table.
Favorites	The number of times that users add the table to favorites.
Views in Last 30 Days	The number of times that users browse the table in the last 30 days.
Created At	The time when the table was created.

My Favorites

After adding a table to favorites, you can view the table information on the **My Favorites** page.

You can click **Remove from Favorites** to remove a table from your favorites.

Permissions

In the left-side navigation pane, click **Permissions**. The Permissions page appears.

- For more information about permission management, see Manage permissions.
- You can click **Apply function and resource permissions** in the upper-right corner to apply for permissions on functions or resources. For more information, see Apply for data permissions.

2.10.4. View table details

This topic describes how to view the details about a table.

You can click the name of a data table in any list on the homepage to go to the details page of the table.

On the details page, you can view the **basic information**, **business information**, **permission information**, **technical information**, **detailed information** (including the **fields**, **partitions**, and **change history**), **output information**, **lineage information**, **reference record**, and **usage notes** of the table. You can also **preview** the table.

Apply for table permissions

For more information, see Apply for table permissions.

Add a table to favorites

To add a table to favorites, click **Add to Favorites** under the table name. To view a table after it is added to favorites, follow these steps: On the **Data Map** page, click **My Tables** in the top navigation bar. On the page that appears, click **My Favorites** in the left-side navigation pane.

View basic information

In the Basic Information section, you can view the number of **reads**, **favorites**, and **views**. You can also check the **output nodeA**, **MaxCompute project name**, **owner name**, **creation time**, **time to live (TTL)**, **storage capacity**, **description**, and **tags** of the table.

- You can click the name of the MaxCompute project to go to the project details page.
- You can click + next to **Tags** to add tags for the table.

View business information

In the Business Information section, you can view the **DataWorks workspace name**, **environment type**, and **category**.

View permission information

In the Permission Information section, you can view your permissions on tables. To apply for more permissions, click **More** on the right side. The **Table Permission Request** page appears.

View technical information

In the Technical Information section, you can view the **technical type**, **last time when the DDL was changed**, **last time when the data was changed**, **last time when the data was viewed**, and **compute engine information**.

- The default time format is yyyy-mm-dd hh:mm:ss.
- Click **Click to View** next to **Compute Engine Information**. In the dialog box that appears, you can view the information about the compute engine.

View detailed information

On the Details tab, you can view the metadata of the table, including the definition, popularity, and security level. You can also check the schema changes and whether a field is a primary key or foreign key.

- **View field information**

  On the Field Information tab, you can view the **name**, **type**, **description**, and **popularity** of fields. You can also check whether a field is a **primary key or foreign key**. In addition, you can edit field information, such as the **display name** and **description**, and determine whether to set a field as the **primary key**.

Action	Description
Download Fields	Click this button to download the corresponding field information.

Action	Description
Generate DDL Statement	Click this button to view the corresponding table creation statements in the dialog box that appears.
Generate SELECT Statement	Click this button to view the corresponding SELECT statements in the dialog box that appears.

- **View partition information**

  On the Partitions tab, you can view the **name**, **number of records**, **storage volume**, **creation time**, and **last update time** of each partition of the table.

- **View the change history**

  On the Change Records tab, you can view the **partition name**, **change type**, **granularity**, **time**, and **operator** involved in each change.

  You can also select a change type from the drop-down list to filter change records.

View output information

If the table data changes periodically with the corresponding node, you can view the change status and data that is continuously updated.

View lineage information

On the Lineage Information tab, you can view the source and destination of data and manage the lineage information with ease.

> **Note** Only the users who have purchased the DataWorks standard edition or a more advanced edition can view the table lineage information.

- **Table Lineage**: You can search for the ancestor and descendant tables of a table based on the GUID.
- **Field Lineage**: You can filter data by field.

View reference records

- **Foreign Key References**: On this tab, you can check the number of users who reference the data.
- **Access Statistics**: On this tab, you can view the reference records in a line chart.

Preview data

On the **Data Preview** tab, you can preview the data information of the current table.

> **Note** Only authorized users can preview tables in the production environment. If you do not have the corresponding permissions, click **Apply** to apply for the permissions.

View instructions

On the Instructions tab, you can edit the usage notes and view historical versions. You can also learn the relevant information based on the description of the data.

2.10.5. Manage permissions

On the Permissions page, you can manage the applications for permissions on tables, resources, and functions. The page consists of the following tabs: To Be Approved, Submitted by Me, and Handled by Me.

Log on to the DataWorks console. On the DataStudio page, click the DataWorks icon in the upper-left corner and choose **All Products > Data Map (Data Management)**. The **Data Map** page appears.

In the top navigation bar, click **My Tables**. On the page that appear, click **Permissions** in the left-side navigation pane. Then, you can view the **To Be Approved**, **Submitted by Me**, and **Handled by Me** tabs.

To Be Approved

Only administrators can access the **To Be Approved** tab to view and approve the applications for permissions on tables, resources, and functions in all workspaces.

You can click the name of a resource or project to view its details.

Submitted by Me

On the **Submitted by Me** tab, you can view historical permission applications that you submitted.

Handled by Me

If you log on to the system as an administrator, you can click the **Handled by Me** tab to view the processed applications for permissions on tables, resources, and functions in all workspaces.

2.10.6. Apply for data permissions

This topic describes how to apply for data permissions.

DataWorks supports the following three data types:

- Table: data tables.
- Function: user-defined functions (UDFs) that can be used in SQL statements.
- Resource: resources such as text files or MapReduce JAR files.

DataWorks strictly controls permissions on these three types of data. You must apply for the required permissions before using the data.

Apply for the permission to preview table data

1. Log on to the DataWorks console.
2. On the DataStudio page that appears, click the DataWorks icon in the upper-left corner and choose **All Products > Data Map**. The **Data Map** page appears.
3. On the homepage, search for the target data table and click its name to go to the details page of the table.
4. On the table details page, click **Apply for Permission**.
5. Set all parameters in the **Request Permission** dialog box that appears.

Parameter	Description
Table	The table on which you want to apply for permissions. Use the default value.
Object Type	The type of object on which you want to apply for permissions. Valid values: **Table** and **Field**.
Grant To	The user to which the permission is granted. Valid values: **Current Account** and **Specified Account**.
Validity Period	The validity period of the requested data permission. If this parameter is not specified, the permission is permanently valid.
Reason	The reason for applying for the permission. Enter a brief reason for faster approval.

6. After the configuration is completed, click **Submit**. After the application is approved, you can preview the table data.

> **Note** To view the application status, follow these steps: On the **Data Map** page, click **My Tables** in the top navigation bar. On the page that appears, click **Permissions** in the left-side navigation pane. Then, click the **Submitted by Me** tab.

Apply for function and resource permissions

1. On the **Data Map** page, click **My Tables** in the top navigation bar. On the page that appears, click **Permissions** in the left-side navigation pane.
2. Click **Apply function and resource permissions** in the upper-right corner.
3. Set all parameters in the **Request Permission** dialog box that appears.

Parameter	Description
Object Type	The type of object on which you want to apply for permissions. Valid values: **Functions** and **Resources**.
Grant To	The user to which the permission is granted. Valid values: **Current Account** and **Specified Account**. ◦ If you select **Current Account**, the permission will be granted to you after the application is approved. ◦ If you select **Specified Account**, you must set the **Account** parameter. After the application is approved, the permission is granted to the specified user.
Project Name	The name of the MaxCompute project that contains the requested function or resource. The project must belong to the current organization. Fuzzy match is supported.
Function Name or **Resource Name**	The name of the function or resource in the project. Enter the full name of the resource, including the file suffix, such as my_mr.jar.

Parameter	Description
Validity Period	The validity period of the applied permission, in days. If this parameter is not specified, the permission is permanently valid. When the validity period expires, the system automatically revokes the permission.
Reason	The reason for applying for the permission. Enter a brief reason for faster approval.

4. After the configuration is completed, click **Submit** and wait for approval. To view the application status, follow these steps: On the **Data Map** page, click **My Tables** in the top navigation bar. On the page that appears, click **Permissions** in the left-side navigation pane. Then, click the **Submitted by Me** tab.

2.10.7. Manage configurations

This topic describes how to manage configurations on the Settings page of Data Map.

1. Log on to the DataWorks console.
2. On the DataStudio page that appears, click the DataWorks icon in the upper-left corner and choose **All Products > Data Map**. The **Data Map** page appears.
3. On the **Data Map** page, click **Settings** in the top navigation bar.

   The Settings page consists of the **Manage Categories** and **Manage Workspaces** tabs.

Manage categories

On the Manage Categories page, you can create a category and add tables to the category. With categories created, you can better manage tables.

1. Move the pointer over **Categories** and click **+** next to **Categories** to add a level-1 category.
2. Click **+** next to a level-1 category to add a level-2 category.

   A maximum of four category levels are supported. You can click to rename a category or click to delete a category.
3. After a category is configured, you can perform the following operations:
   - **Add Tables**: You can only add tables that are not in the category. If a table has been removed from a category, you can add it to the category again.
   - **Search**: You can search for tables by table name or by project or data store.
   - **Remove from Category**: You can remove one or more tables from a category.

Manage workspaces

On the Manage Workspaces page, you can view the workspaces for which you serve as the owner or administrator. In addition, you can turn on or off the **Preview Table Data in Development Environment** or **Preview Table Data in Production Environment** switch in the **Manage MaxCompute Tables** section.

> **Note** For a workspace in basic mode, only **Preview Table Data in Production Environment** is available.

2.11. Data Asset Management

2.11.1. Overview

Data Asset Management provides you with an overview of your data assets. Data Asset Management requires that data be synchronized by using Data Integration and processed by using DataStudio before you manage your tables and APIs stored in your business system and DataWorks.

Data Asset Management controls the permissions of users independently. You must grant the permissions on the Project Management page because Data Asset Management is a tenant-level feature.

Log on to the DataWorks console. On the DataStudio page that appears, click the DataWorks icon in the upper-left corner and choose **All Products > Project Management**. On the **Project Management** page, click **Member Management** in the left-side navigation pane. On the Member Management page, you can assign the following roles to members: **Data Asset Management-Asset Manager**, **Data Asset Management-Class Manager**, and **Data Asset Management-Home Visitor**.

Click the DataWorks icon in the upper-left corner and choose **All Products > Data Asset Management** to manage data assets in Data Asset Management. The following table lists the permissions of each role.

Role	Description
Data Asset Management-Asset Manager	In the top navigation bar of the **Data Asset Management** page, click the **Assets** tab. On the Assets tab, you can manage data assets, such as adding business units and classes. You can also add data assets to a class.
Data Asset Management-Class Manager	In the top navigation bar of the **Data Asset Management** page, click the **Classes** tab. On the Classes tab, you can view the data assets of each class.
Data Asset Management-Home Visitor	In the top navigation bar of the **Data Asset Management** page, click the **Home** tab. On the Home tab, you can view the statistics of data assets of different classes and business units.

2.11.2. Asset manager

Asset managers can view the information about data assets.

Procedure

1. Log on to the DataWorks console.
2. On the DataStudio page that appears, click the DataWorks icon in the upper-left corner and choose **All Products > Data Asset Management**.
3. On the **Home** page that appears, enter keywords in the search box and click **Search**.
4. On the search results page that appears, click the **Tables**, **File**, or **API** tab to view details and apply for permissions.

   You can click the **Classes** tab in the top navigation bar to filter data assets by class.

2.11.3. Asset user

Asset users can access Data Asset Management to perform operations such as searching for assets, applying for permissions, and using assets.

1. Log on to the DataWorks console.
2. On the DataStudio page that appears, click the DataWorks icon in the upper-left corner and choose **All Products > Data Asset Management**.
3. On the **Home** page that appears, enter keywords in the search box and click **Search**.
4. On the search results page that appears, click the **Tables**, **File**, or **API** tab to view details and apply for permissions.

   You can click the **Classes** tab in the top navigation bar to filter data assets by class.

2.11.4. Asset administrator

Asset administrators can manage assets and authorizations in Data Asset Management.

> **Note** You can submit a ticket to apply for the asset administrator role.
>
> An administrator can grant the administrator role to common users. An administrator can perform any operations in Data Asset Management, and no approval is required.

Go to the Assets tab

1. Log on to the DataWorks console.
2. On the DataStudio page that appears, click the DataWorks icon in the upper-left corner and choose **All Products > Data Asset Management**.
3. In the top navigation bar, click the **Assets** tab.

   Under the **Assets** tab, you can click **Data Management**, **Classes**, or **Business Management** in the left-side navigation pane to manage your data assets accordingly.

Manage data

In the left-side navigation pane, you can click **Data Management** and then **Tables**, **Files**, or **APIs** to manage tables, files, or APIs.

- **Manage tables**

  In the left-side navigation pane, choose **Data Management > Tables** to go to the **Tables** page.

  On the Tables page, you can view, edit, publish, or delete a table.

  - Click the name of a table to view table details.
  - Click **Edit** in the Actions column of a table. In the Edit dialog box that appears, you can edit the configuration of the table.

- Move the pointer over **Publish** in the Actions column of a table. In the dialog box that appears, click **Publish**. After the request is submitted, click the **Permissions** tab in the top-navigation bar. In the left-side navigation pane, click **Submitted by Me** to view the request you submitted.

  > **Note** You can search for a published table in Data Asset Management.

- Move the pointer over **Delete** in the Actions column of a table. In the dialog box that appears, click **Delete**. After the request is submitted, click the **Permissions** tab in the top-navigation bar. In the left-side navigation pane, click **Submitted by Me** to view the request you submitted.

  > **Note** You cannot search for a deleted table in Data Asset Management.

- **Manage files**

  In the left-side navigation pane, choose **Data Management > Files** to go to the **Files** page.

  On the **File Management** page that appears, you can upload a file. Then, you can view, edit, download, or delete the file.

  - In the upper-right corner, click **Upload File**. In the **Upload File** dialog box that appears, click **Add File**. In the Add dialog box that appears, select the file to be uploaded and click **Open**. Alternatively, you can drag and drop a file to the **Upload File** dialog box. Then, click **Next**.

    > **Note**
    > - To upload a file, make sure that the size of the file does not exceed 50 MB.
    > - You can only upload a file with one of the following file name extensions:
    >
    >   3DX, 7Z, A3D, ATX, AVI, BMP, SV, DBF, DOC, DOCX, DWG, EPS, ESP, FREELIST, GDB, GDBINDEXES, GDBTABLE, GDBTABLX, GIF, GZ, HTM, HTML, IVE, JPEG, JPG, LOCK, LSP, LST, MP3, MP4, MPJ, OSG, OSGB, PDF, PNG, PPT, PPTX, PRJ, PSD, RAR, S3C, SBN, SBX, SCP, SHP, SPX, TFW, TIF, TIFF, TTF, TXT, WAV, WL, WP, WT, XLS, XLSX, ZIP, XML, SHX, and SKP

  - Click the name of a file to view file details.
  - Click **Edit** in the Actions column of a file. In the Edit dialog box that appears, you can edit the configuration of the file.
  - Move the pointer over **Publish** in the Actions column of a file. In the dialog box that appears, click **Publish**. After the request is submitted, click the **Permissions** tab in the top-navigation bar. In the left-side navigation pane, click **Submitted by Me** to view the request you submitted.

    > **Note** You can search for a published file in Data Asset Management.

  - Move the pointer over **Delete** in the Actions column of a file. In the dialog box that appears, click **Delete**. After the request is submitted, click the **Permissions** tab in the top-navigation bar. In the left-side navigation pane, click **Submitted by Me** to view the request you submitted.

    > **Note** You cannot search for a deleted file in Data Asset Management.

- Click **Download** in the Actions column of a file to download the file.

  > **Note** Before downloading a file, apply for the download permission.

- **Manage APIs**

  In the left-side navigation pane, choose **Data Management** > **APIs** to go to the **APIs** page.

  On the **APIs** page, you can edit, publish, or delete an API.

  - Click **Edit** in the Actions column of an API. In the **Edit** dialog box that appears, you can edit the configuration of the API. Then, click **Submit**.
  - Move the pointer over **Publish** in the Actions column of an API. In the dialog box that appears, click **Publish**. After the request is submitted, click the **Permissions** tab in the top-navigation bar. In the left-side navigation pane, click **Submitted by Me** to view the request you submitted.

    > **Note** You can search for a published API in Data Asset Management.

  - Move the pointer over **Delete** in the Actions column of an API. In the dialog box that appears, click **Delete**. After the request is submitted, click the **Permissions** tab in the top-navigation bar. In the left-side navigation pane, click **Submitted by Me** to view the request you submitted.

    > **Note** You cannot search for a deleted API in Data Asset Management.

Manage classes

1. In the left-side navigation pane, click **Classes** to go to the **Classes** page.

   On the Classes page, you can import or export a class.

2. Click the icon. In the **Add Class** dialog box that appears, set relevant parameters and click **OK** to add a level-1 class

Parameter	Description
Name	The name of the class, which can be up to 128 characters in length.
Code	The code of the class. This parameter cannot be left empty.
Description	The description of the class.
Confidential	Specifies whether the class is confidential. Valid values: **Yes** and **No**.
Share	Specifies whether to share the class. Valid values: **Yes**, **Conditional**, and **No**.

   To create a subclass under a class, click the icon next to the class.

3. Click a class. On the page that appears, click the **Tables** tab.

4. Click **Add Table**. In the **Add Table** dialog box that appears, select the tables to be added to the class and click **OK**.

   You can add files and APIs to a class in the same way.

   To change the class of a table, click **Modify Class** in the Actions column. In the **Change Class** dialog box that appears, change the class as needed.

Manage business

In the left-side navigation pane, you can click **Business Management** and then **Business Units**, **Business Systems**, or **Connections** to manage business units, business systems, or connections.

> **Note** Connections belong to a business system, and business systems belong to a business unit.
>
> - A business system with connections cannot be deleted.
> - A business unit with business systems cannot be deleted.

- **Manage business units**

  In the left-side navigation pane, choose **Business Management > Business Units** to go to the **Business Units** page.

  Click the icon. In the **Add Business Unit** dialog box that appears, set relevant parameters and click **OK** to add a business unit.

Parameter	Description
Name	The name of the business unit. This parameter cannot be left empty.
Code	The code of the business unit. By default, the code cannot be modified.
Description	The description of the business unit.
Confidential	Specifies whether the business unit is confidential. Valid values: **Yes** and **No**.
Share	Specifies whether to share the business unit. Valid values: **Yes**, **Conditional**, and **No**.
Business system included	Select the business systems to be added to the business unit and click the **>** icon.

  To create a sub-business unit under a business unit, click the icon next to the business unit.

- **Manage business systems**

  In the left-side navigation pane, choose **Business Management > Business Systems** to go to the **Business Systems** page.

  On the Business Systems page, you can add a business system. Then, you can view, edit, or delete the business system.

- Click **Add Business System**. In the **Basic information** dialog box that appears, set relevant parameters and click **Submit**.
- Click **View** in the Actions column of a business system to view its details.
- Click **Edit** in the Actions column of a business system. In the **Business System Properties** dialog box that appears, you can edit the configuration of the business system.
- Click **Delete** in the Actions column of a business system. In the **Delete business system** dialog box that appears, click **OK** to delete the business system.

- **Manage connections**

  In the left-side navigation pane, choose **Business Management > Connections** to go to the **Connections** page.

  On the **Connections** page, you can view the information of connections. The connection information includes the connection name, the number of tables, the owner, the business system to which the connection belongs, the data type, and the update time. You can also edit the configuration of a connection.

2.11.5. Manage authorizations

Under the Permissions tab, you can view permissions in different states on the Submitted by Me, To Be Handled, Handled by Me, and My Permissions pages respectively.

Go to the Permissions tab

1. Log on to the DataWorks console.
2. On the DataStudio page that appears, click the DataWorks icon in the upper-left corner and choose **All Products > Data Asset Management**.
3. In the top navigation bar, click the **Permissions** tab.

   Under the **Permissions** tab, you can view permissions in different states on the **Submitted by Me**, **To Be Handled**, **Handled by Me**, and **My Permissions** pages respectively.

Submitted by Me

In the left-side navigation pane, click **Submitted by Me**.

On the **Submitted by Me** page, you can view request details or cancel requests submitted by you. To resubmit a request that was not approved, find the target request and click **Reapply**.

To Be Handled

In the left-side navigation pane, click **To Be Handled**. On the To Be Handled page, you can view request details and approve or reject requests.

Handled by Me

In the left-side navigation pane, click **Handled by Me** to view requests handled by you.

My Permissions

In the left-side navigation pane, click **My Permissions**. On the My Permissions page, you can view your permissions on tables, files, and APIs respectively.

2.12. Organization management

2.12.1. Project management

2.12.1.1. Description

On the Project Management page, you can create, change, enable, and disable workspaces.

2.12.1.2. Create a workspace

This topic describes how to create a workspace on the Project Management page.

Prerequisites

A compute engine is created to initialize MaxCompute projects.

Overview

DataWorks provides various preset templates for a workspace administrator to select when the administrator creates workspaces that contain one or more working environments, including development, testing, staging, and production. DataWorks can also automatically generate associations between workspaces. A one-to-many relationship exists between departments and workspaces. That is, multiple workspaces can be created under a department.

You can create a workspace in one of the following modes:

- **Standard Mode (Development and Production Environments)**: A DataWorks workspace corresponds to two MaxCompute projects. One MaxCompute project serves as the development environment and the other serves as the production environment.
- **Basic Mode (Production Environment Only)**: A DataWorks workspace corresponds to only one MaxCompute project.

> **Note** For more information about the two workspace modes, see Workspace modes.

Procedure

1. Log on to the DataWorks console as a workspace administrator.
2. On the DataStudio page that appears, click the DataWorks icon in the upper-left corner and choose **All Products > Project Management**. By default, the **Workspaces** page appears.
3. On the Workspaces page, click **Create Workspace** in the upper-right corner.
4. In the **Create Workspace** dialog box that appears, set the parameters in the Basic Information section.

   > **Note** If you select the standard mode, you must associate the workspace with two MaxCompute projects.

5. Set the parameters in the **Advanced Settings** section. You can select whether to enable the recurrence and whether to allow downloading the query results returned by SELECT statements. You must associate the workspace with MaxCompute projects.
6. Click **OK**.

2.12.2. Member management

1. Log on to the DataWorks console as a workspace administrator.
2. On the DataStudio page that appears, click the DataWorks icon in the upper-left corner and choose All Products > **Project Management**.
3. On the Project Management page, click **Member Management** in the left-side navigation pane. The **Members** page appears.
4. You can enter a member name or logon name in the search box to search for a member to which you want to assign a role or a member to be removed from the current organization.
   - Assign a role to a member

     To assign a role to a member, click the **Roles** drop-down list next to the member and select the role to be assigned.

     To delete a role from a member, click **x** next to the role in the Roles column.
   - Remove a member from the organization

     To remove a member from the current organization, find the member, click **Delete** in the Actions column, and then click **OK** in the **Remove from Tenant** dialog box that appears.

2.12.3. Resource groups

2.12.3.1. About scheduling resources

You can use the Scheduling Resource page to create, configure, and edit a scheduling resource.

A scheduling resource is an object within an organization. A dedicated scheduling resource may contain multiple physical machines or ECS instances that are used to implement a specific task.

1. Log on to the DataWorks console.
2. In the left-side navigation pane, choose **Organization Management > Scheduling Resources**.

> **Note** On the **Scheduling Resources** page, the tenant administrator can create a dedicated scheduling resource, and edit an existing scheduling resource.

2.12.3.2. Create a scheduling resource

A tenant administrator can create a dedicated scheduling resource and allocate the resource to a workspace to implement a specific task, which may be a data synchronization task, shell script, MaxCompute SQL script, MaxCompute MapReduce, or machine learning. When no dedicated scheduling resource is specified, all tasks within a workspace are implemented by using the resources of the cluster that hosts the system.

Example

A scheduling resource can be created to address the following issues:

- Many tasks of the current workspace are waiting for resources, and the number of tasks has reached a threshold. Existing gateways can no longer meet service requirements, and more gateways are required.

- Some special tasks, such as shell scripts of the workspace must be implemented on a specific server. You must apply for a separate gateway to implement this task.

To meet the requirements of data development, a tenant administrator needs to create a dedicated scheduling resource and allocate it to the workspace to implement a specific data synchronization task.

Procedure

Follow these steps to create a scheduling resource:

1. Log on to the DataWorks console as a tenant administrator.
2. In the left-side navigation pane, choose**Organization Management > > Scheduling Resources**.
3. Click **Add Scheduling Resource** in the upper right corner.
4. In the **Add Scheduling Resource** dialog box, specify the required fields.

Field	Description
Resource Name	The resource name. The specified name can contain Chinese characters, letters, underscores, and digits. It can be up to 60 characters in length.
Workspace	The workspace to which the resource group allocates.

5. Click **OK**.

2.12.3.3. Change the workspace of scheduling resources

You can change the workspace of dedicated scheduling resources that have been created and configured.

Procedure

To change the workspace of dedicated scheduling resources, the tenant administrator performs the following operations:

1. Log on to the DataWorks console as a tenant administrator.
2. Choose **Organization Management > Scheduling Resources**.
3. On the page that appears, enter a scheduling resource name for a fuzzy search to find the target scheduling resource.
4. Click **Change Workspace**.
5. Click **OK**.

2.12.3.4. Manage servers

After successfully creating a scheduling resource, the tenant administrator must bind the resource to servers to complete resource configuration. A dedicated scheduling resource can be bound to a maximum of 1,000 servers. The servers must be selected from the ECS instances of the tenant. One ECS instance can be bound to only one dedicated scheduling resource.

Example

Scenario: The tenant administrator has added a dedicated scheduling resource for the data synchronization task. However, the dedicated scheduling resource has not been bound to a server (Create a scheduling resource). Now the administrator needs to select and add a server from the ECS instances.

Existing scheduling resources cannot meet the production needs during the daily scheduling process. As a result, many data synchronization tasks are waiting for resources. Now the tenant administrator needs to add servers for the dedicated scheduling resource that is used for the data synchronization task.

Procedure

1. Click **Server Management**.

   > **Note** You can find name of the server from your instance.

2. Click **Add Server**, and specify the required fields in the dialog box that appears.

   > **Note** You can find name of the server from your instance.

3. Click **Initialization** and perform operations as prompted.

2.12.4. Compute engine

2.12.4.1. Configure the compute engine

Currently, DataWorks only supports MaxCompute as its compute engine. All business flows and nodes in a workspace are run on the MaxCompute project associated to the workspace.

Example

> **Note** Tenant administrators can modify the settings for MaxCompute projects. The following settings are changeable: the project description, whether to use the MaxCompute project owner account to run MaxCompute jobs, the account used for running MaxCompute jobs, and the AccessKey of the account.

Assume that the account used for running MaxCompute jobs is no longer available, for example, because the account owner has resigned. If Run MaxCompute Task Using MaxCompute Owner Account is not selected, the tenant administrator needs to immediately modify the account used for running MaxCompute jobs and its AccessKey so that tasks can properly run in the workspace that uses the corresponding MaxCompute project.

Procedure

You can modify the account used for running MaxCompute jobs and its AccessKey as follows:

1. Log on to the DataWorks console as a tenant administrator. For more information, see Log on to the DataWorks console.
2. Choose **Project Management > Compute Engine**.
3. In the search box on the **Project Management > Compute Engine** page, enter the compute engine name. Fuzzy search is supported.

4. Find the target compute engine, and click **Configure** in the Actions column.
5. In the **Configure Compute Engine** dialog box, specify the Alibaba Cloud Account and the AccessKey.

   > **Note** You can also select Run MaxCompute Task Using MaxCompute Owner Account or create a new Alibaba Cloud account.

6. Click **Submit**.

2.13. Data Service

2.13.1. Overview

With Data Service, you can manage all your table APIs after you create new APIs or register existing APIs. You can also easily publish your APIs to API Gateway. Together with API Gateway, Data Service provides a secure, stable, low-cost, and easy-to-use data sharing service.

Data Service adopts a serverless architecture and allows you to develop table APIs without thinking about infrastructure such as compute resources. Data Service supports automatic scaling for compute resources, which significantly reduces your OPEX.

Create an API

In Data Service, you can quickly create APIs based on tables in relational databases or NoSQL databases using a visual wizard. It takes only a few minutes to configure a data API, and coding is not required. You can also create APIs by specifying SQL scripts. The script mode supports advanced functions such as associative tables, complex criteria, and aggregate functions.

Register an API

You can register existing RESTful APIs to Data Service for unified API management. Four request methods and three data formats are supported. The four request methods are GET, POST, PUT, and DELETE. The three data formats are tables, JSON, and XML.

API Gateway

API Gateway provides API lifecycle management services, including API publishing, management, maintenance, and monetization. It enables low-risk, simple, cost-effective, and fast microservice integration, front and back end separation, and system integration. You can use API Gateway to share functions and data with your partners and third-party developers.

API Gateway supports authorization, authentication, flow control, and billing for Data Service.

2.13.2. Terms

This section introduces terms of Data Service.

Name	Description
Data source	Indicates database links. Data Service accesses data through data sources. Data sources are configured in Data Integration.
Create an API	Creates APIs based on data tables.

Name	Description
Register an API	Registers existing APIs to Data Service for unified management.
Wizard mode	Guides you through the procedure of API creation. This method is suitable for beginners who want to create simple APIs. You do not need to write any code.
Script mode	Allows you to create APIs by writing SQL scripts. This method supports associative tables, complex queries, and aggregate functions. This method is suitable for experienced developers who want to create complex APIs.
API group	Indicates a set of APIs for a specific scenario or for consuming a specific service. An API group is the smallest group unit in Data Service, and the smallest unit for API Gateway management. API groups are published in Alibaba Cloud API Marketplace as API products.
API Gateway	Indicates a hosted service provided by Alibaba Cloud to manage APIs. API Gateway supports API lifecycle management, permission management, access management, and traffic control.

2.13.3. Create an API

In Data Service, you can quickly create APIs based on tables in relational databases or NoSQL databases using a visual wizard. It takes only a few minutes to configure a data API, and coding is not required.

You can also create APIs by specifying SQL scripts. The script mode supports advanced functions such as associative tables, complex criteria, and aggregate functions.

The differences between the wizard mode and script mode are described as follows:

Differences between the wizard mode and script mode

Category	Description	Wizard mode	Script mode
Query object	Queries a single table from one data source	Supported	Supported
	Queries associative tables from one data source	Not supported	Supported
Search condition	Searches for an exact number	Supported	Supported
	Searches for a range of numbers	Not supported	Supported
	Matches an exact string	Supported	Supported
	Performs fuzzy search for strings	Supported	Supported
	Sets required and optional parameters	Supported	Supported

Category	Description	Wizard mode	Script mode
Query result	Returns the field value	Supported	Supported
	Performs a mathematical calculation for field values	Not supported	Supported
	Performs an aggregate operation on field values	Not supported	Supported
	Displays results with pagination	Supported	Supported

2.13.3.1. Configure connections

DataService Studio allows you to obtain table schemas and query data through APIs from connections.

> **Note** Before generating an API, make sure that you have configured the relevant connections.

You can click **Connections** on the **Data Integration** page to configure connections. The following table lists the available connection types and supported configuration modes.

Connection name	Create an API in the codeless UI	Create an API in the code editor
ApsaraDB for RDS	Supported	Supported
DRDS	Supported	Supported
ApsaraDB for MySQL	Supported	Supported
ApsaraDB for PostgreSQL	Supported	Supported
ApsaraDB for SQL Server	Supported	Supported
Oracle	Supported	Supported
AnalyticDB	Supported	Supported
Table Store	Supported	Not supported
MongoDB	Supported	Not supported

2.13.3.2. Create an API in the codeless UI

This topic describes how to create an API by using the codeless user interface (UI).

You only need to follow simple steps to generate APIs in the codeless UI without writing any code. If you do not require advanced API features or have limited experience in code development, we recommend that you generate APIs by using the codeless UI.

> **Note** Before configuring the API, ensure that you have configured a connection. To configure a connection, go to the **Data Integration** page and choose **Sync Resources > Connections**.

Create a group

1. Log on to the DataWorks console.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > DataService Studio**.
3. Go to the **Service Development** page, right-click **Service List**, and then select **New API Group**.
4. In the **Create API Group** dialog box that appears, enter values for **Group Name** and **Description**.
5. Click **OK**.

Configure basic API information

1. Right-click the new group and choose **Create API > Codeless UI**.
2. In the **Create API** dialog box that appears, set each parameter.

Configuration item	Description
API Name	The name must be 4 to 50 characters in length. It must start with a letter and can contain letters, digits, and underscores (_).
API Group	An API group is a collection of APIs for a specific feature or scenario. It is also the minimum API management unit of API Gateway. To create an API group, move the pointer over the **Create** icon and select **New API Group**.
API Path	The path for storing APIs, such as /user.
Protocol	Currently, HTTP and HTTPS are supported.
Request Method	Currently, GET and POST requests are supported.
Return Type	Currently, only the JSON return type is supported.
Description	The description of the API, which contains up to 2,000 characters in length.

> **Note** The following example describes how to configure an API group:
>
> Assume that you want to configure an API product for querying weather information. The product consists of three APIs for querying weather by city name, by scenic spot name, and by zip code, respectively. Then, you can create an API group named weather query and add the three APIs to this group.
>
> If you generate APIs for your own application, you can use the API group for classification.

3. After configuring the basic API information, click **OK** to go to the API parameter configuration page.

Configure API parameters

1. Specify values for **Connect To**, **Connection Name**, and **Table Name**.

   > Note
   > - Before setting the API parameters, you must configure a connection in Data Integration. In the Select Table drop-down list, you can search for a table by name.
   > - After the API is created, the table configuration page automatically appears, allowing you to configure a data table directly.

2. Enter values for **Memory** and **Timeout**.
3. After you select a table, all fields of the table are displayed in the lower **Select Parameters** section. Select the fields that need to be set as **request parameters** and the fields that need to be set as **response parameters**. Add them to the request parameter list and the response parameter list, respectively.
4. Edit request parameters.

   Click **Request Parameters** on the right, and set **Parameter Name**, **Parameter Type**, **Operator**, **Required**, **Example Value**, **Default Value**, and **Description**.

5. Edit response parameters.

   Click **Response Parameters** on the right, and set **Parameter Name**, **Parameter Type**, **Example Value**, and **Description**. You can also perform advanced settings, such as **Pagination** and **Filter**.

   Set Pagination based on the actual requirements.

   - If the **Pagination** feature is disabled, the API returns a maximum of 2000 records by default.
   - If the API may return more than 2000 records, we recommend that you enable the **Pagination** feature.

   The following common parameters are available when the Pagination feature is enabled:

   - Common request parameters
     - pageNum: the current page number.
     - pageSize: the number of records per page.
   - Common response parameters
     - pageNum: the current page number.
     - pageSize: the number of records per page.
     - totalNum: the total number of records.

> Note
>
> - Only exact match is supported for table queries through APIs. Field values are returned in the response as they are in the table.
> - To enhance the matching efficiency, set an indexed field as a request parameter.
> - You are allowed to specify no request parameters for an API. In that case, the pagination feature must be enabled.
> - To make it easier for API callers to know the details of an API, we recommend that you specify the sample value, default value, description, and other parameters of the API.
> - You can click APIs Created to view a list of APIs that have been generated for the current table. Avoid generating an API that already exists in the system.

Test the API

After you have configured and saved the API parameters, click **Test** in the upper-right corner to go to the API test page.

Set the parameters and click **Test** to send an API request. The request and response details are displayed on the right. If the test fails, check carefully the error message, make modifications accordingly, and test the API again.

Pay attention to the settings of the successful response example in the configuration process. When testing an API, the system automatically generates error response examples and error codes. However, successful response examples are not automatically generated. To enable the system to save the test result as the successful response example, you need to select **Save as Successful Response Example** before performing the test. If the response contains sensitive data that must be masked, you can manually edit the response.

> Note
>
> - The successful response example is an important reference for API callers, and therefore must be configured.
> - The Call Latency value is the latency of the current API request, which is used to evaluate the API performance. If the latency is long, consider optimizing the database.

After the API test is passed, return to the **Service Development** page, and click **Publish** to generate an API.

View API details

Return to the View APIs page. Right-click the corresponding API service and select **View Details** to view the API details.

The API details page provides the detailed information about the API from the perspective of callers.

2.13.3.3. Create an API in the code editor

This topic describes how to create an API by using the code editor.

To meet the requirements of advanced data query, DataService Studio allows you to create an API by writing an SQL script. This feature supports table join queries, complex queries, and aggregate functions.

Create a group

1. Log on to the DataWorks console.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > DataService Studio**.
3. Go to the **Service Development** page, right-click **Service List**, and then select **New API Group**.
4. In the **Create API Group** dialog box that appears, enter values for **Group Name** and **Description**.
5. Click **OK**.

Configure basic API information

1. Right-click the new group and choose **Create API > Write Code**.
2. In the **Create API** dialog box that appears, set each parameter.

Configuration item	Description
API Name	The name must be 4 to 50 characters in length. It must start with a letter and can contain letters, digits, and underscores (_).
API Group	An API group is a collection of APIs for a specific feature or scenario. It is also the minimum API management unit of API Gateway. To create an API group, move the pointer over the **Create** icon and select **New API Group**.
API Path	The path for storing APIs, such as /user.
Protocol	Currently, HTTP and HTTPS are supported.
Request Method	Currently, GET and POST requests are supported.
Return Type	Currently, only the JSON return type is supported.
Description	The description of the API, which contains up to 2,000 characters in length.

> **Note** The following example describes how to configure an API group:
>
> Assume that you want to configure an API product for querying weather information. The product consists of three APIs for querying weather by city name, by scenic spot name, and by zip code, respectively. Then, you can create an API group named weather query and add the three APIs to this group.
>
> If you generate APIs for your own application, you can use the API group for classification.

3. After configuring the basic API information, click **OK** to go to the API parameter configuration page.

Configure SQL statements and parameters for API query

1. Specify values for **Connect To** and **Connection Name**.

   > **Note**
   > - You must configure the connection in advance in Data Integration.
   > - You must select a connection. Table join queries across multiple connections are not supported.

2. Enter values for **Memory** and **Timeout**.
3. Enter an SQL statement in the code editor.

   > **Note** The SELECT clause specifies the fields that the API response returns. The WHERE clause specifies the API request parameters. You must use ${} to interpolate a request parameter.

4. Edit request parameters.

   After editing the SQL statement used for API query, click **Request Parameters** on the right, and set **Parameter Name**, **Parameter Type**, **Required**, **Example Value**, **Default Value**, and **Description**.

   > **Note** To allow API users to learn more about this API, we recommend that you configure all parameters.

5. Edit response parameters.

   Click **Response Parameters** on the right, and set **Parameter Name**, **Parameter Type**, **Example Value**, and **Description**. You can also perform advanced settings, such as **Pagination** and **Filter**.

   Set Pagination based on the actual requirements.

   - If the **Pagination** feature is disabled, the API returns a maximum of 2000 records by default.
   - If the API may return more than 2000 records, we recommend that you enable the **Pagination** feature.

   The following common parameters are available when the Pagination feature is enabled:

   - Common request parameters
     - pageNum: the current page number.
     - pageSize: the number of records per page.
   - Common response parameters
     - pageNum: the current page number.
     - pageSize: the number of records per page.
     - totalNum: the total number of records.

Note Restrictions to the SQL script:

- You can enter only one SQL statement in the script editor.
- Only the SELECT clause is supported. Other clauses such as INSERT, UPDATE, and DELETE are not supported.
- The SELECT clause specifies the fields that the API response returns. The variable param in ${param} of the WHERE clause specifies an API request parameter.
- The clause `SELECT \*` is not supported. You must specify the columns to be queried.
- Single-table queries, table join queries, and nested queries under the same connection are supported.
- If the name of the column that the SELECT clause specifies has a table prefix, such as t.name, you must create an alias for the corresponding response parameter, for example, t.name as name.
- If you use an aggregate function, such as min, max, sum, or count, you must create an alias for the corresponding response parameter, for example, sum(num) as total_num.
- ${param} in SQL statements and character strings are uniformly regarded as request parameters and replaced. If an escape character \ is placed before ${param}, ${param} is processed as a common string.
- ${param} cannot be enclosed in single quotation marks ('). For example, `'${id}'` and `'abc${xyz}123'` are not allowed. If necessary, you can use `concat('abc', ${xyz}, '123')` instead.
- Parameters cannot be configured as optional.

Test the API

After you have configured and saved the API parameters, click **Test** in the upper-right corner to go to the API test page.

Set the parameters and click **Test** to send an API request. The request and response details are displayed on the right. If the test fails, check carefully the error message, make modifications accordingly, and test the API again.

Pay attention to the settings of the successful response example in the configuration process. When testing an API, the system automatically generates error response examples and error codes. However, successful response examples are not automatically generated. To enable the system to save the test result as the successful response example, you need to select **Save as Successful Response Example** before performing the test. If the response contains sensitive data that must be masked, you can manually edit the response.

Note

- The successful response example is an important reference for API callers, and therefore must be configured.
- The Call Latency value is the latency of the current API request, which is used to evaluate the API performance. If the latency is long, consider optimizing the database.

After the API test is passed, return to the **Service Development** page, and click **Publish** to generate an API.

View API details

Return to the View APIs page. Right-click the corresponding API service and select **View Details** to view the API details.

The API details page provides the detailed information about the API from the perspective of callers.

2.13.3.4. Use filters

This topic describes how to use a filter to process the result data returned by APIs.

What is a filter?

In DataService Studio, a filter is a function used to process the result data returned by APIs. By using one or more filters, you can customize the structure of the result data returned by APIs and process the result data.

- Currently, only Python 3.0 functions can be used as filters.
- Filters only support importing the following modules: json, time, random, pickle, re, and math.
- The function name of a filter must be `def filter(context,data):` .

Function template

The built-in function template is as follows:

```
# import module limit: json,time,random,pickle,re,math
import json
def filter(context, data):
  return data
```

You can modify the function template to write your own function. You can modify the names of the input parameters as needed.

Parameter 1 [context]: the context of calling APIs. The value is of the String type. Currently, the parameter is empty and is not in use.

Parameter 2 [data]: the result data returned by APIs or the preceding filter. The value is of the String type.

Create a filter

1. On the left-side navigation submenu of the **DataService Studio** page, click the **Function** icon.
2. In the Function section, right-click **Function** or a folder name and select **Create Python Function**.
3. In the **Create Python Function** dialog box that appears, set each parameter.

Configuration item	Description
Function Name	The name of the function to be created. The name can be up to 64 characters in length.

Configuration item	Description
Function Template	The template used to create the function. Currently, only the template named Python3 Standard v1 is supported.
Running Environment	The runtime environment of the function. Currently, only Python 3.0 is supported.
Function Description	The description of the function.
Target Folder	The folder where you create the function.

4. After the parameters are set, click **OK**.

Use a filter

1. On the left-side navigation submenu, click the **Service Development** icon.
2. Click the **Service List** folder and double-click the target API. In the right-side navigation pane, click the **Response Parameters** tab.
3. Select **Filter** and select the created function from the drop-down list.

   > **Note** You can create a function on the Function page and use it as a filter to process the query results returned by the API.

4. Click **Preview Response** to view the processing results of the filter.

2.13.4. Register APIs

This topic describes how to register APIs and manage and publish them to API Gateway together with APIs created based on data tables.

Currently, DataService Studio allows you to register only RESTful APIs. Supported request methods include GET, POST, PUT, and DELETE. Supported data types include forms, JSON data, and XML data.

Create a group

1. Log on to the DataWorks console.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > DataService Studio**.
3. Go to the **Service Development** page, right-click **Service List**, and then select **New API Group**.
4. In the **Create API Group** dialog box that appears, enter values for **Group Name** and **Description**.
5. Click **OK**.

Configure basic API information

1. Right-click the new group and select **Register API**.
2. In the **Create API** dialog box that appears, set each parameter.

Configuration item	Description
API Name	The name must be 4 to 50 characters in length. It must start with a letter and can contain letters, digits, and underscores (_).
API Group	An API group is a collection of APIs for a specific feature or scenario. It is also the minimum API management unit of API Gateway. To create an API group, move the pointer over the **Create** icon and select **New API Group**.
API Path	API Path is the alias of Backend Service Path. APIs with different API paths can share the same backend service path and backend service host. Parameters defined in Backend Service Path must also be defined in brackets in API Path.
Protocol	Currently, HTTP and HTTPS are supported.
Request Method	You can select GET, POST, PUT, or DELETE as the request method. The parameters to be configured vary with the request method.
Return Type	Currently, JSON and XML return types are supported.
Description	The description of the API.

3. After configuring the basic API information, click **OK** to go to the API parameter configuration page.

Configure API parameters

On the API parameter configuration page, you need to define the backend service, request parameters, response content, and error codes.

Configuration item	Description
Define the back-end Service	• **Backend Service Host**: Enter the host of the API. The host must start with http:// or https://, and cannot contain the path. • **Backend Service Path**: Enter the path of the API. Place parameter names in brackets, for example, /user/[userid]. In the next step, parameters defined in Backend Service Path are automatically added to the request parameter list. • **Backend timeout**: Set the backend timeout period.

Configuration item	Description
Define Request Parameters	• **Parameter Type**: The available request parameter locations (Path, Header, Query, or Body) vary with the request method. • **Constant Parameters**: A constant parameter is fixed and is invisible to the caller. You do not have to specify the constant parameters when calling an API. Instead, the constant parameters and their values are automatically sent to the backend service. This is useful when you want to set a parameter to a fixed value and hide the parameter value from the caller. • **Request Body Definition**: This configuration item is available only when the request method is POST or PUT. You can enter the body description in Request Body Definition. It is equivalent to an example of the request body so that API callers can refer to the format of the request body. The content type of the request body can be JSON or XML. **Note** If a parameter has been defined in both the request body and the request parameter list, the parameter value in the request body takes priority.
Define Response Content	You can enter a successful response example or an error response example for API callers to refer to when writing the return parse code.
Error Codes	Enter the common errors and solutions in API calling. This enables API callers to troubleshoot and solve these errors. **Note** To ensure that the API is easily used by the callers, provide complete API parameter information if possible, especially the parameter sample values, default values, and sample responses.

Test the API

After you have configured and saved the API parameters, click **Test** in the upper-right corner to go to the API test page.

Set the parameters and click **Test** to send an API request. The request and response details are displayed on the right. If the test fails, check carefully the error message, make modifications accordingly, and test the API again.

Pay attention to the settings of the successful response example in the configuration process. When testing an API, the system automatically generates error response examples and error codes. However, successful response examples are not automatically generated. To enable the system to save the test result as the successful response example, you need to select **Save as Successful Response Example** before performing the test. If the response contains sensitive data that must be masked, you can manually edit the response.

Note

- The successful response example is an important reference for API callers, and therefore must be configured.
- The Call Latency value is the latency of the current API request, which is used to evaluate the API performance. If the latency is long, consider optimizing the database.

After the API test is passed, return to the **Service Development** page, and click **Publish** to generate an API.

2.13.5. Test APIs

This topic describes how to test APIs.

When creating and registering an API, you can test the API. The system also provides an independent API test feature, which allows you to test APIs online.

1. Go to the **DataService Studio** page and click **Service Management** in the upper-right corner.
2. Click **Test API** in the left-side navigation pane.
3. Select the API to be tested, set the parameters, and then click **Test**.

Note

- The API Test page provides only online API testing. You cannot update or save the successful response example for an API on this page. To update the successful response example for an API, click the API name in the API list to enter the API edit mode. Then, update the successful response example for the API in the API testing step.
- You must test an API before publishing it.

2.13.6. Delete APIs

1. Log on to the DataWorks console and choose **DataService Studio > Service Development**.
2. On the Service Development page that appears, right-click the API that you want to delete, and select **Delete**.
3. In the **Delete API** dialog box that appears, click **OK**.

Note

- Only unpublished APIs can be deleted. Unpublish an API before deleting it.
- Deleted APIs cannot be recovered. Use caution when deleting an API.

2.13.7. Publish APIs

API Gateway provides API lifecycle management services, including API publishing, management, maintenance, and monetization. It helps you easily and quickly aggregate microservices, separate the frontend from the backend, and integrate systems at low costs and low risks, making features and data available to partners and developers.

API Gateway provides permission management, traffic control, access control, and metering services. The services make it easy for you to create, monitor, and secure APIs. Therefore, we recommend that you publish the APIs that have been created and registered in DataService Studio to API Gateway. DataService Studio and API Gateway are interconnected, which allows you to publish APIs to API Gateway easily.

Publish APIs to API Gateway

Before publishing an API, you must activate API Gateway and register and test the API.

After the API passes the test, click **Publish** in the upper-right corner to publish the API to API Gateway.

The system automatically registers the API with API Gateway during the publish process. The system also creates a group in API Gateway with the same name as the API group to which the API belongs in DataService Studio and publishes the API in this group. After the API is published, you can access the API Gateway console to view API details or configure bandwidth throttling, access control, and other features.

If you generate an API to be called by your own application, you need to create an application in API Gateway, authorize the application to use the API, and enable the application to call the API by using AppKey and AppSecret. For more information, see *API Gateway documentation* . API Gateway also provides SDKs for mainstream programming languages to help you quickly integrate the API into your own application.

2.13.8. Call APIs

This topic describes how to call an API after this API is published on API Gateway.

API Gateway provides the SDKs for authorizing and calling APIs. You can authorize yourself, your associates, or third parties to use APIs. If you want to call an API, perform the following operations.

Three conditions for calling an API

The following three conditions must be met to call an API:

- API: The API that you call is clearly defined by API parameters.
- App: The app that you use to call the API has a key pair that uniquely identifies you. The key pair consists of the AppKey and AppSecret.
- Relationship between the API and app: If you want to call an API by using an app, the app must have the permission to call this API. This permission is granted through authorization.

Procedure

1. Obtain the API documentation.

   The method of obtaining the API documentation varies depending on how you obtain the API. You can obtain the API by purchasing it from the marketplace, or you are authorized to use the API for free.

2. Create an app.

   The app identifies you when you call the API. Each app has a key pair: AppKey and AppSecret, which are equivalent to an account and the corresponding password.

3. Obtain the permission to call the API.

   Authorization means granting the app the permission to call an API. Your app must be authorized to call the API. The authorization method varies depending on how you obtain the API.

4. Call the API.

   You can edit an HTTP or HTTPS request to call the API. Before calling the API, you can use examples of calling APIs in multiple languages in the API Gateway console to test the call.

You can call APIs after you passed the quick authentication or encrypted signature authentication.

Click **API call**. The AppCode and AppKey that are synchronized from API Gateway are available on the page that appears. You can perform **copy** and **reset** operations on them. For more information about API Gateway, see *API Gateway documentation* .

2.13.9. Use workflows

The workflow feature, also called service orchestration, provides a composite API service. This topic describes the benefits of workflows and how to use workflows.

In DataService Studio, a workflow is represented as a directed acyclic graph (DAG). By dragging and dropping nodes to a DAG, you can arrange APIs and functions in a serial, parallel, or branch structure based on the business logic.

When you run a workflow to call APIs, DataWorks runs the nodes in the workflow in sequence, passes parameters among the nodes, and automatically changes the status of each node. The workflow feature simplifies the process of calling multiple APIs or functions and reduces the cost of development and maintenance. This enables you to focus on business development.

Benefits

- Reduced cost of combining multiple APIs

  By dragging and dropping nodes to a DAG, you can arrange APIs and functions in a serial, parallel, or branch structure without writing code. This reduces the cost of developing APIs.

- Higher performance in calling APIs and functions

  A workflow allows you to call multiple APIs and functions in a container. Compared with writing code to combine APIs and functions, the workflow feature reduces the latency of calling APIs and functions.

- Serverless architecture

  The service orchestration uses a serverless architecture. A serverless architecture supports automatic resource scaling based on business needs. You can focus on the business logic, without worrying about the runtime environment.

Obtain values of request and response parameters

DataService Studio uses JSONPath to obtain parameter values. JSONPath is a query language that allows you to extract data from JSON files.

For example, three nodes are run in the following order: A, B, and then C. Node C needs to use the response parameters of nodes A and B.

- Response parameter of node A: {"namea":"valuea"}

  Expression for obtaining the value of the response parameter of node A: ${A.namea}

- Response parameter of node B: {"nameb":"valueb"}

  Expression for obtaining the value of the response parameter of node B: $.nameb or ${B.nameb}

The built-in start node provides request parameters for the whole workflow. Assume that a request parameter of a workflow is {"namewf":"valuewf"}. All nodes of the workflow can obtain the value of the request parameter through the ${START.namewf} expression.

Set parameters

Request parameters:

- If you do not specify a value for a request parameter of a node, DataService Studio obtains the value of the same parameter in the first layer of the JSON string returned by the parent node, and assigns the value to the request parameter. If no value is specified for a request parameter of the first node, DataService Studio obtains the value of the same parameter in the request parameters of the workflow.
- If you specify a value for a request parameter, DataService Studio uses the value that you set.
- If you want to use the value of the specified parameter returned by a specified ancestor node, obtain the value through a JSONPath expression.

Common JSONPath expressions for obtaining parameter values:

- $.: obtains response parameters of the parent node.
- $.param: obtains the value of the param parameter returned by the parent node. To allow you to obtain response parameters of any ancestor nodes, DataService Studio enhances JSONPath expressions.
- ${NODEID1}: obtains response parameters of the node whose ID is NODEID1.
- ${START}: obtains request parameters of the workflow, that is, response parameters of the start node.
- ${NODEID1.param}: obtains the value of the param parameter returned by the node whose ID is NODEID1.

JSONPath expressions for setting response parameters of a node:

- $.: obtains response parameters of the current node.
- $.param: obtains the value of the param parameter returned by the current node.
- ${NODEID1.param}: obtains the value of the param parameter returned by the node whose ID is NODEID1.

Example

Add a connection before you create and use a workflow. In this example, a MySQL connection is used.

1. Register an API.

   In this example, create an API through registration. For more information, see Register an API.

2. Register a function.

   In this example, create a Python function as the branch node to process the result data of the parent node.

   i. In the left-side navigation pane, click **Function**.

   ii. In the Function section, right-click **Function** or a folder name and select **Create Python Function**.

   iii. In the **Create Python Function** dialog box that appears, set each parameter and click **OK**.

iv. In the function editor, enter the following code, configure environment information, and then click **Save**.

```
# -*- coding: utf-8 -*-
# event (str) : in filter it is the API result, in other cases, it is your param
# context : some environment information, temporarily useless
# import module limit: json,time,random,pickle,re,math
import json
def handler(event,context):
  # load str to json object
  obj = json.loads(event)
  # add your code here
  # end add
  return obj
```

3. In the left-side navigation pane, click **Service Development**. Right-click the target group and select **Workflow**.
4. In the **New Workflow** dialog box that appears, set each parameter.
5. Click **OK**. After the workflow is created, drag and drop nodes to the DAG and connect the nodes.
6. Double-click the **API1** node to edit the node. Select the API that you registered earlier as the API to be called in the node.

   Select **set output results** and enter `{"user_id":"$.data[0].id"}`.

   Use JSONPath expressions to set response parameters. The syntax for obtaining the value of a parameter is ${NodeA.namea}, which is the same as that for setting request parameters. `{"user_id":"$.data[0].id"}` assigns the value of the id parameter of the first element in the data array to the user_id parameter. Then, the API1 node returns {"user_id":"value"} in JSON format.
7. Double-click the **PYTHON1** node to edit the node. Select the function that you created earlier as the function to be called in the node.
8. Double-click the **SWITCH2** node to edit the node. On the right-side pane that appears, click **Set branch conditions**. In the Set branch conditions dialog box that appears, enter conditional expressions based on the response parameter of the parent node. For example, you can enter expressions in the `${Node ID. Parameter}>1` or `$. Parameter>1` format. Conditional expressions support the following operators: ==, ! =, >=, >, <=, <, &&, !, (), +, -, *, /, and %.

   In this example, the user_id parameter is the response parameter of the API1 node and is used as the request parameter of the SWITCH2 node.

   ```
   Branch node 1: $.user_id != 1, indicating that the branch node 1 is run if the value of the user_id parame
   ter is not 1.
   Branch node 2: $.user_id == 1, indicating that the branch node 2 is run if the output value of the user_id
   parameter is 1.
   ```
9. Double-click **The end**, and then click **Response Parameters** to configure the response parameters.

10. Click **Test** in the upper-right corner.
11. Set test parameters and click **OK**.

    You can view the test result after the test is passed.

2.13.10. FAQ

- Q: Do I need to activate the API Gateway service?

  A: API Gateway provides you with high-performance and highly available API hosting services. If you need to make your APIs available to others, activate the API Gateway service first.

- Q: Where can I add and change connections?

  A: After logging on to the DataWorks console, click the DataWorks icon in the upper-left corner and choose **All Products > Data Integration** to go to the **Data Integration** page. In the left-side navigation pane, choose **Sync Resources > Connections**. On the page that appears, perform the relevant configuration. DataService Studio automatically reads data from the connections that you have configured.

- Q: What is the role of an API group in DataService Studio? What is the relationship between an API group in DataService Studio and an API group in API Gateway?

  A: An API group is a set of APIs specific to a feature or scenario. It is the smallest organization unit in DataService Studio, which is similar to an API group in API Gateway. An API group in DataService Studio is equivalent to an API group in API Gateway. After you publish an API from DataService Studio to API Gateway, API Gateway automatically creates an API group with the same name.

- Q: How can I configure an API group appropriately?

  A: Typically, an API group includes APIs that provide similar features or solve a specific issue. For example, a weather API group can include APIs that are used to check the weather by city and by longitude and latitude.

- Q: How many API groups can I create?

  A: An Alibaba Cloud account can create up to 100 API groups.

- Q: When do I need to enable the return results to be displayed in multiple pages?

  A: By default, an API call returns a maximum of 500 records. If the API may return more than 500 records, enable the Pagination feature. If you do not specify any request parameters, the API call usually returns a large number of records and the Pagination feature is automatically enabled.

- Q: Do APIs created by DataService Studio support POST requests?

  A: Currently, APIs created by DataService Studio support GET and POST requests.

- Q: Do APIs created by DataService Studio support the HTTPS protocol?

  A: Currently, APIs created by DataService Studio support both HTTP and HTTPS protocols.

2.14. Stream Studio

2.14.1. Overview

Built on Alibaba Cloud Realtime Compute, which is based on Apache Flink, Stream Studio allows you to develop real-time computing nodes in directed acyclic graph (DAG) mode or SQL mode. You can switch between the two modes to edit the code or drag and drop components and configure them in a visual way.

As an ideal platform for developing real-time computing nodes, Stream Studio has the following features:

- Supports developing nodes in DAG mode. You can perform drag and drop components to configure real-time computing nodes.
- Supports developing nodes in SQL mode. You can edit the code to configure real-time computing nodes.
- Supports switching between the DAG mode and the SQL mode for you to easily check SQL operators.
- Supports using Function Studio to create and publish user-defined functions (UDFs) online in exclusive mode.
- Supports smart diagnosis for real-time computing nodes to facilitate online troubleshooting.

2.14.2. Bind a Realtime Compute project

1. Log on to the DataWorks console.
2. Click the **Project Manage** icon in the upper-right corner. The **Project Management** page appears.
3. On the **Project Management** page, click **Add Compute Engine** in the **Compute Engine** section, and select **Add engine service**.
4. Enter the name of the Blink engine to be added and click **Bind**.

2.14.3. Get started with Stream Studio

This topic uses an example to describe how to use Stream Studio to develop and manage a real-time computing node. Stream Studio allows you to create, configure, publish, run, stop, and unpublish a real-time computing node.

Prerequisites

A Realtime Compute project is bound to the current DataWorks workspace.

Context

- Data store: a Datahub table with a created topic, which contains the `m_name, id, m_type, and tag` fields.

  > **Note** The Datahub topic must be created in advance.

- Data processing: splits the tag field by using the `semicolon (;)` as the delimiter to the color, mode, and weight fields.
- Output data: writes the `id, m_type, and weight` fields to a Log Service table.

  > **Note** The Log Service project and Logstore must be created in advance.

Procedure

1. Log on to the DataWorks console. On the DataStudio page that appears, click the DataWorks icon in the upper-left corner and choose **All Products > Stream Studio**.

2. Create a workflow.
   i. On the Stream Studio homepage, click **New business process**.

      You can also move the pointer over the **Create** icon and click **Business process**.

   ii. In the **Create business process** dialog box that appears, set the **Business Name** and **Description** parameters.

   iii. Click **New**.
3. Create a real-time computing node.
   i. Right-click the workflow that you have created and select **Create task**.

   ii. In the **Create node** dialog box that appears, set the relevant parameters.

   iii. Click **Submit**. The **Components** page appears.

   iv. On the left-side navigation submenu, click **Resource Reference** and select **PUBLIC_COMMON**.

   > **Note** If this option is not selected, the message shown when you use the **FixedFieldsSplit** component.
   >
   > You can also go to the Resource Reference page to configure the reference resources after this message appears.
4. Configure the created real-time computing node.

   On the left-side navigation submenu, click **Components**. The **Components** page appears.

   i. Configure the data store of the node on the **Components** page.

      a. Drag and drop the Datahub component in the Data Source section to the directed acyclic graph (DAG).

      b. Click the Datahub component and set the parameters as needed on the **Parameter configuration** tab that appears.

Parameter	Description
oriTableName	The table name used in the CREATE TABLE statement. It must be a globally unique name. If this parameter is not specified, the real table name is used.
table schema	The custom fields and attribute fields to be returned. Click **Custom**. In the **Select field** dialog box that appears, click **+ Add** and enter the name and type of the output field. Then, click **OK**.
endPoint	The endpoint used to access Datahub. It corresponds to the endPoint parameter in the WITH clause of the CREATE TABLE statement.
accessId	The AccessKey ID used to read data from Datahub. It corresponds to the accessId parameter in the WITH clause of the CREATE TABLE statement.

Parameter	Description
accessKey	The AccessKey secret used to read data from Datahub. It corresponds to the accessKey parameter in the WITH clause of the CREATE TABLE statement.
project	The name of the Datahub project from which data is to be read. It corresponds to the project parameter in the WITH clause of the CREATE TABLE statement.
topic	The name of the Datahub topic from which data is to be read. It corresponds to the topic parameter in the WITH clause of the CREATE TABLE statement.
startTime	The beginning of the time range when data is read. It corresponds to the startTime parameter in the WITH clause of the CREATE TABLE statement.
maxRetryTimes	The maximum number of retries for reading data from Datahub. It corresponds to the maxRetryTimes parameter in the WITH clause of the CREATE TABLE statement. Default value: *20*.
retryIntervalMs	The retry interval at which data is read. It corresponds to the retryIntervalMs parameter in the WITH clause of the CREATE TABLE statement. Unit: milliseconds. Default value: *1,000*.
batchReadSize	The number of data records that are read at a time. It corresponds to the batchReadSize parameter in the WITH clause of the CREATE TABLE statement. Default value: *10*.
lengthCheck	The rule for checking the number of fields parsed from a row of data. It corresponds to the lengthCheck parameter in the WITH clause of the CREATE TABLE statement. Default value: *NONE*.
columnErrorDebug	Specifies whether to enable debugging. It corresponds to the columnErrorDebug parameter in the WITH clause of the CREATE TABLE statement. If you turn on this switch, logs about parsing errors are returned. You can view the node details Operation Center.

ii. Configure the data operator.

a. Drag and drop the **FixedFieldsSplit** component to the DAG to split the tag field.

b. Click and hold the highlighted dot at the bottom of the **Datahub** component and move the pointer to link this component with the **FixedFieldsSplit** component.

c. Click the **FixedFieldsSplit** component and set the field to tag and the column separator to semicolon (;) on the Parameter configuration tab that appears.

d. Click **Custom** for the Add column parameter. In the **Select field** dialog box that appears, click + Add and enter the name and type of the output field. Then, click **OK**.

e. Drag and drop the **Select** component to the DAG. Click and hold the highlighted dot at the bottom of the **FixedFieldsSplit** component and move the pointer to link this component with the **Select** component.

f. Click the **Select** component and click **0 Field has been selected** on the **Parameter configuration** tab that appears.

g. In the dialog box that appears, select the fields to be returned and click **OK**.

iii. Configure the result table.

This example uses the LogService component as the destination.

a. Drag and drop the **LogService** component to the DAG. Click and hold the highlighted dot at the bottom of the **Select** component and move the pointer to link this component with the **LogService** component.

b. Click the **LogService** component and set the parameters as needed on the **Parameter configuration** tab that appears.

Parameter	Description
oriTableName	The table name used in the CREATE TABLE statement. It must be a globally unique name. If this parameter is not specified, the real table name is used.
Output Field	The fields to be returned. Click **0 Field has been selected** for the Output Field parameter. In the dialog box that appears, select the fields to be returned and click **OK**.
endPoint	The endpoint used to access Log Service. It corresponds to the endPoint parameter in the WITH clause of the CREATE TABLE statement.
project	The name of the Log Service project to which data is to be written. It corresponds to the project parameter in the WITH clause of the CREATE TABLE statement.
topic	The name of the Log Service topic to which data is to be written. It corresponds to the topic parameter in the WITH clause of the CREATE TABLE statement.
source	The name of the Log Service table to which data is to be written. It corresponds to the source parameter in the WITH clause of the CREATE TABLE statement.
accessId	The AccessKey ID used to access Log Service. It corresponds to the accessId parameter in the WITH clause of the CREATE TABLE statement.
accessKey	The AccessKey secret used to access Log Service. It corresponds to the accessKey parameter in the WITH clause of the CREATE TABLE statement.
mode	The mode of data writing. It corresponds to the mode parameter in the WITH clause of the CREATE TABLE statement. Default value: *random*.
logStore	The name of the Logstore in the Log Service project to which the data is to be written. It corresponds to the logStore parameter in the WITH clause of the CREATE TABLE statement.

iv. Switch between the DAG mode and SQL mode.

Stream Studio allows you to configure a real-time computing node in both DAG mode and SQL mode. You can switch between these two modes.

By default, you configure a node in DAG mode. You can click **Switch to SQL mode** in the upper-right corner to switch to the SQL mode.

In SQL mode, you can click **Switch to DAG mode** in the upper-right corner to switch back to the DAG mode.

v. Configure the execution plan.

a. Click **Execution Plan** on the right-side navigation submenu to generate an execution plan.

b. Click **Save execution plan**.

5. Publish the real-time computing node.

You can publish the real-time computing node that you have configured. Click **Save** and then click **Submit** to publish the node.

i. Click **Save** and then click **Submit**. If you have not saved the node, a message appears, indicating that you must save it.

ii. In the **Submit New version** dialog box that appears, enter the remarks for the node and click **OK**.

iii. After you publish the node, you can go to the **OAM** page to view the node status and manage the node.

6. Perform O&M on the real-time computing node.

Click **OAM** in the upper-right corner to perform O&M on the real-time computing node.

i. Start the real-time computing node.

Find the real-time computing node that you have created in the node list and click **Start** to start the node.

You can set a custom start time for the real-time computing node based on your business requirement.

After starting the real-time computing node, you can click the node name to view its running status. If the real-time computing node is started properly, it enters the **Run** state.

ii. Stop and unpublish the real-time computing node.

a. Click **Stop** to stop the real-time computing node.

b. After the real-time computing node is stopped, click **Offline** to unpublish it.

Result

Now you have created, configured, published, run, stopped, and unpublished a real-time streaming node.

2.14.4. Collect data

Data must be collected before it can be processed in DataWorks.

Realtime Compute integrates various streaming storage systems that can store source tables. This enables you to offload the heavy lifting of data collection.

2.14.5. Create a real-time computing node

This topic describes how to create a real-time computing node and develop data in Stream Studio.

Prerequisites

A workflow is created. You can create real-time computing nodes and develop data under an existing workflow.

Procedure

After a workflow is created, you can create real-time computing nodes under the workflow. By default, data is developed for a real-time computing node in directed acyclic graph (DAG) mode.

1. Right-click the workflow that you have created and select **Create task**.
2. In the **Create Node** dialog box that appears, set the parameters and click **Submit**.
3. Develop data in DAG mode on the **Components** page.

   The Components page includes the following four sections:

   - Component list section: In this section, you can view the list of available components. You can click **Components** on the left-side navigation submenu to go to the Components page and view the list.
   - DAG section: In this section, you can drag and drop components to the DAG and connect them. To configure the dependency between two components, click and hold the highlighted dot at the bottom of a component and move the pointer to link this component with a descendant component. A DAG corresponds to a real-time computing node.
   - Parameter configuration section: Double-click a component in the DAG. Then, you can set the related parameters in this section.
   - Toolbar section: In this section, you can click the icons to perform the save, submit, steal lock, pre-compilation, test, stop, reload, and format operations respectively.

   When you configure the DAG, you can right-click a component and select an operation from the menu that appears to perform it on the selected component. Available operations include **Rename**, **View schema**, **Delete node**, **View error message**, **New component group**, and **Copy**.

2.14.6. Configure components

2.14.6.1. Source tables

2.14.6.1.1. Datahub

Datahub is a real-time data distribution platform that is designed to process streaming data. It provides a channel for the Apsara Stack DTplus platform to process big data.

Realtime Compute typically uses Datahub to store source and result tables for streaming data processing. Data Transmission Services (DTS) and the Internet of Things (IoT) also use Datahub to access big data platforms. Datahub stores streaming data that can be used as input data for Realtime Compute.

Parameter configuration

Parameter	Description	Remarks
oriTableName	The table name used in the CREATE TABLE statement. It must be a globally unique name.	None
table schema	The custom fields and attribute fields to be read from Datahub.	None

Parameter	Description	Remarks
endPoint	The consumer endpoint.	None
accessId	The AccessKey ID used to read data from Datahub.	None
accessKey	The AccessKey secret used to read data from Datahub.	None
project	The name of the Datahub project from which data is to be read.	None
topic	The name of the Datahub topic from which data is to be read.	None
startTime	The beginning of the time range when data is read.	The format is `yyyy-MM-dd hh:mm:ss`.
maxRetryTimes	The maximum number of retries for reading data from Datahub.	None
retryIntervalMs	The retry interval at which data is read. Unit: milliseconds.	None
batchReadSize	The number of data records that are read at a time.	None
lengthCheck	The rule for checking the number of fields parsed from a row of data.	Valid values: *SKIP*, *EXCEPTION*, and *PAD*. Default value: SKIP. • *SKIP*: skips a data record when the number of fields in the data record is not the specified one. • *EXCEPTION*: throws an exception when the number of fields in the data record is not the specified one. • *PAD*: pads fields in sequence. Pad a field with null when the field does not exist.
columnErrorDebug	Specifies whether to enable debugging. If you turn on this switch, logs about parsing errors are returned.	None
BLOB	Specifies whether the type of data read from Datahub is BLOB.	None
Data Quality	Specifies whether to open the Data Quality page to view related monitoring nodes.	None

Field type mapping

The following table lists the mapping between Datahub and Realtime Compute data types. We recommend that you declare the type mapping in the DDL statement.

Datahub data type	Realtime Compute data type
BIGINT	BIGINT
DOUBLE	DOUBLE
TIMESTAMP	BIGINT
BOOLEAN	BOOLEAN
DECIMAL	DECIMAL

Attribute fields

You can obtain the attribute field indicating the system time at which each data record is written to Datahub.

Field	Description
System Time	The system time at which each data record is written to Datahub.

2.14.6.1.2. Log Service

As an all-in-one real-time data logging service, Log Service allows you to quickly finish tasks such as data ingestion, consumption, delivery, query, and analysis without any extra development work. This can help you improve O&M and operational efficiency, and build up the capability to process large amounts of logs in the data technology era.

Log Service stores streaming data that can be used as input data for Realtime Compute.

The data format of Log Service is consistent with JSON. Example:

```
{
  "a": 1000,
  "b": 1234,
  "c": "li"
}
```

Parameter configuration

Parameter	Description	Remarks
oriTableName	The table name used in the CREATE TABLE statement. It must be a globally unique name.	None

Parameter	Description	Remarks
table schema	The custom fields and attribute fields to be read from Log Service.	None
endPoint	The consumer endpoint.	Log Service endpoints
accessId	The AccessKey ID used to read data from Log Service.	None
accessKey	The AccessKey secret used to read data from Log Service.	None
project	The name of the Log Service project from which data is to be read.	None
logStore	The name of the Logstore under the Log Service project.	None
consumerGroup	The name of the consumer group.	You can specify a custom consumer group name. The format of the name is not fixed.
startTime	The beginning of the time range when the log data is consumed.	None
heartBeatIntervalMills	Optional. The heartbeat interval at which the client sends heartbeat messages. Unit: milliseconds.	None
maxRetryTimes	The maximum number of retries for reading data from Log Service.	None
columnErrorDebug	Specifies whether to enable debugging. If you turn on this switch, logs about parsing errors are returned.	None

Field type mapping

The following table lists the mapping between Log Service and Realtime Compute data types. We recommend that you declare the type mapping in the DDL statement.

Log Service data type	Realtime Compute data type
STRING	VARCHAR

Attribute fields

Currently, Log Service supports the following three attribute fields by default. You can also specify other custom fields.

Field	Description
__source__	Specifies a log source.
__topic__	Specifies a log topic.
__timestamp__	Specifies the time when a logged event occurs.

Note

- Currently, Log Service does not support the MAP type.
- We recommend that you define the fields in the same order as the fields in the preceding table. Unordered fields are also supported.
- If the input data is in JSON format, define the delimiter and use the built-in function JSON_VALUE to parse the JSON value. Otherwise, the parsing fails and the following error is returned:

```
2017-12-25 15:24:43,467 WARN [Topology-0 (1/1)] com.alibaba.blink.streaming.connectors.com
mon.source.parse.DefaultSourceCollector - Field missing error, table column number: 3, data co
lumn number: 3, data field number: 1, data: [{"lg_order_code":"LP00000005","activity_code":"T
EST_CODE1","occur_time":"2017-12-10 00:00:01"}]
```

- The batchGetSize value must not exceed 1,000. Otherwise, an error occurs.
- The batchGetSize parameter specifies the number of log items read at a time in a log group. If both the size of a single log item and the batchGetSize value are too large, frequent garbage collection (GC) may be triggered. To avoid this, you must set batchGetSize parameter to a smaller value.

2.14.6.2. Dimension tables

2.14.6.2.1. ApsaraDB for RDS

ApsaraDB for Relational Database Service (RDS) offers stable, reliable, and scalable cloud database services.

Parameter configuration

Parameter	Description	Remarks
oriTableName	The table name used in the CREATE TABLE statement. It must be a globally unique name.	None
url	The URL of the RDS instance.	None

Parameter	Description	Remarks
tableName	The name of the dimension table.	None
userName	The username used to access RDS.	None
password	The password used to access RDS.	None
Output Field	The fields to be returned to the descendant component.	None
maxRetryTimes	The maximum number of retries for reading data from RDS.	None
Cache Policy	The policy for caching data.	Valid values: *None*, *LRU*, and *ALL*.
primaryKey	The primary key field of the output fields.	• You must specify the primary key when you declare the dimension table. • When you join a dimension table with another table, the ON condition must contain an equivalence condition that includes the primary key of either table. • The primary key in RDS or Distribute Relational Database Service (DRDS) is the primary key or unique index column of an RDS or DRDS dimension table.

Note

- RDS and DRDS provide the following three cache policies:
  - **None**: indicates that no data is cached.
  - **LRU**: indicates that the recently used data is cached.

    When this cache policy is used, you must set the cacheSize and cacheTTLMs parameters.
  - **ALL**: indicates that all data is cached.

  Before Realtime Compute runs a node, it loads all data in the remote table to the memory. Then Realtime Compute searches the cache for data in all subsequent dimension table query operations. In the case of a cache miss, the corresponding data does not exit. All data is cached again after the cache expires. The ALL cache policy applies to scenarios where the remote table is small but there are a large number of missing keys. When this cache policy is used, you must set the cacheTTLMs and cacheReloadTimeBlackList parameters.
- When the cache policy is set to ALL, Realtime Compute reloads data asynchronously. Therefore, you must increase the memory of the JOIN operator. The size of the increased memory is twice the data

size of the remote table.

- When the cache policy is set to ALL, pay special attention to the memory of the JOIN operator to prevent out of memory (OOM) errors.

2.14.6.2.2. Table Store

Table Store is a distributed NoSQL database service built on Alibaba Cloud Apsara system. It is designed to provide high availability and data reliability.

Parameter configuration

Parameter	Description
oriTableName	The table name used in the CREATE TABLE statement. It must be a globally unique name.
instanceName	The ID of the Table Store instance.
tableName	The name of the dimension table.
Output Field	The fields to be returned to the descendant component.
endPoint	The endpoint used to access Table Store. It corresponds to the endPoint parameter in the WITH clause of the CREATE TABLE statement.
accessId	The AccessKey ID used to read data from Table Store.
accessKey	The AccessKey secret used to read data from Table Store.
Cache Policy	The policy for caching data. Valid values: **None** and **LRU**.
primaryKey	The primary key field of the output fields.

2.14.6.2.3. MaxCompute

This topic describes the parameter configuration, field type mapping, and metrics of a MaxCompute dimension table.

Parameter configuration

Parameter	Description	Remarks
oriTableName	The table name used in the CREATE TABLE statement. It must be a globally unique name.	None

Parameter	Description	Remarks
endPoint	The endpoint used to access MaxCompute. It corresponds to the endPoint parameter in the WITH clause of the CREATE TABLE statement.	None
tunnelEndpoint	The endpoint of the Tunnel service. It corresponds to the tunnelEndPoint parameter in the WITH clause of the CREATE TABLE statement.	This parameter is required for a MaxCompute dimension table deployed in a Virtual Private Cloud (VPC).
project	The name of the MaxCompute project to which the dimension table belongs.	None
accessId	The AccessKey ID used to read data from MaxCompute.	None
accessKey	The AccessKey secret used to read data from MaxCompute.	None
Output Field	The fields to be returned to the descendant component.	None
partition	The partition name of the MaxCompute dimension table.	None
maxRowCount	The maximum number of data records that can be read from the MaxCompute dimension table	None
Cache Policy	The policy for caching data.	Default value: **ALL**.
cacheSize	The maximum number of data records that can be cached.	This parameter is required if you set the Cache Policy parameter to `LRU`. Default value: 100,000.
cacheTTLMs	The time interval at which the cache is refreshed. It corresponds to the cacheTTLMs parameter in the WITH clause of the CREATE TABLE statement. Units: milliseconds.	This parameter specifies the cache refresh interval when the Cache Policy parameter is set to `ALL`. The cache is not refreshed by default.

Parameter	Description	Remarks
cacheReloadTimeBlackList	Optional. The time period during which the cache is not refreshed. This parameter is valid when the Cache Policy parameter is set to `ALL`. During the time period specified by this parameter, for example, the Double 11 Shopping Festival, the cache is not refreshed.	This parameter is left empty by default. If you want to set this parameter, specify the time period in the format shown in the following example: `2017-10-24 14:00 -> 2017-10-24 15:00, 2017-11-10 23:30 -> 2017-11-11 08:00` Separate multiple time periods with commas (,). Separate the start and end time for a time period with the string "->".
primaryKey	The primary key field of the output fields.	None

Field type mapping

MaxCompute data type	Realtime Compute data type
TINYINT	TINYINT
SMALLINT	SMALLINT
INT	INT
BIGINT	BIGINT
FLOAT	FLOAT
DOUBLE	DOUBLE
BOOLEAN	BOOLEAN
DATETIME	TIMESTAMP
TIMESTAMP	TIMESTAMP
VARCHAR	VARCHAR
STRING	STRING
DECIMAL	DECIMAL
BINARY	VARBINARY

Metrics

When you join the dimension table to another table, you can view metrics such as the correlation degree and cache hit ratio. You can use K-Monitor to view the metrics.

Query statement	Description
fetch qps	Queries the total number of queries per second (QPS) against the dimension table, including hits and misses. The metric name is `blink.projectName.jobName.dimJoin.fetchQPS`.
fetchHitQPS	Queries the number of hits (in QPS) against the dimension table, including cache hits and hits against the physical dimension table. The metric name is `blink.projectName.jobName.dimJoin.fetchHitQPS`.
cacheHitQPS	Queries the number of cache hits (in QPS) against the dimension table. The metric name is `blink.projectName.jobName.dimJoin.cacheHitQPS`.
dimJoin.fetchHit	Queries the correlation degree of the dimension table and the table to which the dimension table is joined. The metric name is `blink.projectName.jobName.dimJoin.fetchHit`.
dimJoin.cacheHit	Queries the cache hit ratio of the dimension table. The metric name is `blink.projectName.jobName.dimJoin.cacheHit`.

Note

- We recommend that you use Realtime Compute V2.1.1 and later.
- To use a MaxCompute dimension table, you must grant the read permission to the account for accessing MaxCompute.
- When you declare a dimension table, you must specify the primary key. When you join a dimension table with another table, the ON condition must contain an equivalent condition that includes the primary key of either table.
- The primary key value for each row of a MaxCompute dimension table must be unique. Otherwise, the duplicate records are removed.
- If the dimension table is a partitioned table, Realtime Compute does not currently support writing the partition key column to the schema.
- When the cache policy is set to ALL, Realtime Compute reloads data asynchronously. Therefore, you must increase the memory of the JOIN operator. The size of the increased memory is twice the data size of the remote table.
- The following failover message may appear when you run a node:

```
RejectedExecutionException: Task
java.util.concurrent.ScheduledThreadPoolExecutor$ScheduledFutureTas,
```

Generally, this message appears because dimension table joining in Realtime Compute V1.x has certain issues. We recommend that you upgrade Realtime Compute to V2.1.1 or later. If you want to continue using the existing version, we recommend that you pause the node and resume it after troubleshooting. To troubleshoot the failover, check the specific error information that was generated for the first failover record in the failover history.

2.14.6.3. Data operators

2.14.6.3.1. Filter

The Filter component allows you to configure filter conditions. It corresponds to the WHERE clause in SQL statements.

Parameter configuration

Enter the filter expression to configure this component. The filter expression supports functions and operators (=, <>, >, >=, <, and <=), for example, `city = 'Beijing'` .

2.14.6.3.2. GroupBy

The GroupBy component corresponds to the GROUP BY clause in SQL statements.

Parameter configuration

Parameter	Description
Select grouping field	The fields based on which data is grouped. You can specify multiple fields.
Output Field	The fields to be returned, that is, the fields to be selected. You can specify the fields in the same way that you configure the Select component.

2.14.6.3.3. Join

The Join component corresponds to the JOIN clause in SQL statements.

Parameter configuration

Parameter	Description
JoinMode	The JOIN mode to be used. Valid values: INNER JOIN, LEFT OUTER JOIN, RIGHT OUTER JOIN, and FULL OUTER JOIN.
expression	The JOIN expression. An equijoin is supported, for example, leftId = rightId AND limit = 0, whereas a non-equijoin is not supported.
Select Field	The fields to be returned, that is, the fields to be selected.

2.14.6.3.4. Select

The Select component allows you to configure the fields to be returned and supports field expressions. It corresponds to SELECT statements.

Parameter configuration

Select or configure the output fields in the Select field dialog box.

You can select fields to be returned in the **Field list** section and set an alias for a field in the **Field alias** column. To set a field expression, click the Edit icon next to the target field name. In the Edit dialog box that appears, enter the required SQL statement.

2.14.6.3.5. UDTF

The UDTF component allows you to configure custom functions. It corresponds to the UDTF clause in SQL statements.

Parameter configuration

Parameter	Description
JoinMode	The JOIN mode for the custom function. Only *INNER JOIN* and *LEFT OUTER JOIN* are supported. • *INNER JOIN*: returns an empty result set when the UDTF clause returns no result. • *LEFT OUTER JOIN*: returns the NULL string when the UDTF clause returns no result.
Select function	The name of the function that the current node references. To reference a function for the current node, upload the related resources on the Resource Reference page and select the target resource.
parameter expression	The input parameters and output parameters of the referenced function.
Output Field	The fields to be returned. You can configure the name, alias, and expression of each field.

2.14.6.3.6. UnionAll

The UnionAll component corresponds to the UNION ALL clause in SQL statements.

Parameter configuration

No parameter configuration is required.

2.14.6.3.7. Dynamic column splitting

Dynamic column splitting allows you to split data records with a dynamic number of columns.

Example

Input data:

```
k1=v1,k2=v2,k3=v3,k4=v4
```

In the preceding example, the data is stored in key-value pairs in the format of key=value. Different data records may have different numbers of key-value pairs, that is, they may have different numbers of columns. In this case, you can use the first-level delimiter, which is comma (,) in the preceding example, to split the data to different key-value pairs. Then, you can use the secondary-level delimiter, which is equal sign (=) in the preceding example, to split each key-value pair to the key and value.

Parameter configuration

Parameter	Description
Select Field	The name of the field to split.
first level column delimiter	The delimiter used to split the field at the first level. Default value: \u0001.
secondary level column delimiter	The delimiter used to split the field at the secondary level. Default value: \u0002.
Add column	The fields that store the split data. Specify a key for each field. An alias is allowed.

2.14.6.3.8. Static column splitting

Static column splitting allows you to split data records with fixed columns that are separated by a fixed delimiter.

Example

You can use commas (,) as the delimiter to split the following data to four new columns, that is, 1111, 2222, 3333, and 4444.

```
1111,2222,3333,4444
```

The static column splitting method is applicable to data records with fixed columns that are separated by a fixed delimiter.

Parameter configuration

Parameter	Description
Select Field	The name of the field to split.
column separator	The delimiter used to split the field. You can use full-width characters or half-width characters as needed.
Add column	The fields that store the split data. Specify a key and a sequence number for each field. An alias is allowed.

2.14.6.3.9. Row splitting

Row splitting allows you split a row to multiple rows based on a field by using the specified delimiter.

Example

The following table lists the input data.

id	num
1	1,2

Split the row to multiple rows based on the num field by using the comma (,) as the delimiter, and place the split data in the new field new_num. The following table lists the output data.

id	num	new_num
1	1,2	1
1	1,2	2

Parameter configuration

Parameter	Description	Remarks
Select Field	The name of the field to split.	This parameter is set to num in the preceding example.
Field separator	The delimiter used to split the field. Default value: (\n).	This parameter is set to comma (,) in the preceding example.
Define new column name	The name of the new field that stores the split data.	This parameter is set to new_num in the preceding example.

2.14.6.4. Result tables

2.14.6.4.1. Datahub

Datahub is a real-time data distribution platform that is designed to process streaming data. It provides a channel for the Apsara Stack DTplus platform to process big data. Datahub works with multiple Apsara Stack services to provide an end-to-end data processing solution. Realtime Compute typically uses Datahub to store source and result tables for streaming data processing.

Parameter configuration

Parameter	Description
oriTableName	The table name used in the CREATE TABLE statement. It must be a globally unique name.

Parameter	Description
Output Field	The fields to be returned.
endPoint	The endpoint used to access DataHub. It corresponds to the endPoint parameter in the WITH clause of the CREATE TABLE statement.
project	The name of the Datahub project to which data is to be written. It corresponds to the project parameter in the WITH clause of the CREATE TABLE statement.
topic	The name of the Datahub topic to which data is to be written. It corresponds to the topic parameter in the WITH clause of the CREATE TABLE statement.
accessId	The AccessKey ID used to access Datahub. It corresponds to the accessId parameter in the WITH clause of the CREATE TABLE statement.
accessKey	The AccessKey secret used to access Datahub. It corresponds to the accessKey parameter in the WITH clause of the CREATE TABLE statement.
maxRetryTimes	The maximum number of retries for writing data to DataHub. It corresponds to the maxRetryTimes parameter in the WITH clause of the CREATE TABLE statement.
batchSize	The number of data records that are written at a time. It corresponds to the batchSize parameter in the WITH clause of the CREATE TABLE statement.
batchWriteTimeoutMs	The interval at which the cache is cleared. It corresponds to the batchWriteTimeoutMs parameter in the WITH clause of the CREATE TABLE statement.
maxBlockMessages	The maximum number of data blocks that are written at a time. It corresponds to the maxBlockMessages parameter in the WITH clause of the CREATE TABLE statement.

Field type mapping

The following table lists the mapping between Datahub and Realtime Compute data types. We recommend that you declare the type mapping in the DDL statement.

Datahub data type	Realtime Compute data type
BIGINT	BIGINT
DOUBLE	DOUBLE

Datahub data type	Realtime Compute data type
TIMESTAMP	BIGINT
BOOLEAN	BOOLEAN
DECIMAL	DECIMAL

2.14.6.4.2. Log Service

As an all-in-one real-time data logging service, Log Service allows you to quickly finish tasks such as data ingestion, consumption, delivery, query, and analysis without any extra development work. This can help you improve O&M and operational efficiency, and build up the capability to process large amounts of logs in the data technology era.

Parameter configuration

Parameter	Description
oriTableName	The table name used in the CREATE TABLE statement. It must be a globally unique name.
Output Field	The fields to be returned.
endPoint	The endpoint used to access Log Service. It corresponds to the endPoint parameter in the WITH clause of the CREATE TABLE statement.
project	The name of the Log Service project to which the data is to be written. It corresponds to the project parameter in the WITH clause of the CREATE TABLE statement.
primaryKey	The primary key field of the output fields.
source	The name of the log source. It corresponds to the source parameter in the WITH clause of the CREATE TABLE statement.
accessId	The AccessKey ID used to access Log Service.
accessKey	The AccessKey secret used to access Log Service.
mode	The mode of data writing. It corresponds to the mode parameter in the WITH clause of the CREATE TABLE statement. Default value: `random`. If you set this parameter to `partition`, data is written by partition.
logStore	The name of the Logstore in the Log Service project to which the data is to be written.

2.14.6.4.3. HybridDB for MySQL

HybridDB for MySQL is a Hybrid Transaction/Analytical Processing (HTAP) relational database that supports both online transaction processing (OLTP) and online analytical processing (OLAP).

HybridDB for MySQL features a combination of transaction processing (TP) and analytical processing (AP) to process and analyze data in real time. HybridDB for MySQL is compatible with MySQL syntax and functions. It also supports analytic functions of Oracle databases and complies with the following decision support benchmarks: TPC-H and TPC-DS.

Parameter configuration

Parameter	Description
oriTableName	The table name used in the CREATE TABLE statement. It must be a globally unique name.
Output Field	The fields to be written to the HybridDB for MySQL table.
URL	The URL used to access HybridDB for MySQL.
Table Name in Data Store	The name of the HybridDB for MySQL table to which data is to be written.
Username	The username used to access HybridDB for MySQL.
Password	The password used to access HybridDB for MySQL.
Maximum INSERT Attempts	The maximum number of retries for writing data to HybridDB for MySQL.
Data Records Written per Batch	The number of data records that are written at a time.
Buffer Size	The buffer size after data deduplication. You can only use this parameter when the primary key is defined.
Write Timeout	The timeout period for writing data to HybridDB for MySQL. Unit: milliseconds. If no data is written within the specified timeout period, the cached data records are written one time.
Skip DELETE Operations	Specifies whether to skip DELETE operations.
Primary Key Fields	The primary key field of the output fields.
Add Parameters	You can click this button to create other custom parameters as required.

Note

- Realtime Compute runs an SQL statement to write each row of output data to the result table in HybridDB for MySQL.
- You can set the Buffer Size parameter (hashmap-based buffer size), which defaults to 1000 data records. If the number of cached data records reaches the parameter value, the cached data records are written to the result table. If you specify the batchSize parameter, you also need to specify the bufferSize parameter. You can set the two parameters to the same value.
- We recommend that you specify batchSize='4096' and do not set the parameter to an excessively large value.

2.14.6.4.4. ApsaraDB for RDS

Alibaba Cloud ApsaraDB for Relational Database Service (RDS) offers stable, reliable, and scalable cloud database services.

Parameter configuration

Parameter	Description
oriTableName	The table name used in the CREATE TABLE statement. It must be a globally unique name.
Output Field	The fields to be written to the RDS table.
url	The URL used to access RDS. It corresponds to the url parameter in the WITH clause of the CREATE TABLE statement.
tableName	The name of the RDS table to which data is to be written. It corresponds to the tableName parameter of the WITH clause in the CREATE TABLE statement.
userName	The username used to access RDS. It corresponds to the userName parameter in the WITH clause of the CREATE TABLE statement.
password	The password used to access RDS. It corresponds to the password parameter in the WITH clause of the CREATE TABLE statement.
maxRetryTimes	The maximum number of retries for writing data to RDS. It corresponds to the maxRetryTimes parameter in the WITH clause of the CREATE TABLE statement.
batchSize	The number of data records that are written at a time. It corresponds to the batchSize parameter in the WITH clause of the CREATE TABLE statement.

Parameter	Description
bufferSize	The buffer size after data deduplication. It corresponds to the bufferSize parameter in the WITH clause of the CREATE TABLE statement. You can only use this parameter when the primary key is defined.
flushIntervalMs	The interval at which the data cache is cleared. Unit: milliseconds. It corresponds to the flushIntervalMs parameter in the WITH clause of the CREATE TABLE statement.
excludeUpdateColumns	The fields that will not be updated when Realtime Compute updates data records with the same primary key value. It corresponds to the excludeUpdateColumns parameter in the WITH clause of the CREATE TABLE statement.
ignoreDelete	Specifies whether to skip DELETE operations. It corresponds to the ignoreDelete parameter in the WITH clause of the CREATE TABLE statement.
partitionBy	Specifies the partitioning rule for the result table. Before writing data to the result table, Realtime Compute performs a Hash partitioning based on a partition key. The data records with the same key are then distributed to the same operator. It corresponds to the partitionBy parameter in the WITH clause of the CREATE TABLE statement.
primaryKey	The primary key field of the output fields.

Field type mapping

RDS data type	Realtime Compute data type
TEXT	VARCHAR
BYTE	VARCHAR
INTEGER	INT
LONG	BIGINT
DOUBLE	DOUBLE
DATE	VARCHAR
DATETIME	VARCHAR
TIMESTAMP	VARCHAR
TIME	VARCHAR

RDS data type	Realtime Compute data type
YEAR	VARCHAR
FLOAT	FLOAT
DECIMAL	DECIMAL
CHAR	VARCHAR

JDBC connection parameters

Parameter	Description	Default value	Since version (JDBC driver)
useUnicode	Specifies whether to use the Unicode character set. If you want to set the characterEncoding parameter to gb2312 or gbk, this parameter must be set to true.	*false*	1.1g
characterEncoding	Specifies the character encoding when the useUnicode parameter is set to true. You can set this parameter to gb2312 or gbk.	*false*	1.1g
autoReconnect	Specifies whether to automatically re-establish a connection when the connection to the database is unexpectedly interrupted.	*false*	1.1
autoReconnectForPools	Specifies whether to use the reconnection policy for a database connection pool.	*false*	3.1.3
failOverReadOnly	Specifies whether to set the connection to read-only after the database is automatically reconnected.	*true*	3.0.12

Parameter	Description	Default value	Since version (JDBC driver)
maxReconnects	Specifies the maximum number of reconnection attempts allowed if the autoReconnect parameter is set to true.	*3*	1.1
initialTimeout	Specifies the interval between two reconnection attempts if the autoReconnect parameter is set to true. Unit: seconds.	*2*	1.1
connectTimeout	Specifies the timeout period when you use a socket connection to access the database server. Unit: millisecond. The default value of 0 indicates no timeout (only works on JDK V1.4 and later).	*0*	3.0.1
socketTimeout	The timeout period for a socket operation (read or write). Unit: milliseconds. The default value of 0 indicates no timeout.	*0*	3.0.1

FAQ

- Q: When output data is written to an RDS table, is a new data record generated in the table? If not, is the result table updated based on the primary key value?

  A: If a primary key is defined in the DDL statement, the result table is updated by using the statement: `INSERT INTO tablename(field1,field2, field3, ...) VALUES(value1, value2, value3, ...) ON DUPLICATE KEY UPDATE field1=value1,field2=value2, field3=value3, ...;`. For a data record, if the value of the primary key field does not exist, the record is inserted to the table as a new row. If the value of primary key field exists, the original row in the table is updated. If no primary key is declared in the DDL statement, output data is added to the result table by using the `INSERT INTO` statement.

- Q: How can I perform GROUP BY operations based on the unique index of an RDS table?

  A: An RDS table has only one auto-increment primary key, which cannot be declared as the primary key in the DDL statement of a real-time computing node. If you want to perform GROUP BY operations based on the unique index of the RDS table, declare the unique index in the Primary Key() element of the DDL statement.

2.14.6.4.5. Table Store

Table Store is a distributed NoSQL database service built on the Apsara distributed operating system of Alibaba Cloud. Based on data sharding and load balancing technologies, Table Store has high performance in scaling out and handling concurrent transactions. You can use Table Store to store and query large amounts of structured data.

Parameter configuration

Parameter	Description
oriTableName	The table name used in the CREATE TABLE statement. It must be a globally unique name.
Output Field	The fields to be written to the Table Store table.
instanceName	The name of the Table Store instance. It corresponds to the instanceName parameter in the WITH clause of the CREATE TABLE statement.
tableName	The name of the Table Store table to which data is to be written. It corresponds to the tableName parameter in the WITH clause of the CREATE TABLE statement.
endPoint	The endpoint used to access Table Store. It corresponds to the endPoint parameter in the WITH clause of the CREATE TABLE statement.
accessId	The AccessKey ID used to access Table Store. It corresponds to the accessId parameter in the WITH clause of the CREATE TABLE statement.
accessKey	The AccessKey secret used to access Table Store. It corresponds to the accessKey parameter in the WITH clause of the CREATE TABLE statement.
valueColumns	The names of fields to be inserted to the result table. Separate multiple names with commas (,).
bufferSize	The buffer size after data deduplication. It corresponds to the bufferSize parameter in the WITH clause of the CREATE TABLE statement.
batchWriteTimeoutMs	The timeout period for writing data to Table Store. Unit: milliseconds. It corresponds to the batchWriteTimeoutMs parameter in the WITH clause of the CREATE TABLE statement.
batchSize	The maximum number of retries for writing data to Table Store. It corresponds to the batchSize parameter of the WITH clause in the CREATE TABLE statement.
retryIntervalMs	The retry interval at which data is written. It corresponds to the retryIntervalMs parameter in the WITH clause of the CREATE TABLE statement.

Parameter	Description
ignoreDelete	Specifies whether to skip DELETE operations. It corresponds to the ignoreDelete parameter in the WITH clause of the CREATE TABLE statement.
primaryKey	The primary key field of the output fields.

Field type mapping

Table Store data type	Realtime Compute data type
INTEGER	BIGINT
STRING	VARCHAR
BOOLEAN	BOOLEAN
DOUBLE	DOUBLE

2.14.6.4.6. MaxCompute

Realtime Compute supports creating a MaxCompute table as the result table.

Parameter configuration

Parameter	Description
oriTableName	The table name used in the CREATE TABLE statement. It must be a globally unique name.
tableName	The name of the MaxCompute table to which data is to be written.
Output Field	The fields to be written to the MaxCompute table.
endPoint	The endpoint used to access MaxCompute. It corresponds to the endPoint parameter in the WITH clause of the CREATE TABLE statement.
tunnelEndPoint	The endpoint of the Tunnel service, which is required for a MaxCompute project deployed in a Virtual Private Cloud (VPC). It corresponds to the tunnelEndPoint parameter in the WITH clause of the CREATE TABLE statement.
project	The name of the MaxCompute project to which data is to be written. It corresponds to the project parameter in the WITH clause of the CREATE TABLE statement.

Parameter	Description
accessId	The AccessKey ID used to access MaxCompute. It corresponds to the accessId parameter in the WITH clause of the CREATE TABLE statement.
accessKey	The AccessKey secret used to access MaxCompute. It corresponds to the accessKey parameter in the WITH clause of the CREATE TABLE statement.
partition	The partitions to which the data is to be written. It corresponds to the partition parameter in the WITH clause of the CREATE TABLE statement. This parameter must be specified for a partitioned table. For example, if the partition name of a table is `ds=20180905`, you can specify the parameter as `` `partition` = 'ds=20180905' ``. Separate multiple levels of partitions with commas (,), for example, `` `partition` = 'ds=20180912,dt=xxxyyy' ``.

Note Realtime Compute writes cached data to a MaxCompute table every time when a checkpoint is reached.

Field type mapping

MaxCompute data type	Realtime Compute data type
TINYINT	TINYINT
SMALLINT	SMALLINT
INT	INT
BIGINT	BIGINT
FLOAT	FLOAT
DOUBLE	DOUBLE
BOOLEAN	BOOLEAN
DATETIME	TIMESTAMP
TIMESTAMP	TIMESTAMP
VARCHAR	VARCHAR
STRING	STRING
DECIMAL	DECIMAL

MaxCompute data type	Realtime Compute data type
BINARY	VARBINARY

FAQ

Q: Does a real-time computing node clear the result table before it writes data to the MaxCompute sink that is in Stream mode when `isOverwrite` is set to `true`?

A: The `isOverwrite` parameter is set to `true` by default. That is, a real-time computing node clears the result table and result data before it writes data to the sink. Every time a real-time computing node starts or resumes after being paused, it clears data of the existing result table or the result partition before it writes data. Certain data may be lost when data is cleared after a paused real-time computing node is resumed.

2.14.6.4.7. AnalyticDB

Parameter configuration

Parameter	Description
oriTableName	The table name used in the CREATE TABLE statement. It must be a globally unique name.
Output Field	The fields to be written to the AnalyticDB table.
url	The URL used to access AnalyticDB. It corresponds to the url parameter in the WITH clause of the CREATE TABLE statement.
tableName	The name of the AnalyticDB table to which data is to be written. It corresponds to the tableName parameter in the WITH clause of the CREATE TABLE statement.
userName	The username used to access AnalyticDB. It corresponds to the userName parameter in the WITH clause of the CREATE TABLE statement.
password	The password used to access AnalyticDB. It corresponds to the password parameter in the WITH clause of the CREATE TABLE statement.
maxRetryTimes	The maximum number of retries for writing data to AnalyticDB. It corresponds to the maxRetryTimes parameter in the WITH clause of the CREATE TABLE statement. Default value: 3.
bufferSize	The buffer size after data deduplication. It corresponds to the bufferSize parameter in the WITH clause of the CREATE TABLE statement.

Parameter	Description
batchSize	The maximum number of retries for writing data to AnalyticDB. It corresponds to the batchSize parameter in the WITH clause of the CREATE TABLE statement.
batchWriteTimeoutMs	The timeout period for writing data to AnalyticDB. It corresponds to the batchWriteTimeoutMs parameter in the WITH clause of the CREATE TABLE statement.
connectionMaxActive	The maximum number of connections in a single connection pool. It corresponds to the connectionMaxActive parameter in the WITH clause of the CREATE TABLE statement.
ignoreDelete	Specifies whether to skip DELETE operations. It corresponds to the ignoreDelete parameter in the WITH clause of the CREATE TABLE statement.
primaryKey	The primary key field of the output fields.

2.14.6.5. Node O&M

On the **Stream Studio** page, click **OAM** in the upper-right corner to go to the OAM page.

2.14.6.6. FAQ

This topic describes the frequently asked questions (FAQs) about Stream Studio.

Q: What computing engine do I need to activate before using Stream Studio?

A: You must first activate Realtime Compute because Stream Studio is a development platform based on Realtime Compute.

Q: Where can I create a Realtime Compute project? How do I bind the project to Stream Studio?

A: You can create a Realtime Compute project in the Realtime Compute console. After a project is created, you can bind it to an existing DataWorks workspace in the DataWorks console or directly create a workspace and bind the project to it. After the Realtime Compute project is bound to your workspace, you can develop real-time computing nodes in Stream Studio.

Q: What are the advantages of the directed acyclic graph (DAG) mode in Stream Studio? What are the similarities and differences between the DAG mode and SQL mode?

A: Stream Studio supports both the DAG mode and the SQL mode to develop real-time computing nodes. In DAG mode, you can perform drag-and-drop operations on components to configure real-time computing nodes without writing code. In this mode, what you see is what you get. You can also switch to the SQL mode to configure nodes by writing SQL statements.

Q: What types of SQL does Stream Studio support?

A: Realtime Compute is based on Apache Flink. Therefore, Stream Studio supports Flink SQL.

2.15. Graph Studio

2.15.1. Overview

Graph Compute is a next-generation one-stop platform for graph data management and analysis. Based on Graph Compute, Graph Studio provides an all-in-one R&D platform for Graph Compute. This topic describes how to use Graph Compute through Graph Studio.

Graph Compute allows you to model, import, and modify graph data and use the standard Gremlin language of Apache TinkerPop to query graph data. It also supports common graph analysis algorithms. Graph Compute features fast data loading, auto scaling, millisecond-level query latency, hybrid compute engines for online and offline graph computing, and shared data storage. You can use Graph Compute to easily build graph applications with large amounts of relational data.

Graph Studio provides graph application developers with all-in-one R&D services, including instance modeling, data import, data query, visualized analysis, instance management, and node O&M.

> **Note** You must bind a Graph Compute instance to your DataWorks workspace to use Graph Studio. The message shown in the following figure appears if you have not bound a Graph Compute instance to the current workspace. Bind a Graph Compute instance accordingly.

- Instance modeling: allows you to create vertices and edges to design a graph schema for your Graph Compute instance. You can configure the vertices, edges, and their attributes flexibly.
- Data import: allows you to create automatic sync nodes to import data to vertices and edges. You can schedule the sync nodes flexibly to automatically update data. Currently, you can import data stored in MaxCompute tables to Graph Compute. For more information, see Data import.
- Data query: allows you to use the standard Gremlin language of Apache TinkerPop to query graph data. For more information, see Data query.
- Node O&M: allows you to quickly filter and view the details of sync nodes. For more information, see Node O&M.

2.15.2. Instance modeling

During instance modeling, you can create vertices and edges to design a graph schema for your Graph Compute instance in visual mode or tabular mode.

Go to the Model Design page

1. Log on to the DataWorks console.
2. Click the DataWorks icon in the upper-left corner and choose **All Products > Graph Studio**.
3. On the Graph Studio page, click **Model Design**.

Visual mode

On the **Model Design** page, click the Graph Compute instance for which you want to design a schema. By default, the tab for designing the schema in **visual mode** appears.

- Create a vertex

  You can drag and drop the vertex icon to the canvas and set vertex parameters to create a vertex.

Drag and drop the icon to the canvas. In the right-side **Add To** dialog box that appears, set parameters as required and click **Save**.

Parameter	Description
Types	The type of the item to create. Valid values: **Point** and **Side**.
Type Name	The name of the vertex. A vertex name can contain letters, digits, and underscores (_). It can be up to 128 characters in length. **Note** The name of each vertex in the same Graph Compute instance must be unique.
Display Name	The display name of the vertex.
Remarks	The description of the vertex.
Display Color	The default color of the vertex in visual mode. Default value: *green*.
Display Size	The default size of the vertex in visual mode. Default value: *M*.
Display Content	The display content of the vertex in visual mode. Default value: the value of the **Type Name** parameter.
Attribute Configuration	You can view the name, type, description, default value, and primary key of each property of the vertex. You can click **+New Attribute** to add a property for the vertex. **Note** You can delete a property that has not been saved.

- Create an edge
  i. Move the pointer over the vertex where you want to create an edge. The icon appears.
  ii. Drag and drop the icon to the target vertex to connect to. In the right-side **Add To** dialog box that appears, set parameters as required.

Parameter	Description
Types	The type of the item to create. Valid values: **Point** and **Side**.
Type Name	The name of the edge. **Note** The name of each edge in the same Graph Compute instance must be unique.
Display Name	The display name of the edge.

Parameter	Description
Display Color	The default color of the edge in visual mode. Default value: *primary*.
Display Content	The display content of the edge in visual mode. Default value: the value of the *Type Name* parameter.
Remarks	The description of the edge.
Attribute Configuration	You can view the name, type, description, and default value of each property of the edge and perform operations on the properties. You can click **+New Attribute** to add a property for the edge.
Relationship Configuration	You must select two vertices from the created ones to set them as the source and target vertices of the edge. You can click **+Add Point-Edge Relationship** to add a vertex-edge connection for the edge as required. **Note** An edge can have multiple vertex-edge connections.

iii. Click **Save** to create the edge.

- Modify a vertex

Note Note the following limits when you modify a vertex:

- You cannot change the name of the vertex, but you can change the description, display color, display size, and display content of it.
- You cannot add a property as the primary key to the vertex.
- You cannot delete the primary key property from the vertex. The corresponding sync node may fail after you delete a property from the vertex. In this case, you must manually modify the node. Delete a property with caution.
- You can only change the description of existing properties for the vertex.

i. Click a vertex that you want to modify. The **Overview** dialog box appears on the right side.

ii. Click **Edit**. In the **Update** dialog box that appears, change the parameter configuration.

iii. Verify that the settings are correct and click **Save**.

- Modify an edge

> **Note** Note the following limits when you modify an edge:
>
> - You cannot change the name of the edge, but you can change the description, display color, and display content of it.
> - You can only change the description of existing properties for the edge.
> - You can add or delete properties for the edge. However, make sure that at least one vertex-edge connection exists.
> - The corresponding sync node may fail after you modify properties or vertex-edge connections of the edge. In this case, you must manually modify the node. Modify properties or vertex-edge connections with caution.

i. Click an edge that you want to modify. The **Overview** dialog box appears on the right side.
ii. Click **Edit**. In the **Update** dialog box that appears, change the parameter configuration.
iii. Verify that the settings are correct and click **Save**.

- Delete a vertex or an edge
  i. Right-click a vertex or an edge that you want to delete.
  ii. Select **Delete**.
  iii. In the **Note** dialog box that appears, click **OK**.

Tabular mode

On the **Model Design** page, click the Graph Compute instance for which you want to design a schema. By default, the tab for designing the schema in **visual mode** appears.

Click **Tabular Mode** in the upper-right corner to switch to the tabular mode.

- Create a vertex

  In this mode, you can set relevant parameters to create a vertex.

  i. Move the pointer over the **+** icon and click **New Point**.

     You can also click **Add To** in the **Model Design** section to create a vertex.
  ii. In the **Add To** dialog box that appears, set parameters as required. For more information about the parameters, see the parameter description for the visual mode.
  iii. After the configuration is completed, click **Save**.

- Create an edge
  i. Move the pointer over the **+** icon and click **New Side**.

     You can also click **Add To** in the **Model Design** section to create an edge.
  ii. In the **Add To** dialog box that appears, set parameters as required. For more information about the parameters, see the parameter description for the visual mode.
  iii. After the configuration is completed, click **Save**.

- Modify a vertex

  Click **Change Settings** in the Actions column of a vertex that you want to modify. In the **Update** dialog box that appears, change the parameter configuration as required and click **Save**.

> **Note** Note the following limits when you modify a vertex:
>
> - You cannot change the name of the vertex, but you can change the description, display color, display size, and display content of it.
> - You cannot add a property as the primary key to the vertex.
> - You cannot delete the primary key property from the vertex. The corresponding sync node may fail after you delete a property from the vertex. In this case, you must manually modify the node. Delete a property with caution.
> - You can only change the description of existing properties for the vertex.

- Modify an edge

  Click **Change Settings** in the Actions column of an edge that you want to modify. In the **Update** dialog box that appears, change the parameter configuration as required and click **Save**.

> **Note** Note the following limits when you modify an edge:
>
> - You cannot change the name of the edge, but you can change the description, display color, and display content of it.
> - You can only change the description of existing properties for the edge.
> - You can add or delete properties for the edge. However, make sure that at least one vertex-edge connection exists.
> - The corresponding sync node may fail after you modify properties or vertex-edge connections of the edge. In this case, you must manually modify the node. Modify properties or vertex-edge connections with caution.

2.15.3. Data import

Currently, Graph Studio only allows you to import data stored in MaxCompute tables to Graph Compute.

Go to the Data Import page

After you create a vertex or an edge, a corresponding sync node is automatically generated for the vertex or edge. You can import data stored in MaxCompute tables to the vertex or edge in **visual mode** or **tabular mode**. Follow these steps to open the data import page in the visual mode and tabular mode respectively:

- **Visual mode**

  Open the Graph Compute instance. The tab for importing data in **visual mode** appears by default, where you can import data to vertices and edges.

  - Import data to a vertex: Right-click a vertex and select **Data Import**.
  - Import data to an edge: Right-click an edge, select **Data Import**, and then click a vertex-edge connection.

- **Tabular mode**

  Open the Graph Compute instance. The tab for importing data in visual mode appears by default. Click **Tabular Mode** in the upper-right corner switch to the tabular mode. Click **Data Import** in the Actions column of a vertex or an edge to import data.

Configure the sync node

After you select or click **Data Import** for a vertex or an edge, the **DataStudio** page appears.

- Import data to a vertex
  i. Configure the source and destination connections for the sync node.

     Set Connection in the **Source** section to ODPS and specify the MaxCompute table and partitions from which data is imported. The Connection parameter in the **Target** section is set to the target vertex of the Graph Compute instance by default.

  ii. Fields in the source table on the left have a one-to-one mapping with fields in the destination table on the right. You can click **Add** to add a field or move the pointer over a field and click the **Delete** icon to delete the field.

  iii. Configure the channel.

Parameter	Description
Expected Maximum Concurrency	The maximum number of concurrent threads to read and write data to data storage within a single sync node. You can configure the concurrency for a node on the codeless UI.
Bandwidth Throttling	Specifies whether to enable bandwidth throttling. You can enable bandwidth throttling and set a maximum transmission rate to avoid heavy read workload of the source. We recommend that you enable bandwidth throttling and set the maximum transmission rate to a proper value.
Dirty Data Records Allowed	The maximum number of dirty data records allowed.
Resource Group	The servers on which nodes are run. If an excessively large number of nodes are run on the default resource group, some nodes may be delayed due to insufficient resources. In this case, you can add a custom resource group.

  iv. Configure the node properties.

     Click the **Properties** tab in the right-side navigation pane. On the **Properties** tab that appears, set the parameters. For more information, see Schedule.

  v. Commit the node.

     After you set the properties, click **Save** in the tool bar to commit the node to the development environment. After you commit the node to the development environment, the node is unlocked.

  vi. Deploy the node.

     For more information, see Deploy.

  vii. Test the node in the production environment.

     For more information, see Recurring tasks.

- Import data to an edge

  The procedure of importing data to an edge is similar to that of importing data to a vertex. The difference is that you must specify a target vertex-edge connection to which data is imported. In addition, you must specify the primary keys of the source and destination vertices connected by the edge For more information, see Import data to a vertex.

> **Note** If you want to delete a vertex or an edge from a schema, you must also manually delete it from the sync node.

2.15.4. Data query

Graph Studio allows you to use the graph traversal language, Gremlin, of Apache TinkerPop to query graph data.

Create a graph query node

1. Go to the Graph Studio page. In the left-side navigation pane, click **Data Query**.
2. On the Data Query page, move the pointer over the **Create** icon and choose **Create > Graph Query**.
3. In the **Create Node** dialog box that appears, set the **Diagram Example**, **Location**, **Node Name** parameters.
4. Click **Submit** to create the graph query node.
5. Enter and run the Gremlin query statement in the editor. The query result is returned.

View the query results

The following figure shows the query results of running the `g.V().limit(10)` statement.

As shown in the preceding figure, the results section provides three tabs to display the query results in graph mode, display the query results in tabular mode (in the form of an Excel file), and display operational logs, respectively. By default, operational logs appear when you run the graph query node. If the query results contain vertices or edges, they are provided in graph mode. Otherwise, the query results are provided in tabular mode.

- Graph mode

  In graph mode, vertices or edges are provided in a graph so that you can clearly view them. You can click a vertex or an edge to view its detailed information and properties.

- Tabular mode

  In tabular mode, the detailed information and properties of each vertex or edge are provided in a table.

- Operational logs

  The log tab displays the operational logs generated when you run the Gremlin statement in the graph query node.

2.15.5. Node O&M

The Operation and Maintenance page displays all sync nodes of a Graph Compute instance, so that you can view the data update status.

Click **Operation and Maintenance** in the upper-right corner to go to the corresponding page. You can also filter sync nodes by instance name, vertex or edge name, running status, node type, and data timestamp to find the required sync node and view its details.

2.16. Data Protection

2.16.1. Overview

Data Protection is a data security management platform. It can be used to detect data assets, detect sensitive data, classify data, de-identify data, monitor data access behavior, report alerts, and audit risks.

Data Protection provides security management services for MaxCompute.

Access Data Protection

1. Log on to the DataWorks console.
2. On the DataWorks page that appears, click the icon in the upper-left corner and choose **All Products > Data Protection**.
3. Click **Try now** to go to the Data Protection page.

Features

Data Protection provides the following features:

- Intelligent sensitive data detection

  Data Protection automatically detects an enterprise's sensitive data based on self-training models and algorithms, and clearly displays statistics on data types, volume, and visitors. It also recognizes custom data types.

- Accurate data classification: Data Protection allows you to classify data and create custom levels for better data management.
- Flexible data de-identification

  Data Protection provides diverse and configurable methods for dynamic data de-identification.

- Risky behavior monitoring and auditing

  Data Protection uses various correlation analysis algorithms to detect risky behavior. It also provides alerts and supports visualized auditing for detected risks.

2.16.2. Services

This topic describes the commonly used services provided by Data Protection.

Service	Description
Configure rules for defining sensitive data	You can configure rules to define sensitive data based on the security regulations and requirements of your organization. Data Protection can detect the sensitive data you have defined.
View the distribution of data	With an authorized account, Data Protection automatically detects sensitive data in the tenant's MaxCompute projects based on the data detection rules that are defined. Then, you can view the distribution of detected data on the next day.
View the information about data activities	Data Protection provisions manipulate, query, and export activities related to sensitive data from different perspectives.

Service	Description
View the information about data export	Data Protection monitors activities with sensitive data exported from MaxCompute based on the risk detection rules you have configured.
Manage the data security levels	You can specify data security levels based on security regulations and requirements of your organization.
Manage data that is incorrectly detected	You can manually correct detected data types and remove or recover sensitive data.

2.16.3. Access Data Protection

This topic describes how to access Data Protection.

1. Log on to the DataWorks console.
2. Move the pointer over the DataWorks icon in the upper-left corner and then choose **All Products > Data Protection**.

Data Protection provides security management services for MaxCompute.

Toolbar	Description
Top navigation bar	The services that the current user has permissions to access, including DataStudio, Data Management, Operation Center, Organization Management, Project Management, Real-Time Analysis, DataService Studio, Machine Learning Platform For AI, and Data Protection.
User information	The personal information that can be viewed and edited by the current user, including the email address, mobile number, and AccessKey.
Left-side navigation pane	The left-side navigation pane for the services that can be navigated to from the top navigation bar. Items in the navigation pane vary depending on the specific service.
Home page of Data Protection	The brief description of core features.

2.16.4. Configure rules for defining sensitive data

This topic describes how to configure rules for defining sensitive data.

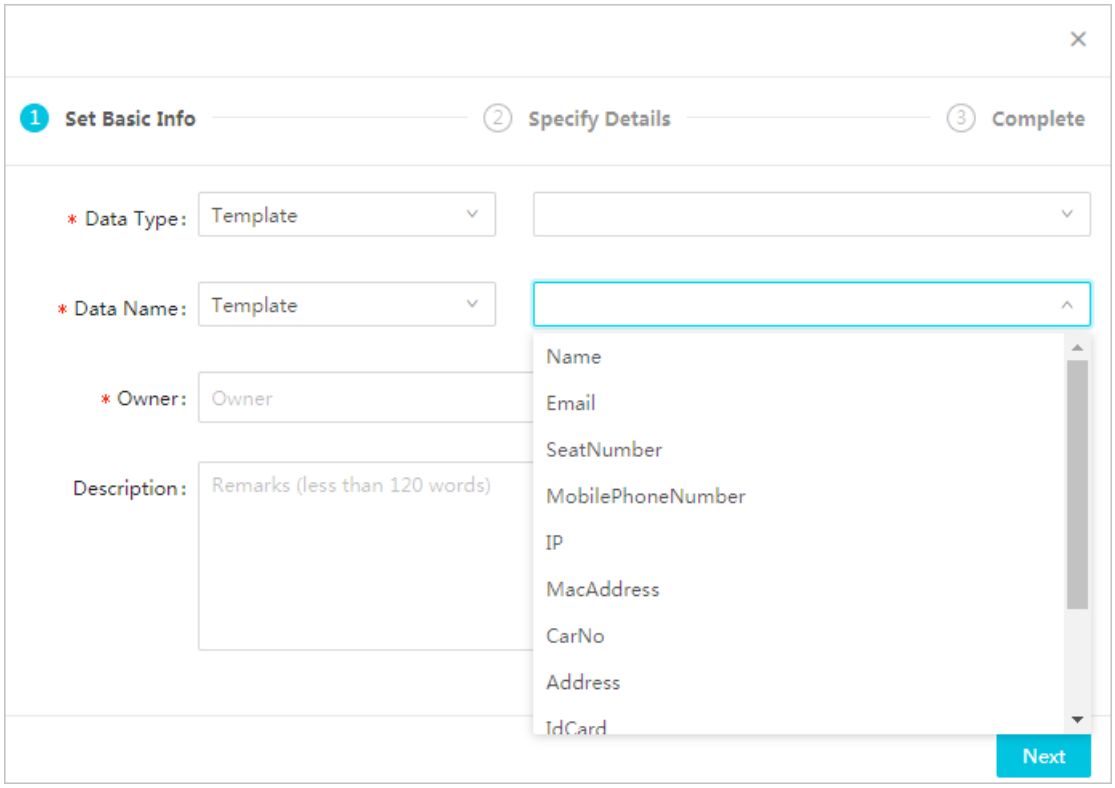
Procedure

1. Log on to the DataWorks console.
2. On the DataStudio page that appears, click the DataWorks icon in the upper-left corner and choose **All Products > Data Protection**.
3. Click **Try now** to go to the **Data Security Guard** page.
4. In the left-side navigation pane, choose **Management > Data Definition**. On the Data

Recognition Rules page that appears, click **Create Rule**.

5. In the dialog box that appears, set parameters in the **Set Basic Info** step.

   You can create a template-based identification rule or a custom identification rule.



Parameter	Description
Data Type	The category of the rule. You can select Template or Custom from the Data Type drop-down list. ◦ If you select **Template**, you can select **Personal Information**, **Merchant Information**, or **Company Information** from the right drop-down list. ◦ If you select **Custom**, you can enter a data type.
Data Name	◦ If you select **Template** from the drop-down list, you can select a built-in identification rule template from the right drop-down list. You can select **Email**, **SeatNumber**, **MobilePhoneNumber**, **IP**, **MacAddress**, **CarNo**, **PostCode**, **IdCard**, or **BankCard**. ◦ If you select **Custom**, you can enter a data name.
Owner	The owner of the rule.
Description	The description of the rule.

6. Click **Next**. Set the **Level** and **Data Definition** parameters.

Parameter	Description
Level	The security level of the sensitive data to which the rule is applied. If the existing security levels cannot meet your needs, click **Levels** in the left-side navigation pane to change the level settings.
Content Scanning	Specifies whether to enable content scanning. This option is selected by default for all the built-in data identification templates. ○ If you select a template, you cannot modify the identification rule, but you can verify the accuracy of the identification rule. ○ If you select regular expression matching, you can customize the identification rule.
Field Scanning	Specifies whether to enable field scanning. This approach provides two matching methods: exact matching and fuzzy matching of field names. Multiple-field matching is supported, and the relationship between the fields is OR.

7. Click **Next**. After you confirm the configuration, click **Save and Apply**.

> **Note** When you create a rule to define sensitive data, note the following:
> - The rule name must be unique.
> - The content scanning and field scanning configuration must be unique.
> - You can only view the sensitive data that is detected based on the data identification rule one day after the rule takes effect.

2.16.5. View the distribution of sensitive data

On the next day after you configure and activate sensitive data identification rules as a data security administrator, you can access Data Recognition to view the distribution of sensitive data.

1. Log on to the DataWorks console.
2. On the DataStudio page that appears, click the DataWorks icon in the upper-left corner and choose **All Products > Data Protection**.
3. In the left-side navigation pane, click **Data Recognition**. On the Data Recognition page that appears, you can view the overall data distribution and field details.

2.16.6. View the information about data activities

On the next day after you configure and activate sensitive data identification rules as a data security administrator, you can access Data Activities to view related activity statistics, trend, and details.

1. Log on to the DataWorks console.
2. On the DataStudio page that appears, click the DataWorks icon in the upper-left corner and choose **All Products > Data Protection**.
3. In the left-side navigation pane, click **Data Activities** to go to the **Data Activities** page.

The Data Activities page allows you to view the information of each activity that involves sensitive data. On the Manipulations and Queries tab, you can view the statistics, trend, user, and details of data access activities. On the Export tab, you can view the statistics and details of data export.

2.16.7. View the data audited as risky

Data activities are audited manually or based on the risk identification rules and AI-based identification rules. The Data Risks page displays data activities that are audited as risky. You can comment audit results as required.

1. Log on to the DataWorks console.
2. On the DataStudio page that appears, click the DataWorks icon in the upper-left corner and choose **All Products > Data Protection**.
3. Click **Try now** to go to the **Data Security Guard** page.
4. In the left-side navigation pane, click **Data Risks** to filter and view the data audited as risky as needed.

2.16.8. Manage the data security levels

When creating a rule, you can specify a security level for the data to which the rule applies. On the Levels page, you can create and delete security levels. You can also modify the priority of each security level and manage rules by security level.

1. Log on to the DataWorks console.
2. On the DataStudio page that appears, click the DataWorks icon in the upper-left corner and choose **All Products > Data Protection**.
3. Click **Try now** to go to the **Data Security Guard** page.
4. In the left-side navigation pane, choose **Management > Levels**.

   On the **Levels** page, you can create and delete security levels. You can also modify the priority of each security level and manage rules by security level.

Operation	Description
Create a security level	Click **Create Level**. Specify the security level name and operator.
Manage rules by security level	Find the target security level and click the icon in the Actions column. In the Manage Rules by Level dialog box that appears, you can select a rule and adjust its security level.
Delete a security level	Find the target security level and click the icon in the Actions column. In the dialog box that appears, click **Delete**.
Modify the priority of a security level	Find the target security level. Drag and drop the icon in the Actions column.

2.16.9. Manage data that is incorrectly detected

On the Manual Check page, you can manually correct the sensitive data that is incorrectly detected by rules. For example, you can delete incorrectly detected data, change the type of the detected data, and delete or recover data in batches.

1. Log on to the DataWorks console.
2. On the DataStudio page that appears, click the DataWorks icon in the upper-left corner and choose **All Products > Data Protection**.
3. Click **Try now** to go to the **Data Security Guard** page.
4. In the left-side navigation pane, choose **Management > Manual Check**.

   On the Manual Check page, you can delete incorrectly detected data, change the type of the detected data, and delete or recover data in batches.

   - To delete a data record that is incorrectly detected, turn off the switch in the Status column of the data record.

     > **Note** You can recover data records that you have deleted.

   - To change the type of a data record, click the edit icon next to the name of the target rule and select a rule.

     > **Note** You can only select a rule that has been configured in DataWorks.

   - To delete or recover multiple data records at the same time, you can select the data records and click **Remove** or **Recover**.

2.16.10. Customize de-identification rules

This topic describes how to customize de-identification rules in Data Protection so that DataWorks can dynamically de-identify the results of ad-hoc queries.

Customize de-identification rules in Data Protection

1. Log on to the DataWorks console.
2. On the DataStudio page that appears, click the DataWorks icon in the upper-left corner and choose **All Products > Data Protection**.
3. Click **Try now** to go to the **Data Security Guard** page.
4. In the left-side navigation pane, choose **Management > Data Masking**.
5. On the Data Masking page, set **Masking Scene** to **Default (_default_scene_code)** and then click **Create Rule** in the upper-right corner.
6. In the **Create Rule** dialog box that appears, set the **Rule**, **Owner**, and **Method** parameters.

   > **Note** You must first create sensitive data identification rules and activate them on the **Data Definition** page. Then, you can use the rules when configuring data de-identification rules.

Currently, Data Protection provides two methods for data de-identification, including **Hashing** and **Masking Out**.

- **Hashing**

  If you select this method, you must specify a security domain. Rules with different security domains generate different hash values for the same data record.

- **Masking Out**

  This method uses asterisks (*) to mask specified parts of a data record. It is commonly used.

Parameter	Description
Recommended	You can select recommended policies to mask data of common types such as ID card numbers and bank card numbers.
Custom	You can flexibly specify whether to mask the specified number of characters at the first, middle, or last part of a data record.

7. After the configuration is completed, click **OK**. The **Data Masking** page appears.
8. On the **Data Masking** page, change the status of a rule to **Active** or **Inactive** as needed.

   After the configuration is completed, click the icon in the Actions column of the rule to test whether it works.
9. Click the **Whitelist** tab on the **Data Masking** page. On the tab, click **Add Account**.
10. In the **Add Account** dialog box that appears, set the **Rule**, **Account**, and **Effective From** parameters and click **Save**.

> **Note** If you query data beyond the time range specified for the whitelist, the query results will still be de-identified.

Verify the de-identification effect in DataWorks

After you create and configure de-identification rules, DataWorks dynamically de-identifies the results of queries in your workspace based on the rules.

> **Note** You must first turn on Mask Data in Page Query Results for your workspace in the DataWorks console. For more information, see Project Configuration.

2.17. App Studio

2.17.1. Overview

App Studio is a tool designed to help you develop data products. It comes with a rich set of front-end components that you can drag and drop to simply and quickly build front-end apps.

With App Studio, you do not need to download and install a local integrated development environment (IDE) or configure and maintain environment variables. Instead, you can use a browser to write, run, and debug apps and enjoy the same programming experience as that in a local IDE. App Studio also allows you to publish apps online.

Advantages

App Studio has the following core advantages:

- Data development anytime, anywhere

  You do not need to download and install a local IDE or configure and maintain environment variables. Instead, you can use a browser to develop data in your office, at home, or anywhere that you can connect to the network.

- Editor with complete features

  App Studio provides a browser-based editor that allows you to easily write, run, and debug projects. When you enter the code, App Studio provides code hinting, code completion, and repair suggestions. You can also find all references and the definition of a method to automatically generate code.

- Online debugging

  App Studio comes with all breakpoint types and operations of a local IDE. It supports thread switching and filtering, variable checking and watching, remote debugging, and hot code replacement.

- Multi-feature terminal

  You can directly access the runtime environment, which is currently built based on CentOS as the base image. The multi-feature terminal supports all bash commands, including vim and other interactive commands.

- Collaborative coding

  You and your team members can use App Studio to share the development environment for collaborative coding. Currently, App Studio allows a maximum of eight users to edit the same file of a project online concurrently, improving work efficiency. In the future, the collaborative coding component will support chatting, bullet screen messages, code annotations, videos, and other features to make teamwork efficient and pleasant.

- Plug-in system

  App Studio supports business plug-ins, tool plug-ins, and language plug-ins.

  - App Studio allows you to customize any required menu or add any service portal based on your business needs.
  - You can customize project management processes, project types, and templates dedicated to your business.
  - You can develop common tools, such as enhanced Git features, code rule scanning, keyboard shortcuts, enhanced editing features, and code snippets, and integrate them into App Studio.
  - You can use language plug-ins to enrich the languages supported by App Studio, enabling App Studio to serve users with more languages while addressing your own business needs.

- Visual building

  App Studio provides a WYSIWYG designer that has rich components and deeply integrates DataService Studio and DataStudio. Among all components of DataWorks, you can call DataWorks API operations only in App Studio. In addition to calling the API operations, you can quickly build front-end apps by dragging and dropping components and configuring them in the WYSIWYG designer based on the santa file system, developing web apps without code.

- Rich templates and flexible project management

App Studio provides rich project templates, allowing you to develop your project accordingly with fewer steps and higher efficiency. You can also save your project as a template for future development and use, or share it with other users.

2.17.2. Get started with App Studio

To build a data portal, engineers need to develop data, build backend services, and develop front-end pages. This topic describes the basic features of App Studio and how to use App Studio.

Originally, DataWorks is mainly used by data engineers to implement offline or streaming data development. As DataWorks becomes increasingly easy to use, many roles such as algorithm engineers, BI analysts, operators, and product managers who are familiar with SQL can use DataWorks to develop data.

App Studio helps different types of users quickly build webpages for data viewing and apps for data query.

Go to the App Studio page

1. Log on to the DataWorks console.
2. On the DataStudio page that appears, click the DataWorks icon in the upper-left corner and choose **All Products > App Studio**. The **Projects** page appears.

Create a front-end project

App Studio provides complete front-end development capabilities that allow you to develop front-end projects in the same way as in a local integrated development environment (IDE). Without the need to master or understand any new concepts, you can create front-end projects in App Studio and develop HTML, CSS, JavaScript, and React files in a way that you are familiar with.

1. Create a project based on the sample project.
   i. Go to the **App Studio** page and click **Projects** in the left-side navigation pane. On the Projects page, click **Create Project from Code**.
   ii. On the **Create Project** page, set the **Name** and **Description** parameters, and set the runtime environment to **react-demo**.

   > **Note**
   > - The name of the project must start with a letter and can contain digits, letters, underscores (_), and hyphens (-).
   > - The description of the project can be 2 to 500 characters in length.

   iii. After the configuration is completed, click **Submit**.
2. Set running parameters.

   In the upper-right corner, choose **Edit Config** > Edit Configurations. In the **Run/Debug Configurations** dialog box that appears, set the required parameter. Select the instance type and specify the port number as required. You can use the default configuration unless otherwise required. Then, click **OK**.

Parameter	Description
Install Cmd	The command used to install the dependency, for example, **npm install**.
Start Cmd	The command used to start the app, for example, **npm start**.
Environment Variables	The environment variables.
Initialize Script	The path of the script used to initialize a container in the code library.
PORT	The port of the Elastic Compute Service (ECS) instance. Default value: 3000.
ECS Instance	The instance type. Valid values: **1vCPU 2GMemory**, **2vCPU 3GMemory**, **4vCPU 8GMemory**, and **8vCPU 16GMemory**.

3. Run the project.

   Click the Run icon in the upper-right corner to run the project. Currently, you can run the `tnpm start` command to start front-end projects. You can seamlessly run projects with *webpack-dev-server* configured.

   During project running, you can view the dependency installation and app startup logs. After the project running is completed, the Preview tab appears in the right-side navigation pane. You can edit and save the code in real time. The edited code takes effect immediately.

4. Access the project.

   Click the **Preview** tab in the right-side navigation pane, and click the arrow next to the access link to open the project.

   In App Studio, you can edit and develop front-end projects in the same way as in a local IDE. App Studio supports code completion, method signature, refactoring, and redirection for HTML, CSS, LESS, SCSS, JavaScript, TypeScript, JSX, and TSX files. In addition, you can develop front-end projects based on templates without the need to build any environment or download any dependency.

Create a backend project

1. Create a project based on the sample project.
   i. Go to the **App Studio** page and click **Projects** in the left-side navigation pane. On the Projects page, click **Create Project from Code**.
   ii. On the **Create Project** page, set the **Name** and **Description** parameters, and set the runtime environment to **springboot**.
   - The name of the project must start with a letter and can contain digits, letters, underscores (_), and hyphens (-).
   - The description of the project can be 2 to 500 characters in length.

   iii. After the configuration is completed, click **Submit**.
2. Set running parameters.

In the upper-right corner, choose **Edit Config** > Edit Configurations. In the **Run/Debug Configurations** dialog box that appears, set the required parameter and then click **OK**.

Parameter	Description
Main class	Select the main method. If no main method is available, check whether your project has a main method.
VM options	The virtual machine (VM) options.
Program arguments	The app parameters.
Environment Variables	The environment variables.
JRE	The Java runtime environment (JRE). By default, this parameter cannot be modified.
PORT	The port of the ECS instance. Default value: *7001*.
ECS Instance	The instance type. Valid values: **1vCPU 2GMemory**, **2vCPU 3GMemory**, **4vCPU 8GMemory**, and **8vCPU 16GMemory**.
Pre-Launch Option	The commands to be run before the project is run. You can specify up to three commands.
Enable Hot Code	Specifies whether to enable hot code replacement.

You can click **Add** on the left of the Run/Debug Configurations dialog box to add multiple configurations for running.

3. Run the project.

   Click the Run icon in the upper-right corner to run the project.

   The first time that the project is run takes a longer time because App Studio needs to allocate the ECS instance and initialize the language service. After the running is completed, the Runtime tab appears, showing the access link.

4. Access the project.

   Click **Open Link** to access the project.

Append /testapi to the link and refresh the page.

Understand App Studio

The following operations are supported for created projects:

- Top navigation bar
  - **Project**

    From the Project menu, you can configure the project or view detailed information by selecting **Character Set** or **Project Information**. Provided information about the current project includes the ID specified by **Project ID**, name specified by **Project Name**, type specified by **Project Type**, creation time specified by **Created At**, and **UUID**.

  - **File**

    From the File menu, you can create a file or open a recently created file by selecting **Create File** or **Re-Open Most Recent Files**.

  - **Edit**

    From the Edit menu, you can perform common editing operations. To search all the code in the project and open the related file, select Find in Path.

- **Version**

  From the Version menu, you can select **Switch Branch**, **View Changes**, **Submit**, **View Log**, **Connect to Remote Repo**, and **Merge Abort**.

  - **Switch Branch**

    In the Check Out Branch dialog box, you can click **+Create Branch** to create a local branch and push it to the remote repo. You can click a local branch and select **checkout** from the shortcut menu on the right to switch to the branch. You can also select **merge** to merge the selected branch to the current branch.

    You can click a remote branch and select **check out as a new local branch** from the shortcut menu on the right to check out the remote branch locally. Then rename the branch. You can also select **merge** to merge the selected branch to the current branch.

  - **View Changes**

    Click **View Changes** to view the list of edited files on a local branch in the right-side navigation pane.

  - **Submit**

    Click Submit to commit edits on a local branch for staging. You must enter the commit information.

  - **View Log**

    On the Log page, you can view all commit records of branches and filter them.

  - **Connect to Remote Repo**

    You can associate a new project with a remote repo for version control.

- **View**

  You can click **Toggle Full Screen** or press **Esc** on the keyboard to enter or exit the full screen mode of the page. You can also click **Hide Sidebar** or **Hide Status Bar** to hide the right-side navigation pane or the status bar. If they are hidden, you can click Show Sidebar or Show Status Bar to show them respectively.

- **Debug**

  - If you create a front-end project, you can set running parameters and add custom images.
  - App Studio supports Java-based debugging. In addition to setting running parameters and adding custom images, you can perform many other operations for debugging backend projects. You can also perform full or incremental builds and compile the Main.java file.

- **Settings**

  From the Settings menu, you can set the Git configuration to import the Git code to create a project. You can also configure your preference and shortcut keys.

- **Deploy**

  You can choose **Deploy > Download Source Code** to download the source code.

- **Template**

  You can choose **Template > Manage Templates** to go to the **My Templates** page to manage templates.

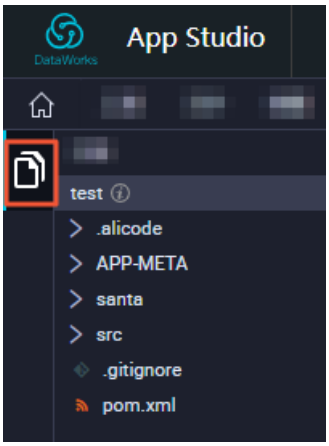
- Left-side navigation pane

- Entry

  Click the icon framed in red. The project section appears.

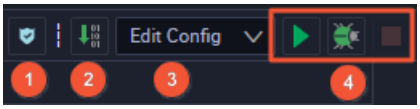
- Edit section

  Double-click a file that you want to edit. In the Edit section that appears, right-click the code section to perform the following operations.



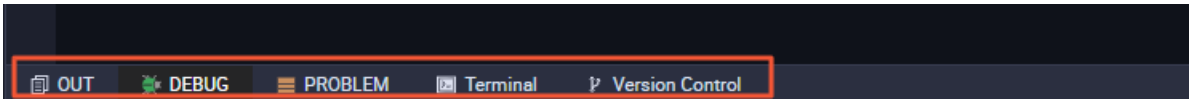
Action	Description
Go to Definition	Navigates to the definition page.
Peek Definition	Previews the definition.
Find All References	Searches for all references.
Workspace Symbol	Searches for a symbol in the project.
Go to Symbol...	Navigates to the symbol in the project.
Generate...	Generates the code.
Rename Symbol	Renames the symbol.
Change All Occurrences	Changes the name of all occurrences of a symbol throughout the file.
Format Document	Formats the file.
Cut	Cuts the file.
Copy	Copies the file.
Command Palette	Goes to the command palette.

- Icons in the upper-right corner



No.	Feature
1	Alibaba Coding Guidelines
2	Build Program. You can perform this operation only when the project is running or being debugged.
3	Run/Debug Configurations. You can set parameters for running or debugging the project.
4	Operations on the project, including running, debugging, or stopping the project.

- Bottom bar



  - OUT tab

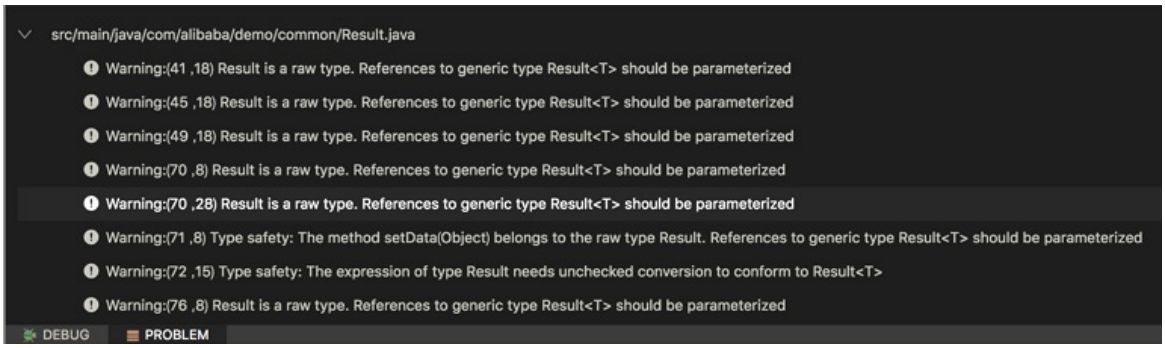
    You can click the OUT tab to view the output.

  - RUN or DEBUG tab

    If you click the Run or Debug icon for a project, this tab appears, showing the progress and information of the project.

  - PROBLEM tab

    If you click the Run or Debug icon for a project that has a problem, this tab appears.



- Terminal tab

  When running or debugging a project, you can click the Terminal tab and run bash or vim commands on the ECS instance.

- Version Control tab

  You can click the Version Control tab to view the logs and history of the project.

2.17.3. Navigation pane

2.17.3.1. View and manage projects

You can create and manage projects on the Projects page.

Go to the App Studio page and click Projects in the left-side navigation pane. On the page that appears, you can view projects that you have created. For more information about how to create template-based and code-based projects, see Project management.

Click a project to go to the project editing page. You can also click **Create Template** of a project to create a template based on the project.

Create a template

1. Click **Create Template** of a project.
2. In the **Create Template** dialog box that appears, set each parameter.

Parameter	Description
Name	The name of the template.
Description	The description of the template.
Class	The class of the template.

3. After the configuration is completed, click **OK**.

2.17.3.2. View and manage templates

You can view all templates created based on projects on the Templates page.

Click a template to go to the template details page. Then, click **Code Editor** to view the project code that this template is based on.

You can also click **Create Project** of a template to create a project based on this template.

2.17.4. Manage projects

This topic describes how to create and manage projects.

You can create a template-based or code-based project.

Create a template-based project

1. Go to the App Studio page and click Projects in the left-side navigation pane. On the **Projects** page, click **Create Project from Template**.
2. On the **Create Project** page, set the **Name** and **Description** parameters, and select a template.

   > Note
   > - The name of the project must start with a letter and can contain digits, letters, underscores (_), and hyphens (-).
   > - The description of the project can be 2 to 500 characters in length.
   > - You can select a custom template or a template provided by the system.
   > - All projects created by using templates support WYSIWYG development.

3. After the configuration is completed, click **Submit**.

Create a code-based project

You can create a project by running code. App Studio provides code templates for three types of runtime environments. Select a code template as required.

1. Go to the App Studio page and click Projects in the left-side navigation pane. On the **Projects** page, click **Create Project from Code**.
2. On the **Create Project** page, set the **Name** and **Description** parameters, and select a runtime environment.

   > Note
   > - The name of the project must start with a letter and can contain digits, letters, underscores (_), and hyphens (-).
   > - The description of the project can be 2 to 500 characters in length.

3. After the configuration is completed, click **Submit**.

View and manage projects

You can view the created projects on the **Projects** page.

You can click a project name to go to the project editing page. You can also click **Create Template** for a project to create a template based on the project.

> **Note** You can view projects shared by others but cannot create templates based on those projects.

2.17.5. Code editing

2.17.5.1. Overview

Code editing supports common IDE features, such as automatic completion, code hinting, syntax diagnosis, and global content search.

The following tables list the basic and advanced features that App Studio supports in different languages.

Basic feature	Java	Python	JavaScript and TypeScript
Completion	Supported	Supported	Supported
Hover	Supported	Supported	Supported
Diagnostics	Supported	Supported	Supported
SignatureHelp	Supported	Supported	Supported
Definition	Supported	Supported	Supported
References	Supported	Supported	Supported
Implementation	Supported (coming soon)	Not supported	Not supported
DocumentHighlight	Supported	Supported	Supported
DocumentSymbol	Supported	Supported	Supported
WorkspaceSymbol	Supported	Supported	Supported
CodeAction	Supported (Alibaba Java Guidelines coming soon)	Supported	Supported
CodeLens	References implementation	Not supported	Not supported
Formatting	Supported	Supported	Not supported
RangeFormatting	Supported	Not supported	Not supported
FindInPath	Supported	Supported	Supported

Advanced feature	Java	Python	JavaScript and TypeScript
Rename	Supported	Supported	Supported
WorkspaceEdit	Supported	Not supported	Not supported

Advanced feature	Java	Python	JavaScript and TypeScript
UnitTest (quick start)	Supported	Not supported	Not supported
MainClass	Supported	Not supported	Not supported
MainClassQuickStart	Not supported	Not supported	Not supported
ListModules	Supported	Not supported	Not supported
Generate	Constructor Override Getter and Setter Implement	Not supported	Not supported

2.17.5.2. Generate code snippets

Currently, App Studio supports the Java class constructor, getter and setter methods, override methods of the parent class that a child class inherits, and API methods to be implemented.

Entry

Perform either of the following operations to generate the Java code:

- Right-click the code section and select **Generate**.
- Press Command+M on the keyboard. The Java code is automatically generated.

Constructor

On the Generate menu, click **Constructor**.

Select the fields to be included in the constructor and click **OK**.

The constructor that contains the initialization statement of the fields is generated.

Getter and setter methods

Generate the getter and setter methods in a way similar to the constructor.

> **Note** If a Java class does not have any field or the Java class is overwritten by the @data annotation of lombok, the getter or setter method is not required for the Java class. In this case, the Getter, Setter, and Getter And Setter options do not appear on the Generate menu.

Override methods

Click Override Methods on the Generate menu. All methods that can be overridden are listed in the Generate Code dialog box.

Select a method. The corresponding method is generated.

2.17.5.3. Run UT

App Studio currently supports unit testing (UT), including automatically generating UT code, detecting the entry for UT, running UT code, and displaying the UT result.

Automatically generate UT code

Open the target file, right-click the code editing section, select **Generate** and then click **Create Test**. The UT class file and UT code are automatically generated in the test directory.

Detect the entry for UT

> Note
> - UT class files must be stored in the *src/test/java* directory. A Java UT class file that is not stored in this directory cannot be identified as the Java UT class.
> - For a method annotated with @Test annotation, Run Test appears, indicating the entry for UT.

After the Java UT class file is created, add the **@Test** annotation of `org.junit.Test` to the corresponding sample UT method.

Run UT code

Click the Run icon in the upper-right corner. The sample UT starts.

2.17.5.4. Find in Path

App Studio provides the Find in Path feature to support global content search.

Move the pointer over **Edit** in the top navigation bar and select **Find in Path**.

You can select **Match Case**, **Words**, **Regex**, and **File Mask** as required. If you select File Mask, you must also select a file name extension from the right drop-down list to search in files of the specified type.

You can also search for content in the specified project, module, or directory.

After selecting a file, you can locate the searched content in the file and open the file in the editor.

2.17.6. Debugging

2.17.6.1. Configuration and startup

You can configure the entry method, start debugging, and set breakpoints to debug an app.

Configure the entry method

Parameter	Description
Main class	The entry method (which is the main method) you want to start. You can select a value from the drop-down list.
VM options	The parameters for starting a Java Virtual Machine (JVM), for example, -D, -Xms, and -Xmx.

Parameter	Description
Program arguments	The startup parameter, which is obtained by the args parameter in the main method.
Environment Variables	The environment variables.
JRE	The Java runtime environment. Default value: *1.8 - SDK*.
PORT	The port you want to expose in the app, for example, classic port 7001 or port 8080 for Spring Boot-based projects.
ECS Instance	The type of the ECS instance used for debugging.
Enable Hot Code	This configuration takes effect only in Run mode. By default, the HotCode2 plug-in that Alibaba Cloud provides is used.

Start debugging

Move the pointer over **Debug** in the top navigation bar and click **Start Debugging**.

The first startup is slower, because the system needs to prepare the runtime environment and download Maven dependencies for you. When you restart debugging, App Studio skips this process and provides user experience similar to that in a local IDE.

2.17.6.2. Online debugging

App Studio supports the online debugging of Java apps and Spring Boot-based web projects.

Before online debugging, you must configure the entry method and start debugging. For more information, see Configuration and startup.

Exposed services

After your app is started, two basic services are provided. You can click the link next to Backend to debug the backend Java code.

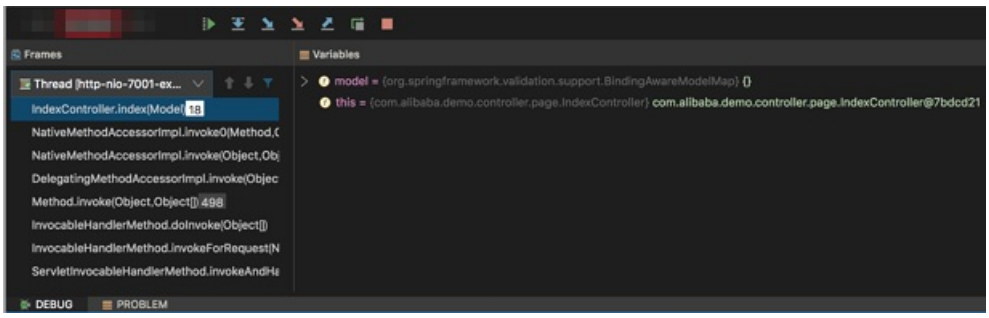
Panel introduction

- Output

  The Output panel displays the standard output, excluding System.in, of all apps. It supports the ANSI color and guarantees consistent experience as a local terminal.

- Call Stack

The Call Stack panel displays the thread list of your app, stack information, variables of the current stack, and observed variables at the current breakpoint. You can double-click a variable in the list and modify the value of the variable to debug your app.

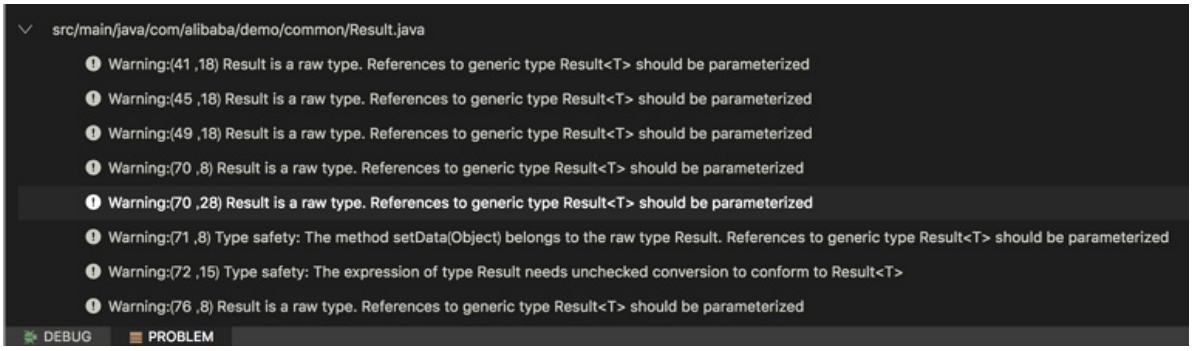


- Breakpoint

  The Breakpoint panel displays the breakpoints that are currently set. For more information about the breakpoint types and usage, see Breakpoint types.

- PROBLEM

  The **PROBLEM** panel displays compilation problems of apps. You can click a record to go to the corresponding line in the file.



2.17.6.3. Breakpoint types

App Studio supports normal line breakpoints, method breakpoints, and exception breakpoints.

Normal line breakpoint

You can click the blank section next to a line in the current file to generate a breakpoint for that line. The breakpoint also appears on the Breakpoint panel.

Method breakpoint

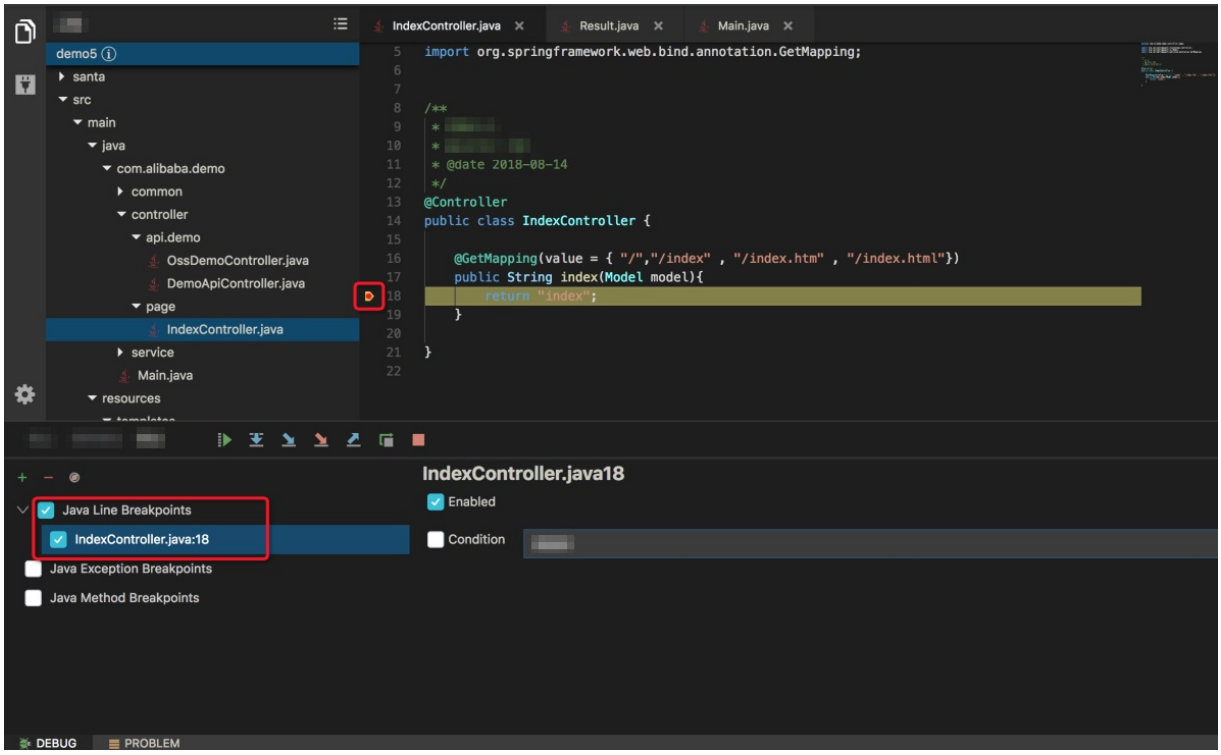
Different from a line breakpoint or an exception breakpoint, a method breakpoint triggers two events, namely, entry and exit. You can manually add a method breakpoint, or set a breakpoint at the place where the method is defined.

If the method breakpoint is triggered, the program stops when stepping into or out of the method.

Exception breakpoint

If an exception breakpoint is set, the program stops when encountering the exception.

As shown in the following figure, after index is triggered, the program stops in line 23 because **NullPointerException** appears.



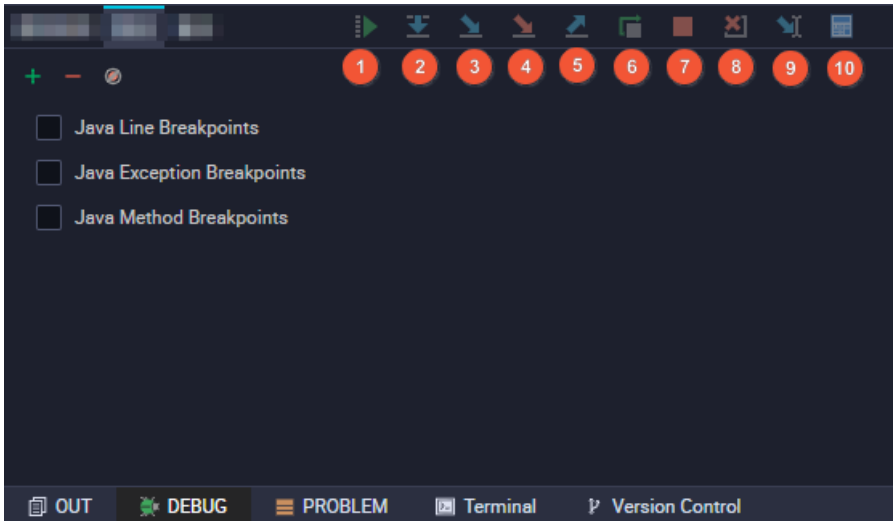
2.17.6.4. Breakpoint operations

The Breakpoint panel displays the breakpoints that are currently set. This topic describes how to operate breakpoints.

Breakpoints can be classified into normal line breakpoints, method breakpoints, and exception breakpoints. For more information, see Breakpoint types.

Debugging buttons

You can perform the debugging operations by clicking the following buttons listed in the table:



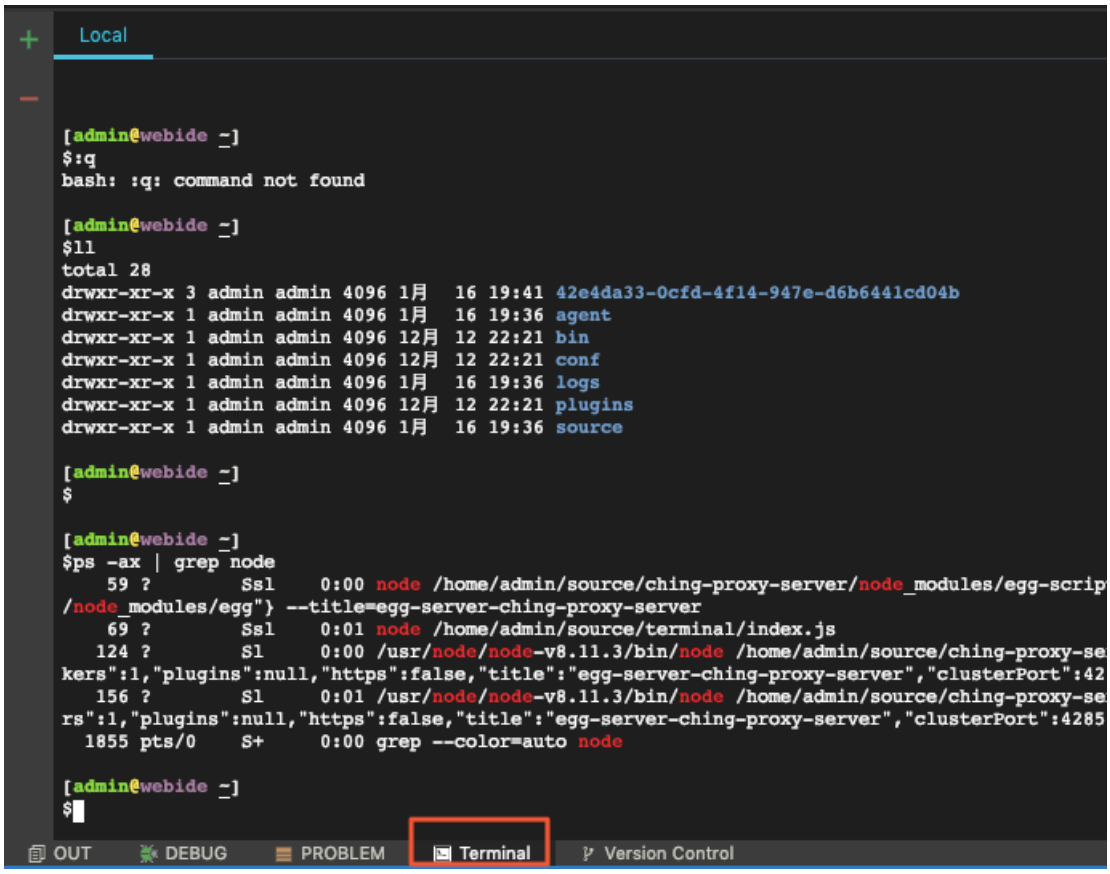
No.	Feature	Description
1	**Continue**	Resumes the current breakpoint to continue the current thread.
2	**Step Over**	Runs to the next line.
3	**Step Into**	Steps into a method.
4	**Force Step Into**	Forcibly steps into a method of a class not to be stepped into. Different from **Step Into**, **Force Step Into** enables you to step into a method from a built-in Java library.
5	**Step Out**	Steps out of the current method.
6	**Restart**	Currently, the **Restart** button is not perfect enough and may not be able to clean up the program. This button is being optimized.
7	**Stop**	Stops debugging.
8	**Drop Frame**	Deletes the current stack and returns to the previous method.
9	**Run to Cursor**	Runs to the current line of code. You can set a temporary breakpoint in a line.
10	**Evaluate Expression**	Calculates an expression.

2.17.6.5. Terminal

The **Terminal** tab appears on the bottom of the panel.

App Studio supports common shell commands such as **ls** and **cat** and interactive commands such as **vi** and **top**.

You can also start multiple terminals.



2.17.6.6. Hot code replacement

Using the hot code replacement feature, you can edit the running code of an app and make the edits effective without restarting the app.

For example, after you edit the code while debugging a Spring Boot-based app, you do not need to restart the app. The edited code takes effect once it is saved. App Studio supports this feature by default.

App Studio also supports hot code replacement while an app is running. To trigger hot code replacement, you only need to save the file without installing any plug-in or manually compiling the file.

If you are editing the code in Debug mode, App Studio automatically deletes the current running stack and returns to the method entry.

Configure hot code replacement in Run mode

Enable hot code replacement on the Run/Debug Configurations page.

After you click Run or Debug, the output information of the HotCode2 plug-in appears on the OUT tab.

Save the file after editing it.

Configure hot code replacement in Debug mode

You can use the native Java Debug Interface (JDI) to enable hot code replacement in Debug mode. However, due to Java Virtual Machine (JVM) restrictions, hot code replacement is unavailable when a method is added to or deleted from a class. You can save the file to trigger hot code replacement.

> **Note** The native JVM supports hot code replacement for operations such as adding or deleting a class. However, hot code replacement is unavailable when you change the class structure.

2.17.7. WYSIWYG designer

2.17.7.1. Get started with the WYSIWYG designer

This topic describes basic operations in the WYSIWYG designer, including creating a project and building a visual page.

Create a project

1. Log on to the DataWorks console.
2. On the DataStudio page that appears, click the DataWorks icon in the upper-left corner and choose **All Products > App Studio**. The **Projects** page appears.
3. Click **Projects** in the left-side navigation pane. On the page that appears, click **Create Project from Code**.
4. On the **Create Project** page, set the **Name** and **Description** parameters, and set **Select the runtime environment** to **appstudio**.
5. After the configuration is completed, click **Submit**.

Build a visual page

Open a project created by using the WYSIWYG designer. Go to the *santa/pages* directory in your project.

Double-click a .santa file to go to the WYSIWYG designer. For example, you can double-click the file named *home.santa*.

You can also right-click **pages** and choose **Create > Template** to develop the page based on a template.

The WYSIWYG designer consists of the component menu and operation panel.

- Component menu

  The component menu lists all components that the WYSIWYG designer presets, including **layout components**, **basic components**, **form components**, **chart components**, and **advanced components**.

  Select a component from the component menu and drag and drop it to the visual operation section. Click the component. The **Component Settings** panel appears on the right.

  On the **Component Settings** panel, you can configure the component on the **Properties**, **Style**, and **Advance** tabs.

- Operation panel

  You can click the corresponding icon on this panel to **undo an operation**, **redo an operation**, **preview the rendering result**, **enable the code mode**, **use the global style**, **configure the navigation**, **configure a global data flow**, **deploy as a template**, and **save edits**.

  Click the **Configure Navigation** icon in the upper-right corner to go to the navigation configuration page. For more information, see Navigation configuration.

Configure a global data flow

For more information about how to configure a global data flow, see Global data flow.

On the Component Settings panel, you can configure the component on the **Properties**, **Style**, and **Advance** tabs.

- Configure component properties

  On the Properties tab, you can visually configure component properties.

  Based on the rules for configuring component properties, a visual form is generated on the Properties tab. After you configure component properties in this form, the WYSIWYG designer re-renders the component in the visual operation section based on the new properties. You can view the rendering results of the component with different properties in real time.

- Configure component styles

  On the Style tab, you can configure the styles of a component.

  A visual panel for configuring common styles is provided on the Style tab. On this panel, you can customize the basic styles of a component, including the layout, text, background, border, and effect.

  After you add or modify the component styles on this tab, the WYSIWYG designer collects all the style settings and re-renders the component in the visual operation section based on the new component style. You can view the component configuration effect in real time.

- Configure association between components

  On the Advanced Settings tab, you can configure association between components.

  Select a component in the visual operation section and click the **Advance** tab. The properties of the selected component are listed on the left of the tab. Click the Magnifier icon on the right and select the component to be associated to your selected component.

  The properties of the associated component appear on the right of the tab.

  Select a property, for example, searchParams, in the left property list and connect it to a property, for example, requestParams, in the right property list.

  In this way, any change of the searchParams parameter of the left component is transferred to the requestParams parameter of the right component in real time. This achieves property-based association between the two components.

Configure the code mode

By using the code mode, you can implement complex interactions in a more advanced way. For more information, see Code mode.

Save, preview, run, and hot code replacement

For more information, see Save, preview, run, and hot code replacement.

2.17.7.2. Code mode

By using the code mode, you can implement complex interactions in a more advanced way.

Click the **Code Mode** icon in the upper-right corner of the operation panel to enable the code mode.

The WYSIWYG designer uses domain-specific language (DSL) at the intermediate layer to switch between the visualization mode and code mode. DSL can be considered as a simplified version of React. The DSL syntax is basically the same as the React syntax.

As shown in the code section in the preceding figure, DSL uses a tag to describe a component. The tag properties are the component properties. The property value can be of a simple data type such as a string or a number. The property value can also be an expression. You can enter `state.xxx` to obtain data from the global data flow.

The code mode has the following features:

- If you drag and drop a component or configure the component properties in the visualization section, the edits are updated in the code in real time.
- If you edit the code in the code section, the edits are updated in the visualization section in real time.
- The drag-and-drop operation and component property configuration in the visualization section and code edits in the code section can be converted between each other.

2.17.7.3. DSL syntax

Domain-specific language (DSL) is a component-based language developed based on the features of React JSX and Vue templates and is more suitable for UI layout design.

JSX

The DSL syntax is similar to the JSX syntax in the React.render method. The following section provides a brief description of JSX:

- You can use `{}` to switch an HTML scope to a JavaScript scope. In a JavaScript scope, you can write any valid JavaScript expression. The return value appears on the page, for example, `<div>{'Hello' + ' Relim'}</div>`.

  > **Note** You can write any JavaScript expressions such as computing statements or literals in `{}`.

- An HTML tag is used to switch a JavaScript scope to an HTML scope, for example, `{<div>Hello Relim</div>}`.
- The HTML scope and JavaScript scope can be nested, for example, `{<div>{'Hello' + ' Relim'}</div>}`.

Valid JavaScript expressions

```
// Computing statements
{aaa} // √ Variable aaa must be defined.
{aaa * 111} // √
{1 == 1 ? 1 : 0} // √
{/^123/.test(aa)} // √
{[1,2,3].join('')} // √
{(()=>{return 1})()} // The self-executing function. √
// Literals
{1}
{true}
{[11,22,33]} // √
{{aa:"11",bb:"22"}} // √
{()=>1} // Describe a function, which is valid but meaningless. √
```

Note If certain complex logic must be implemented by multiple computing statements rather than only one statement, you can wrap the logic in a self-executing function, which must be a valid expression. The following statements provide an example:

```
{(function(){
  // Sum the even digits of a number array.
  var input = [1,2,3,4,5,6,7,8,9,10];
  var temp = input.filter(i => i % 2 == 0)
  return temp.reduce((buf, cur) => buf + cur, 0)
})()}
```

Invalid JavaScript expressions

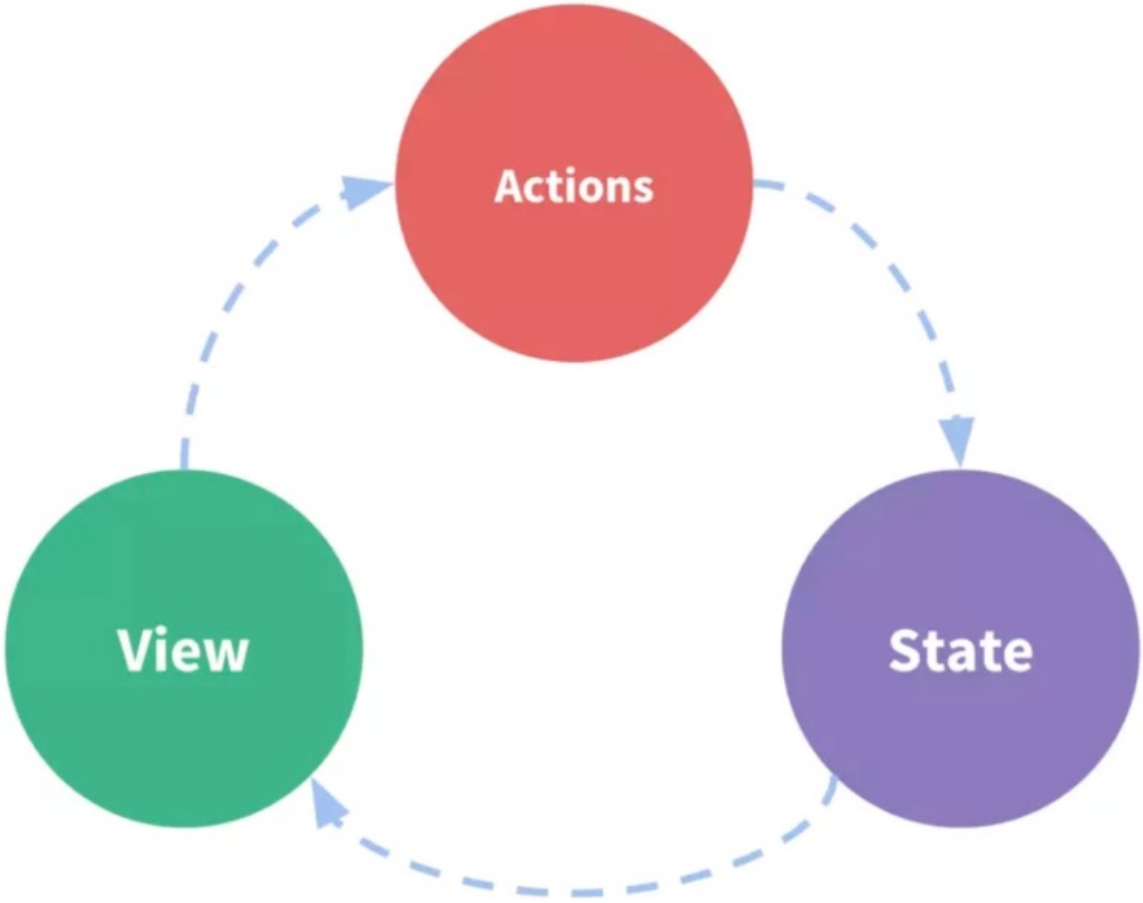
```
{ var a = 1 } // The value assignment statement.
{ aaa * 111; 2} // Multiple statements separated with semicolons (;).
```

2.17.7.4. Global data flow

A global data flow is used for front-end data management. For multiple components that need to share a state, it is difficult to transfer the state among them. To resolve this issue, you can extract the shared state and use a global data flow to transfer it to all related components.

Principles

In a global data flow, global data is transferred in a globally unique way. Once the data declared in global data changes, the data flow shown in the following figure is executed.



1. A component triggers an action when, for example, a user clicks the component.
2. The action triggers global data changes.
3. Upon the global data changes, components that reference the global state are automatically re-rendered.

Scenarios

A global data flow is applicable to the association of two or more components on a page. You can refine public data into global data for unified management, and then use a global data flow to associate two or more components.

Configure a global data flow

1. Click the **Global Data Flow Settings** icon in the upper-right corner of the operation panel.
2. In the **Global Data Flow Settings** dialog box that appears, set **Variable Name** and **Value**.
   - The variable value can be a number, character string, or JSON string.
   - If the variable value is declared as an API endpoint, data obtained from the API is automatically used as the value of the variable name.
3. Click **Save**.

Use a global data flow

- Obtain global data

  Use `state.name` in the component to obtain global data.

  ```
  <Input value={state.name} />
  ```

- Modify global data

  Use the $setState() method in the component to modify global data.

  ```
  <Input onChange={value => $setState({ name: value })} />
  ```

  Note You must use the $setState() method to modify global data. If you use `state.name = 'new value'`, re-rendering cannot be triggered.

2.17.7.5. Save, preview, run, and hot code replacement

In the WYSIWYG designer, you can perform operations such as saving edits, previewing the rendering result, running an app, or making edits in hot code replacement mode.

Save edits

The WYSIWYG designer periodically saves your edits. You can also click the **Save** icon in the upper-right corner of the operation panel to save edits.

Preview the rendering results

In the WYSIWYG designer, code in the operation section is in the editable status. However, special processing is added for the editable status of some components. For these components, you can run the rendering logic only when the app is running. To preview the rendering result, click the Preview icon in the upper-right corner of the operation panel.

Run an app

In the WYSIWYG designer, you can open and edit only one santa file at a time. To view the effect of the entire app,

click the Run Program icon on the Debug panel of App Studio to run the app.

Make edits in hot code replacement mode

If you are not satisfied with any page after running the app, you can edit the code in the WYSIWYG designer and save the edits.

The edited code takes effect on the running page in hot code replacement mode.

2.17.7.6. Navigation configuration

This topic describes how to configure the site navigation in the WYSIWYG designer.

The WYSIWYG designer provides each app with a public page header, a public bottom bar, and public sidebars, where you can configure various menus and themes. You can also specify whether to display the public header, bottom bar, and sidebars as required.

Click the **Navigation Settings** icon in the upper-right corner of the operation panel to go to the page for configuring the navigation of an app.

Configure the public header

You can configure the public header based on your business requirements.

Parameter	Description
Enabled	Specifies whether to display the public header.
Theme	The theme of the public header. You can select a dark or light theme.
Logo Image	The logo image of the site. You can enter an image URL or upload a local image.
Title	The title of the site.
Fix to Page Top	Specifies whether to fix the public header to the top of the page. If you turn on this switch, the public header stays at the top of the page when the page scrolls.
Menu Items	The menu items such as the link name and link URL that are displayed in the public header.

Configure the sidebars

You can configure the sidebars based on your business requirements.

Parameter	Description
Enabled	Specifies whether to display the sidebars.
Theme	The theme of the sidebars. You can select a dark or light theme.
Enable Folding	Specifies whether the sidebar menus can be hidden.

3.Realtime Compute

3.1. What is Realtime Compute?

Realtime Compute is a big data processing platform that provides real-time analysis tools for streaming data based on Apsara Stack. You can create streaming data analysis and computing jobs by using Flink SQL. With Flink SQL, you do not need to develop the underlying logic for stream processing.

Industries have an increasing demand to obtain real-time insights into their data and simplify procedures. This requires software applications to improve data processing efficiency. In traditional models for big data processing, online transaction processing (OLTP) and offline data analysis are separately performed at different times. These models cannot satisfy the increasing demand for real-time big data processing.

Realtime Compute is designed to respond to the increasing demand for the timeliness of data processing. The value of data rapidly decreases over time. Therefore, data must be processed at the earliest opportunity after it is generated. In traditional models for big data processing, data is accumulated and processed on an hourly or daily basis. This cannot meet the demand for real-time computations over data streams. Batch processing cannot meet the business needs in the scenarios where an extremely low processing delay is required. These scenarios include real-time big data analysis, early warning and risk control, real-time forecasting, and financial transactions. Realtime Compute enables real-time processing over data streams. With Realtime Compute, you can shorten the data processing delay, easily implement real-time computational logic, and greatly reduce computing costs. All of these features provided by Realtime Compute allow you to meet your business requirements for real-time processing of big data.

Streaming data

Big data can be viewed as a series of discrete events. These discrete events form event streams or data streams along a timeline. Unlike offline data, streaming data is continuously generated by thousands of data sources. Streaming data is typically sent in data records simultaneously and in small sizes. Each type of data is produced as a stream of events. Streaming data includes a wide variety of data, such as the log files generated by customers using mobile or web applications, online purchases, in-game player activities, information from social networks, financial trade centers, geospatial services, and telemetry data from connected devices in data centers.

Realtime Compute has the following features:

- Real-time and unbounded data streams

  Realtime Compute processes data streams in real time, which are continuously generated from data sources. Streaming data is subscribed and consumed in chronological order. Data streams continuously flow into the Realtime Compute system. For example, in scenarios where Realtime Compute processes data streams from website visit logs, the log data streams continuously enter the Realtime Compute system while the website is online. In Realtime Compute, unbounded data streams are processed in real time.

- Continuous and efficient computations

  Realtime Compute is an event-driven system where unbounded event streams or data streams continuously trigger real-time computations. Each streaming data record triggers a computation task. Realtime Compute performs continuous and real-time computations over data streams.

- Real-time integration of streaming data

Realtime Compute allows you to write the processing result of each streaming data record into the target data store in real time. For example, you can write the result data into the target RDS data store for report display purposes. Realtime Compute enables the result data to be continuously written into the target data store in real time. Therefore, Realtime Compute can be viewed as the data source that generates data streams for the target data store.

3.2. Quick start

3.2.1. Log on to the Realtime Compute console

This topic describes how to log on to the Realtime Compute console.

Prerequisites

- The domain name of the ASCM console is obtained from the deployment personnel before you log on to the ASCM console.
- A browser is available. We recommend that you use the Google Chrome browser.

Procedure

1. In the address bar, enter the URL used to log on to the ASCM console. Press the Enter key.
2. Enter your username and password.

   Obtain the username and password used to log on to the console from the operations administrator.

   > **Note** When you log on to the ASCM console for the first time, you must change the password of your username. For security reasons, your password must meet the minimum complexity requirements. The password must be 8 to 20 characters in length and must contain at least two of the following character types:
   >
   > - Uppercase or lowercase letters.
   > - Digits.
   > - Special characters. Special characters include exclamation points (!), at signs (@), number signs (#), dollar signs ($), and percent signs (%).

3. Click **Login** to go to the ASCM console homepage.
4. In the top navigation bar, move the pointer over **Products**, and click **Realtime Compute**.
5. Select the target organization and region.
6. Click **Blink**.

3.2.2. Real-time security monitoring

3.2.2.1. Overview

With the wide application of digital technologies, every industry is facing the ever-increasing demand for data security, especially for real-time monitoring and alerting. To monitor streaming data and report alerts in real time, you need to ensure that the data is accurate and is processed instantly after it has been generated. To address these challenges, Realtime Compute allows you to perform JOIN operations on source tables of streaming data and dimension tables that include blacklists. The following sections describe a use case of real-time monitoring and alerting.

3.2.2.2. Preparations

Before proceeding with the development process in the Realtime Compute console, you must create a source table and a result table in the upstream and downstream data stores, respectively. You must also upload data to the source table.

Context

To simplify operations, this example organizes incoming streaming data based on a table: datahub_IpPlace.

datahub_IpPlace

Field name	Data type	Description
name	VARCHAR	The name
Place	VARCHAR	The place

The rds_dim dimension table is described as follows.

rds_dim

Field name	Data type	Description
name	VARCHAR	The name
Place	VARCHAR	The place

A result table named rds_IpPlace is obtained after a JOIN operation is performed on the datahub_IpPlace and rds_dim tables. This result table is described as follows.

rds_IpPlace

Field name	Data type	Description
name	VARCHAR	The name
Place	VARCHAR	The place

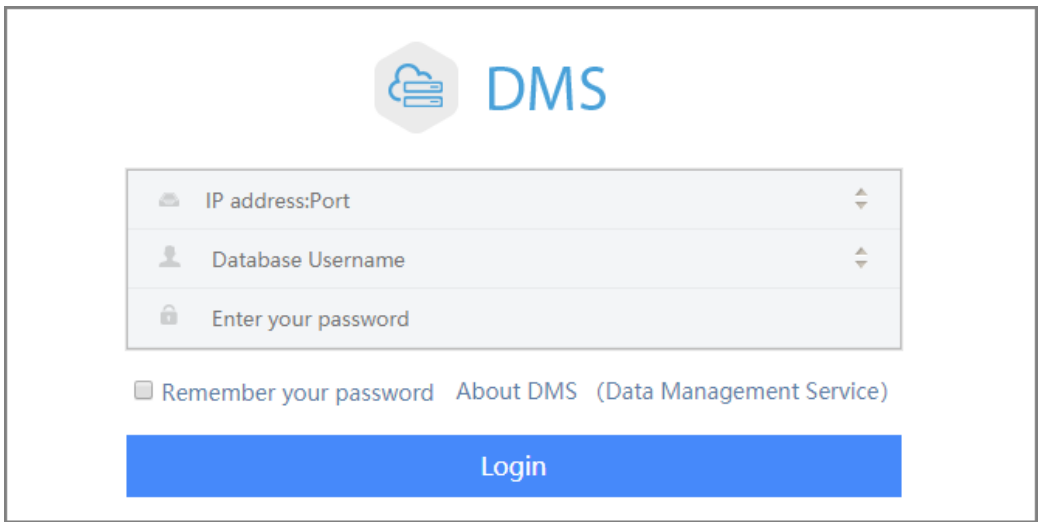
Create source and result tables

Procedure

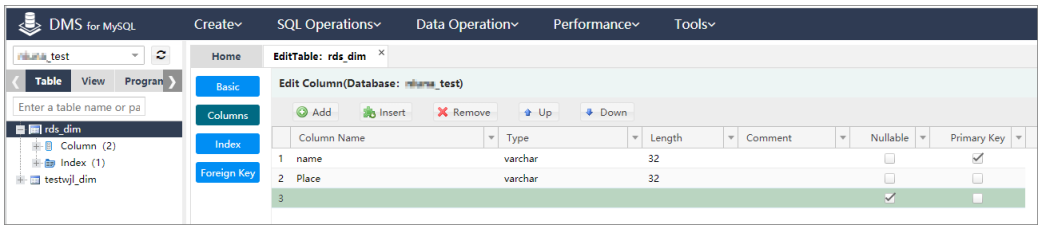
1. Log on to the DataHub console. For more information, see the "Log on to the DataHub console" section in *DataHub User Guide*.

2. Create a project. For more information, see the "Create projects" section in *DataHub User Guide*.
3. On the page that shows the project details, create a topic. The following figure shows the schema of the source table. For more information, see the "Create a topic" section in *DataHub User Guide*.
4. Create an ApsaraDB for RDS instance. For more information, see the "Create an instance" section in *ApsaraDB for RDS User Guide*.
5. On the **Instances** page of the ApsaraDB for RDS console, click the target instance name.
6. On the **Basic Information** page, click **Log On to DB**.
7. Log on to the RDS database, and create a result table in the database.

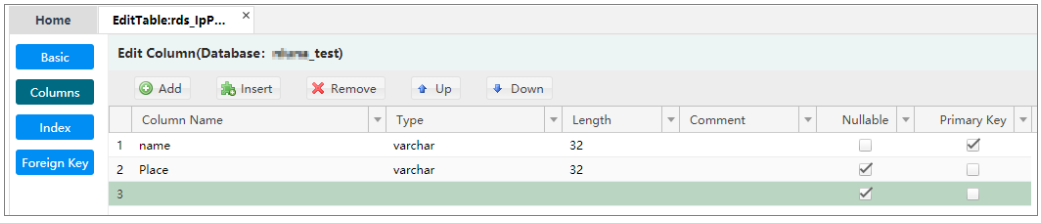
   Log on to the database

   Dimension table schema

   Result table schema

8. Upload data to DataHub.

   Log on to the **DataHub** console. In the left-side navigation pane, click **Data Acquisition**, and then click **Upload File**. On the page that appears, double-click the project, click the target DataHub topic, and then click **Select File** to upload data. For more information, see the "Upload local files" section in *DataHub User Guide*.

9. Write data into the rds_dim dimension table.

i. Log on to the RDS database. In the top navigation bar, choose **SQL Operations > SQL Window**.

ii. On the **SQL Window** tab, enter the following code.

```
insert into 'rds_dim'('name','Place') VALUES('test01','beijing')
```

iii. On the **SQL Window** tab, click **execute**.

3.2.2.3. Development

After you create source and result tables in external data stores, you must register the data stores in Realtime Compute and create references to the source and result tables. After the data stores are registered, you can proceed with the development process.

Context

After data is collected, you can continue to edit Flink SQL statements. The **Development** page of Realtime Compute offers a sample job (`bj_dim_join`) for product ranking. You can click `bj_dim_join` on the left side of the **Development** page to view the job details.

Procedure

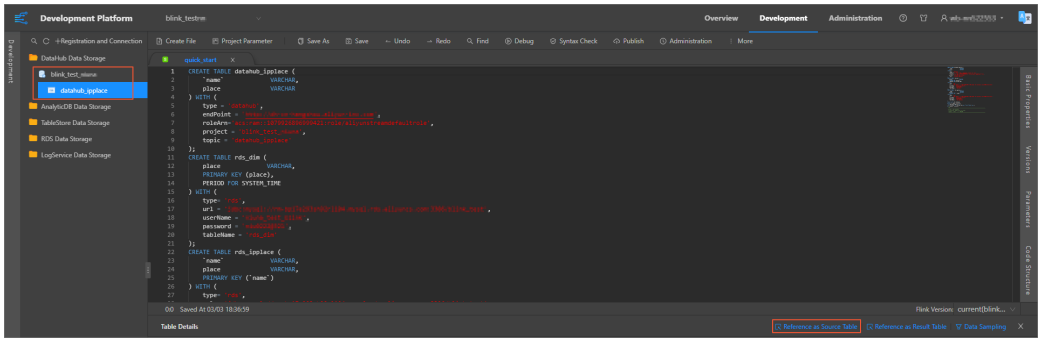
1. Log on to the Realtime Compute console.
2. In the top navigation bar, click **Development**.
3. On the top of the page, click **Create File**.

> Note
>
> Parameters

Parameter	Description
File Name	The name of the file. The specified name must be 3 to 64 characters in length and can contain lowercase letters, digits, and underscores (_). It must start with a lowercase letter.
File Type	The type of the file. Valid values are **FLINKSTREAM/DATASTREAM** and **FLINK_STREAM/SQL**.
Storage Path	The folder where the job SQL file is located. You can click the folder icon on the right side of an existing folder and create a subfolder.

4. Select DataHub as the data store for a source table. You can use the DataHub parameter settings and schema information that are automatically generated by the data store registration feature. For more information, see Register a DataHub project.

   Use DataHub as the data store for a source table



i. Double-click the **DataHub Data Storage** folder, double-click the target DataHub project, and then double-click the target table.

ii. On the top of the section that appears, click **Reference as Source Table**.

5. Create a reference to the ApsaraDB for RDS dimension table. You must specify the required parameters and the table schema. The reason is that dimension tables cannot be registered on the **Storage** tab. The sample code is provided as follows:

```
create table rds_input (
  place varchar,
  `name` varchar,
  primary key (place),
  period for system_time
) with (
  type = 'rds',
  url = '<yourURL>',
  tableName = '<yourTableName>',
  password = '<yourPassword>'
);
```

6. Select RDS as the data store for the result table. You can use the RDS parameter settings and schema information that are automatically generated by the data store registration feature. For more information, see Register an RDS instance.

7. To use RDS to store the result table, double-click the **RDS Data Storage** folder, double-click the target database, and then double-click the target table. On the top of the section that appears, click **Reference as Result Table**.

8. Edit SQL statements that implement the computing logic in the code editor.

```
INSERT INTO rds_output
SELECT
  t.`name`,
  w.place
FROM datahub_input1 as t
JOIN rds_intput FOR SYSTEM_TIME AS OF PROCTIME() as w
ON t.place = w.place
```

9. Debug the SQL code. Publish the job SQL file. After the computing logic is verified in the debugging

phase, click **Publish** on the **Development** page to publish the job SQL file. Then, you can view the job on the **Administration** page of the Realtime Compute console, and manage the job in the production environment, such as starting the job.

3.2.2.4. Administration

After you create and publish the job SQL file on the **Development** page, you can manage the job on the **Administration** page. For example, you can start, suspend, terminate, publish, or unpublish the job.

Procedure

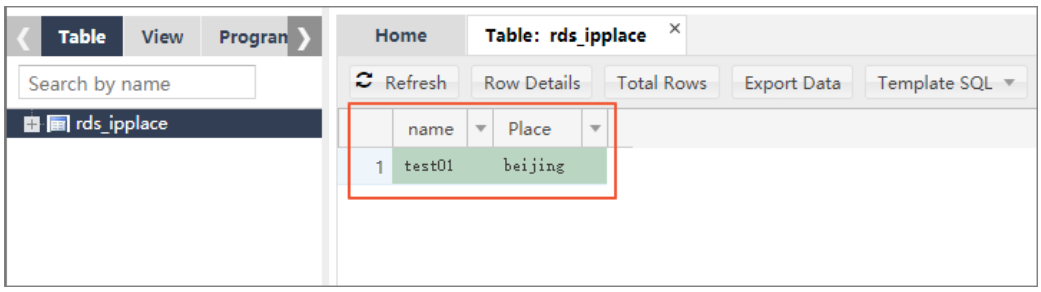
1. Go to the **Administration** page of the Realtime Compute console.
   i. Log on to the Realtime Compute console.
   ii. In the top navigation bar, click **Administration**.
2. Click **Start** for the `bj_dim_join` job.
3. Specify the **Start Time for Reading Data** parameter. The start time for reading data is also known as the start offset. The source data store remains connected to Realtime Compute for only a short period of time. Therefore, we recommend that you specify a time that is earlier than the current time.

   The Start Time for Reading Data parameter specifies the start time for reading data from the source data store.

Parameter	Description
Start Time for Reading Data	Specifies the start time for reading data from the source data store.
Enable Auto Upgrade	Specifies whether to enable auto upgrade.
Upgrade Time	Specifies the upgrade time range.
Offset	Specifies the range of data that is to be updated.

4. Click **OK** to start the job.
5. View the output data in the ApsaraDB for RDS data store.

   View the output data in the RDS data store



3.2.3. Frequently used words

3.2.3.1. Overview

Statistical analysis of frequently used words is widely applied in diverse fields, including the analysis of frequently used words in search engines, forums, and tags. For example, you can easily view the latest and most frequently searched words in microblogging websites through real-time statistics. Statistical analysis of frequently used words is, at its core, a simple word count job. In word count jobs for streaming data, real-time processing logic is used to analyze and display frequently used words in real time.

If you are new to working with big data computing, a word count job is for you to easily get started. The word count job in big data computing is similar to a `Hello, World!` program that is often the first program that a developer learns to write. The following topics take a word count job in Realtime Compute as an example to describe how to create a word count job based on real-time processing logic. This example helps you quickly get familiar with basic Flink SQL syntax and basic operations of Realtime Compute jobs, such as creating an SQL file for a job and publishing the job.

3.2.3.2. Code development

This topic uses a word count job as an example to describe how to create a Realtime Compute job.

Prerequisites

Before creating a word count job, a source table named stream_source and a result table named stream_result are created in external data stores. The stream_source table includes only one column. The column is named word and its data type is STRING. The stream_result table includes two columns. One column is named word and its data type is STRING. The other column is named cnt and its data type is BIGINT. The two tables are registered in Realtime Compute.

1. Log on to the Realtime Compute console.
2. In the top navigation bar, click **Development**.
3. Right-click the folder where you want to store the job file.
4. Click **Create File**, and the **Create File** page appears.
5. On the page that appears, set the following parameters:
   - File Name: Set the value to `wordcount`.
   - File Type: Set the value to FLINK_STREAM/SQL.
   - Storage Path: Keep the default setting.
6. Enter the following code in the code editor.

> **Note** In the SQL statements for the word count job, the STRING data type for the referenced table must be declared as the VARCHAR data type.

```
 create table stream_source (word varchar);
create table stream_result (word varchar, cnt bigint);
insert into
  stream_result
select
  t.word,
  count (1)
from
  stream_source t
group by
  t.word;
```

The following section explains the SQL code.

Line 1 creates a reference to the stream_source source table.

> **Note** Streaming data continuously enters Realtime Compute and triggers stream processing procedures. Each streaming data record or each batch of data from the stream_source table triggers a stream processing procedure.

Line 2 creates a reference to the stream_result result table. The stream_result table stores the computing results of the word count job.

> **Note** Realtime Compute does not have built-in components for data storage, and the result data is stored in external data stores, such as ApsaraDB for RDS and Tablestore. This line of code creates a reference to a result table that contains the result data.

Lines 5 through 11 implement the computing logic: Realtime Compute reads data from the stream_source table and counts how often words occur based on incoming data records.

> **Note** Flink SQL supports most standard SQL statements. This allows you to easily and cost-effectively adopt Realtime Compute for stream processing.

The method of performing a word count job for stream processing is similar to that for batch processing. The word count job for stream processing continuously processes unbounded data streams until the job is terminated.

3.2.3.3. Code debugging

Realtime Compute provides a powerful debugging feature to verify SQL statements. You can debug Realtime Compute jobs by simulating data stores that store streaming data, static data, and result data.

> **Note**
>
> - To avoid negative impacts on online data stores, Realtime Compute is not allowed to read data from these data stores during the debugging process. Before debugging, you must prepare test data for input tables.
> - The outputs of INSERT operations are exported only to local screens that do not affect online systems.

Debugging method

1. On the top of the **Development** page, click **Debug**.
2. On the page that appears, click **Download Template** and edit the template based on your debugging rules.

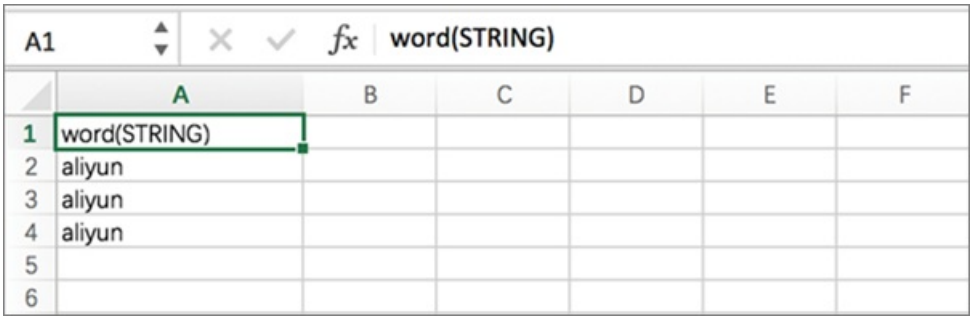
   > **Note** The file that is uploaded for debugging must meet the following requirements:
   >
   > - The file size cannot exceed 1 MB, and the file includes a maximum of 1,000 records.
   > - The file must use UTF-8 encoding.
   > - Commas (,) cannot be used in test data, because the file uses the comma-separated values (CSV) format.
   > - Numeric values can be displayed only in the general format, and cannot be displayed in the scientific notation format.

3. Click **Upload** to upload the file.
4. Click **OK**.
5. View the debugging result in the output window.

Sample file for debugging the word count job

> **Note** The file for debugging uses the CSV format. We recommend that you use the following software applications to open and modify the template:
>
> - Excel for Windows users
> - Vim or Sublime Text for MacOS users (To avoid adding irrelevant fields during the modification of CSV files, we recommend that you do not use Number.)

Sample file for debugging the word count job



Test data

You can download test data, and upload the data on the **Debug File** page.

> **Note** The *test data for statistical analysis of frequently used words* is unavailable for download in the PDF file. You can contact system administrators to download the test data.

View the debugging result

Real-time computing is triggered by data streams. Each data record from the stream_source table triggers a stream processing procedure. After each procedure is completed, a computing result is exported. The test file contains three data records. After each data record reaches Realtime Compute, a stream processing procedure is triggered. Therefore, a total of three data records are displayed on the screen. The computing logic is described as follows:

- The first data record (aliyun) reaches Realtime Compute. This is the first time that the system has detected the word "aliyun." Therefore, the computing result is `<aliyun, 1>`, which is displayed on the screen.
- The second data record (aliyun) reaches Realtime Compute. The system detects an existing record of `<aliyun, 1>`, and adds 1 to the value. Therefore, the computing result is `<aliyun, 2>`, which is displayed on the screen.
- The third data record (aliyun) reaches Realtime Compute. The system detects an existing record of `<aliyun, 2>`, and adds 1 to the value. Therefore, the computing result is `<aliyun, 3>`, which is displayed on the screen.

The third computing result `<aliyun, 3>` is considered as the final output of the debugging. Another sample of test data is provided for you to test the debugging feature. You can use different samples of test data and view the debugging outputs.

3.2.3.4. Administration

After the SQL file has been verified, you can publish the SQL file for the job on the **Administration** page of Realtime Compute. Then, you can start the job. The job runs on a Realtime Compute cluster.

Procedure

1. On the **Development** page, click **Publish**. The **Publish New Version** dialog box appears.
2. In the **Resource Configuration** step, click **Next**.
3. In the **Check** step, click **Next**.
4. In the **Publish File** step, click **Publish**.
5. On the **Administration** page, view the published word count job.
6. Click **Start** in the **Actions** column of the word count job. The **Start** dialog box appears.
7. Specify **Start Time of Reading Data** and click **OK**. Then, the job runs on a Realtime Compute cluster.

Result

After the job is started, click the job name. The **Overview** page appears.

FAQ

Q: Why does the word count job have no input or output while it is running on the distributed compute clusters of Realtime Compute?

A: When you created the `my_source` and `my_result` tables, you did not specify the data storage type of the referenced data source. In this scenario, the source table is considered to be a random table of strings or digits, and the result table is considered to be discarded data.

3.2.4. Big screen service for the Tmall Double Eleven Global Shopping Festival

3.2.4.1. Overview

During the Double 11 Shopping Festival, a big screen shows the total sales volume of Alibaba Group in real time. The big screen service is a highlight for the shopping festival. Stream processing for the big screen service was previously based on Apache Storm that is an open-source distributed real-time computation system. The Storm-based development process took around one month. The application of Flink SQL shortened the development process of the big screen service to three days. The underlying layer of Realtime Compute removes the Apache Storm modules that are designed for execution optimization and troubleshooting. This enables a higher processing efficiency for Realtime Compute jobs.

3.2.4.2. Scenario description

The streaming data input for the Tmall big screen service is the transaction data from the Tmall platform. The incoming transaction data is organized based on a two-dimensional table: `tmall_trade_detail`.

Field	Type	Description
tid	BIGINT	The order ID.
buyer_uid	BIGINT	The buyer ID.
seller_uid	BIGINT	The seller ID.
gmtdate	TIMESTAMP	The time when the order is completed.
payment	DOUBLE	The order amount.

Realtime Compute calculates two metrics based on the preceding table: the total number of orders and the total order amount up to the current time. The two metrics are written to an online RDS system and displayed on a big screen in real time. The online RDS system is used to store the result table: `tmall_trade_state`.

Field	Type	Description
gmtdate	VARCHAR(16)	The date when the order is completed.

Field	Type	Description
trade_count	BIGINT	The total number of orders.
trade_sum	DOUBLE	The total order amount.

The following topics describe how to build an end-to-end solution for the Tmall big screen service in around 10 minutes.

3.2.4.3. Preparations

Before editing Flink SQL statements for a Realtime Compute job, you must register data stores for source tables and result tables in Realtime Compute. This topic uses DataHub as an example to describe how to register a data store in Realtime Compute.

Create a DataHub topic

1. Log on to the DataHub console. For more information, see the "Log on to the DataHub console" section in *DataHub User Guide*.
2. If one or more projects have been created, click **View** in the **Actions** column for the target project. If no projects have been created, click **Create Project** to create a project and click **View** in the **Actions** column.
3. On the page that appears, click **Create Topic**.
4. Configure the topic based on the schema of the tmall_trade_state RDS table in the "Scenario description" section.

After performing these steps, you can edit Flink SQL statements for the Realtime Compute job.

Upload data to DataHub

You can upload data to the DataHub topic that you have created. To do this, follow these steps. Log on to the **DataHub** console. You can upload data to the DataHub topic that you have created. To do this, follow these steps:

1. Log on to the DataHub console.
2. In the left-side navigation pane, click **Data Acquisition**.
3. Click **Upload File**.
4. On the page that appears, double-click the target project and click the target DataHub topic.
5. Click **Select File** to select a file.
6. Click **Upload**.

To simplify the test procedure, you can use the test data about the Double 11. You can download the data and then upload it to the DataHub topic for data collection.

3.2.4.4. Register a data store

The data store registration feature of Realtime Compute allows you to easily register DataHub topics, create tables, and reference data stores. To register a data store, follow these steps:

Procedure

1. Log on to the Realtime Compute console.
2. In the top navigation bar, click **Development**.
3. In the left-side navigation pane, click the **Storage** tab.
4. Click the **DataHub Data Storage** folder.
5. On the top of the page, click **+Registration and Connection**.
6. Register a DataHub project in Realtime Compute. For more information about parameter settings, see Register a DataHub project.

   If you use ApsaraDB for RDS for MySQL to store the result data for data visualization, you must register an RDS data store in Realtime Compute. For more information, see Register an RDS instance.

3.2.4.5. Development

After the data has been collected to Realtime Compute, you can continue to edit Flink SQL statements.

1. Create a reference to the source.

   To create references to the DataHub source table and RDS result table, click Data Storage in the left-side navigation pane of the **Development** page in the Realtime Compute console, and perform the following operations:

   - Find the target DataHub topic, and click **Reference as Source Table**. Realtime Compute automatically parses the schema of the topic and adds the corresponding SQL statements to the **Development** page.
   - Find the target RDS table, and click **Reference as Result Table**. Realtime Compute automatically parses the schema of the table and adds the corresponding SQL statements to the **Development** page.

2. Edit Flink SQL statements.

   If you have created the DataHub topic and RDS table as described in the previous topics, the Flink SQL code for the tmall_d11 job can be executed directly. Otherwise, change the names of the DataHub topic and RDS table based on the topic and table that you have created. The sample code is as follows:

   ```
   replace into tmall_trade_state
     select
       from_unixtime(FLOOR(tmall_trade_detail.gmtdate/1000), 'yyyy-MM-dd') as gmt_date,
       count(tid) as trade_count,
       sum(payment) as trade_sum
     from
       tmall_trade_detail
     group by
       from_unixtime(FLOOR(tmall_trade_detail.gmtdate/1000), 'yyyy-MM-dd');
   ```

   Note You can modify the information about tables and fields as required.

3. Debug the Flink SQL code.

The data during the Double 11 Shopping Festival is available for testing. To debug the code, download the test data and upload the data on the **Development** page for debugging.

4. Publish the SQL file for the tmall_d11 job.

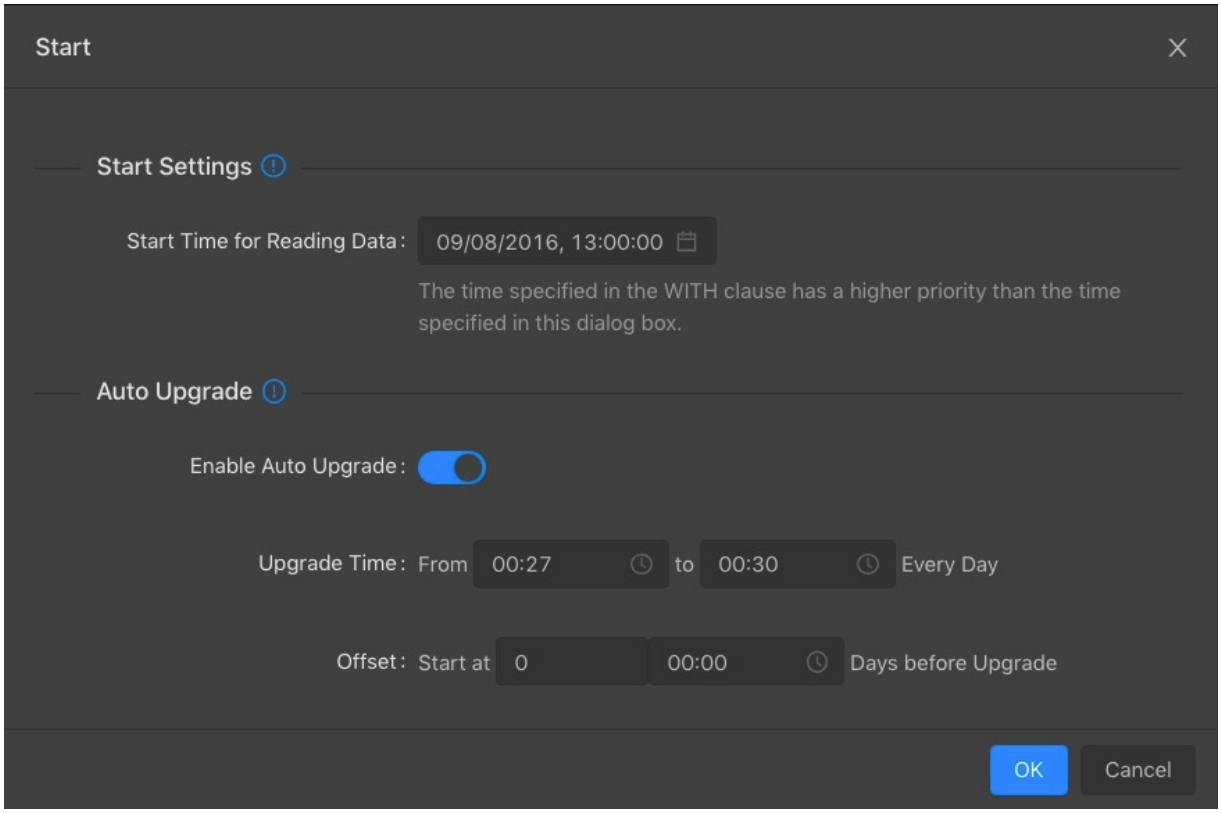
   After the computational logic has been verified in the debugging phase, click **Publish** on the **Development** page to publish the SQL file for the tmall_d11 job. Then, you can view the tmall_d11 job on the **Administration** page of the Realtime Compute console, and manage the job in the production environment, such as starting the job.

3.2.4.6. Administration

On the **Administration** page, you can click **Start** in the **Actions** column and specify the parameters on the page that appears to start a stream processing job, for example, the tmall_d11 job.

> **Note** After you click **Start**, a dialog box is displayed. In the dialog box, you can specify the start time for reading data from the source data store.

The specified start time must be earlier than the file upload time. For example, the start time can be one hour earlier than the file upload time. In the Double 11 use case, the current time is 14:10, and 10 minutes have elapsed since the source data is uploaded. Therefore, the start time is set to 13:00.



You can check the result data in the ApsaraDB for RDS data store after the job runs as expected. In the result table, five transactions and a turnover of CNY 500 are displayed. This is consistent with the source data for testing. In this way, an end-to-end verification is performed to check the SQL code.

3.3. Project management

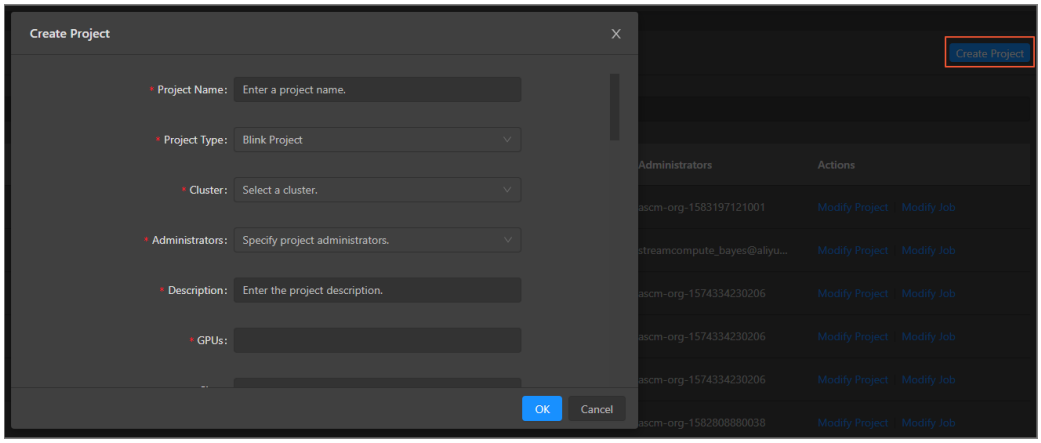
This topic describes how to create and search for a project.

Create a project

You can use an administrator account to log on to the Realtime Compute console and create projects.

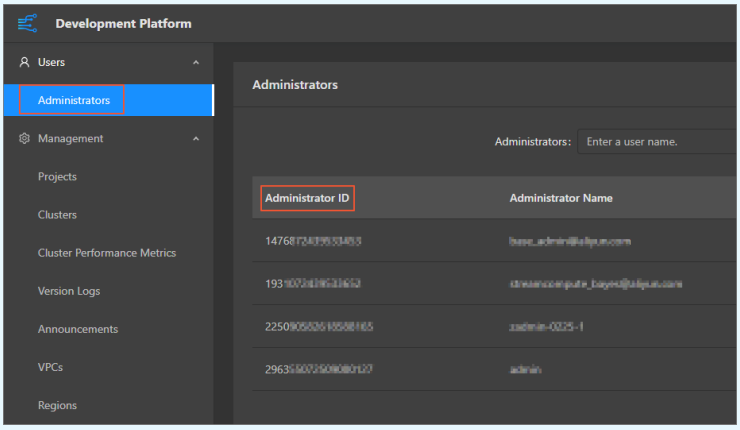
1. Log on to the Realtime Compute console.
2. In the browser address bar, replace the portion that follows the number sign (#) with /admin/user .
3. In the left-side navigation pane, click **Projects** under **Management**.
4. In the upper-right corner of the **Projects** page, click **Create Project**.
5. Configure the project.

Configure the project



Parameters

Parameter	Description
Project Name	The name of the project.
Project Type	The type of the project. **Blink Project** is selected by default.
Cluster	The cluster on which the jobs in the project run.

Parameter	Description
Administrators	The administrators of the project. Only project administrators can manage jobs in the project. **Note** If no administrators are displayed in the **Administrators** drop-down list, you can copy the target administrator ID to the text box of **Administrators** to find the target administrator. To find the administrator ID, click **Administrators** under **Users** and find the **Administrator ID** column. 
Description	The description of the project.
GPUs	The number of GPUs that are used by the project.
Slots	The number of compute units (CUs) that are used by the project. One CU is assigned with one CPU core and 4 GB memory.
Alert Methods	The methods in which alerts are sent when job running errors occur. You can receive alerts by using SMS or TradeManager messages.
File Types	The supported file types. You can keep the default setting.
Storage Types	The supported data store types. You can keep the default setting.
Max Data Stores	The maximum number of data stores that can be registered in Realtime Compute. You can keep the default setting.

Parameter	Description
Max File Versions	The maximum number of code versions for an SQL file. You can keep the default setting.
Max Folders	The maximum number of folders that can be created in the project. You can keep the default setting.
Max Folder Levels	The maximum number of folder levels in the project. You can keep the default setting.
Max Files	The maximum number of job SQL files that can be created in the project. You can keep the default setting.
Max Resources	The maximum number of JAR files and DICTIONARY resources that can be uploaded. You can keep the default setting.
Max Referenced Resources	The maximum number of JAR files and DICTIONARY resources that can be referenced. You can keep the default setting.
Monitoring and Alerting	Specifies whether to enable the monitoring and alerting feature. You can keep the default setting.
Data Collection	Specifies whether to collect data while a job is running. You can keep the default setting.
Data Display	Specifies whether to display data. You can keep the default setting.
Data Storage	Specifies whether to enable the feature of data store registration. This feature is enabled by default. You can keep the default setting.
Engine	Specifies whether to display the engine. You can keep the default setting.
Online Logs	Specifies whether to record the job running logs. This feature is enabled by default. You can keep the default setting.
Resource Management	Specifies whether resources such as JAR files can be uploaded. This feature is enabled by default. You can keep the default setting.
Switch Version	Specifies whether to enable the job version switch feature. This feature is enabled by default. You can keep the default setting.
Project Protection	Specifies whether to enable the project lock feature. You can keep the default setting.

6. Click **OK**.

Search for a project

On the **Projects** page, enter a keyword or full name of a project in the search box to find the project.

3.4. Data storage

3.4.1. Overview

This chapter describes data storage systems supported by Realtime Compute.

3.4.2. Overview

3.4.2.1. Overview

To facilitate data storage management, you can register data storage resources on the Realtime Compute development platform. This enables you to leverage the advantages of the one-stop Realtime Compute service. In Realtime Compute, you can manage multiple data storage systems, such ApsaraDB for RDS, and Table Store. With this one-stop management service, you no longer have to navigate across multiple management consoles of different storage systems.

3.4.2.2. Types

Realtime Compute supports both streaming data storage and static data storage.

Streaming data storage

Streaming data storage systems provide inputs and outputs for downstream Realtime Compute jobs.

Streaming data storage

Storage system	Input	Output
DataHub	Supported	Supported
Log Service	Supported	Supported
MQ	Supported	Supported

Static data storage

Static data storage systems provide outputs for downstream Realtime Compute jobs and allow you to perform association queries.

Static data storage

Storage system	Dimension table	Output
ApsaraDB for RDS	Supported	Supported
Table Store	Supported	Supported

3.4.2.3. Registration and usage

The topic describes how to register and use external data stores in Realtime Compute.

> **Note** If a job requires the use of the data stores owned by another Apsara Stack account, you can write DDL statements to reference the data stores. In the DDL statements, you must specify the required AccessKey ID and AccessKey secret of the account. In this scenario, you cannot use the codeless UI to manage the data stores.

- Register a data store

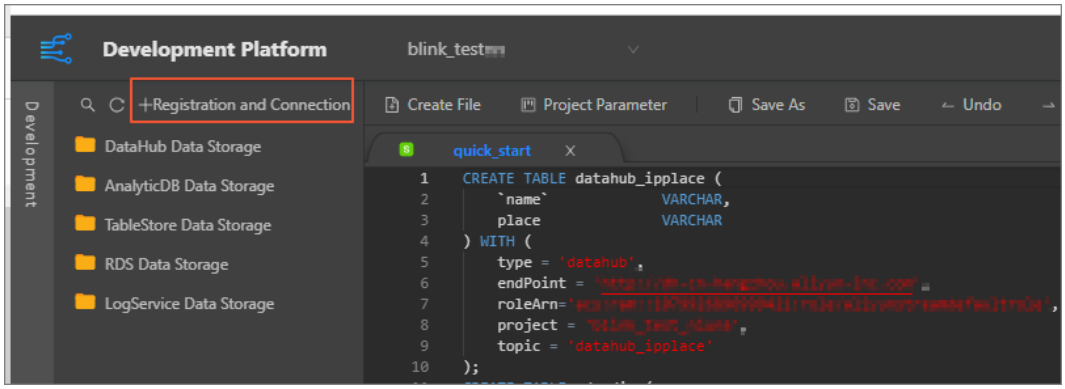
  To register a data store, follow these steps:

  i. Log on to the Realtime Compute console

  ii. In the top navigation bar, click **Development**.

  iii. In the left-side navigation pane of the page that appears, click **Storage**. Select the folder for the data store that you want to register. Then, click **+Registration and Connection**. On the page that appears, specify the required parameters and click **OK**.

  Register a data store



> **Note** After you enable the data store registration feature, you can only register data stores that are owned by your organization.

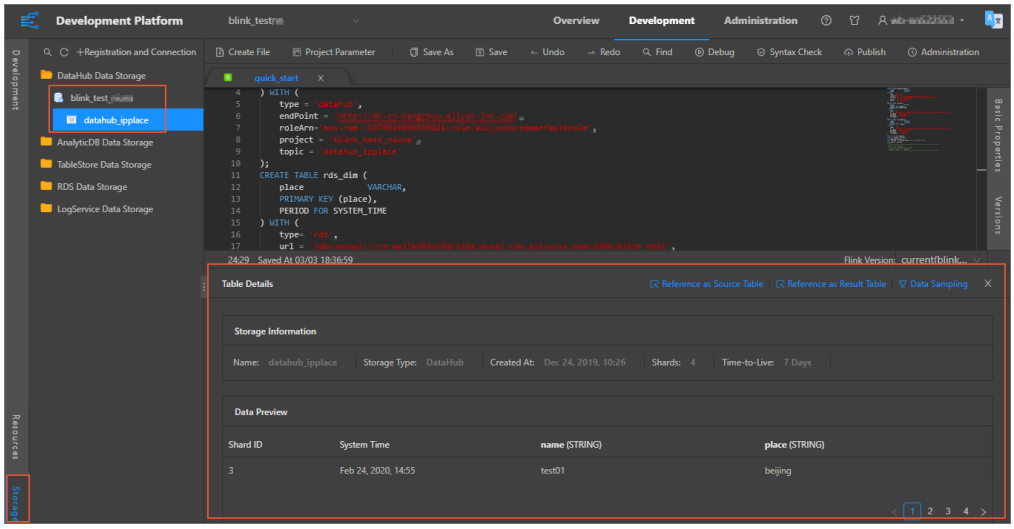
- Preview data from a data store

  Realtime Compute provides the data preview feature for each registered data store. To preview data, click **Storage** and double-click one of the folders on the left side of the page. The following example shows how to preview data from a DataHub data store.

  i. Log on to the Realtime Compute console. In the top-navigation bar, click **Development**. On the page that appears, click the **Storage** tab, and double-click the **DataHub Data Storage** folder.

  ii. Double-click the target project and double-click the target topic to view the details.

  Table details



- Use the auto DDL generation feature

  You must declare tables from external data stores before you can reference these tables. The following example shows how to reference a source table that contains streaming data:

```
CREATE TABLE in_stream(
 a varchar,
 b varchar,
 c timeStamp
) with (
 type='datahub',
 endPoint='http://dh-cn-hangzhou.aliyuncs.com',
 project='blink_test',
 topic='ip_count02',
 accessId='<yourAccessId>',
 accessKey='<yourAccessSecret>'
);
```

  > **Note** The field names in the table that is referenced on the **Development** page must be the same as those in the DataHub topic. You must declare the field data types in the code based on the type mapping between DataHub and Realtime Compute to ensure that Realtime Compute can recognize the data.

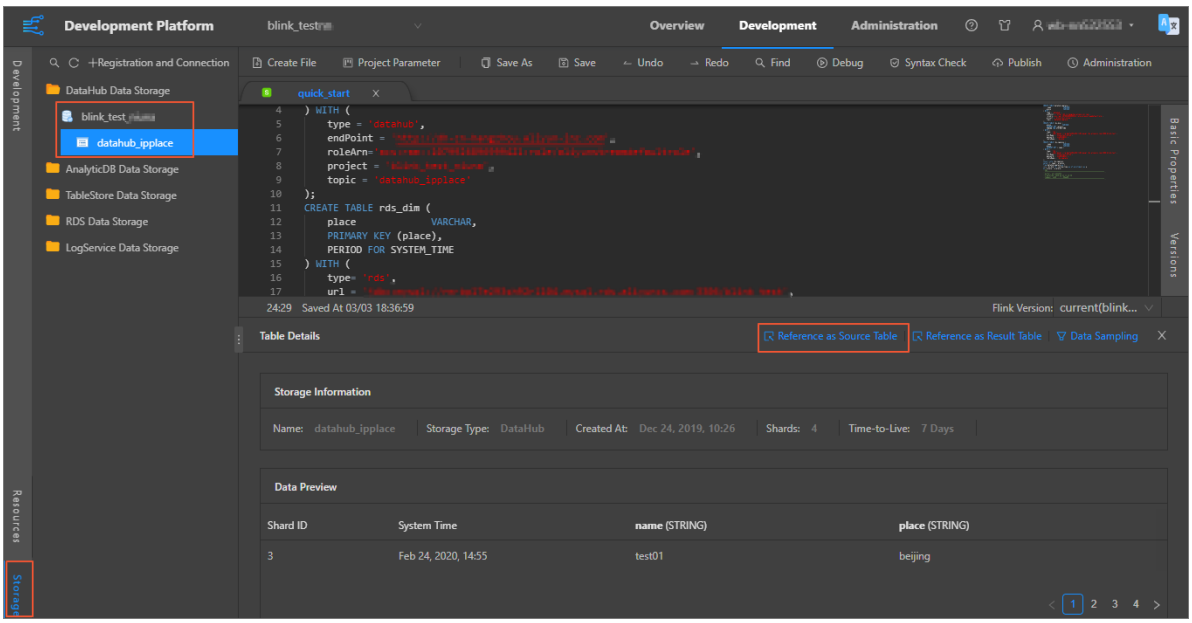
  Realtime Compute offers the auto DDL generation feature. The following section introduces how to use this feature.

  i. In the left-side navigation pane of the **Development** page, click **Storage**.

  ii. On the **Storage** tab, navigate through cascaded folders and nodes to find the target table. Then, double-click the name of the target table.

  iii. In the **Table Details** dialog box, click **Reference as Source Table**, **Reference as Result Table**, or **Reference as Dimension Table** based on your business requirements. Then, you can obtain the DDL statements that are automatically generated for referencing the target table.

To reference a source table, log on to the Realtime Compute console and open the target SQL file on the **Development** page. Click **Storage**, select the table for reference, and then click **Reference as Source Table**. The required DDL statements are displayed on the current page.



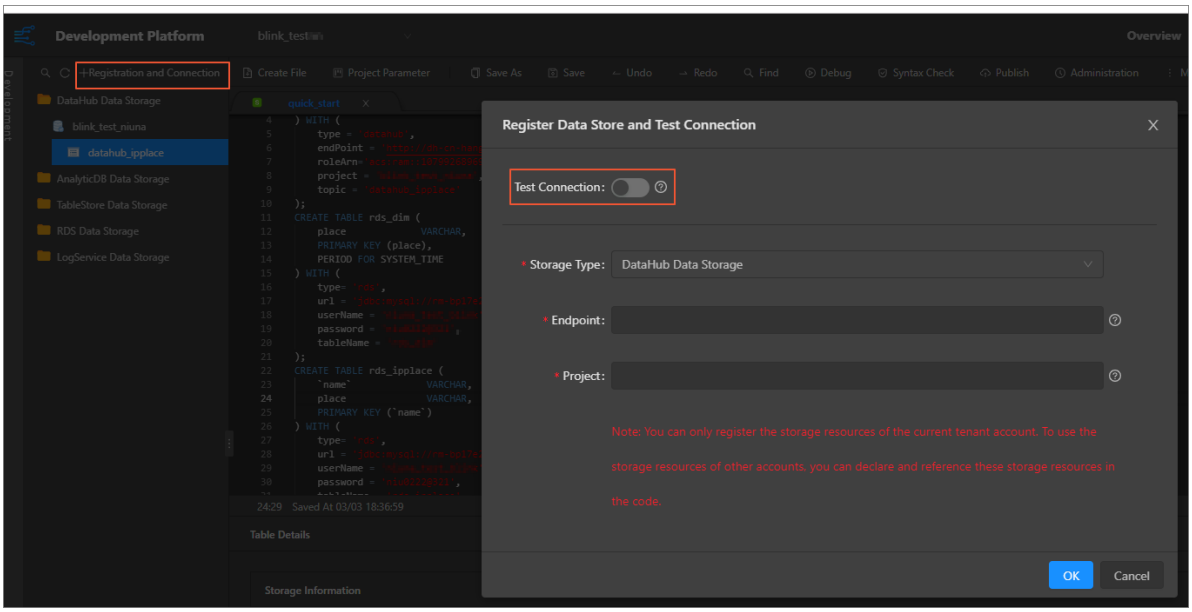
- Test network connection

  Realtime Compute offers the network connection test feature for data stores, which allows you to test the connection between Realtime Compute and a target data store. To enable the network connection test feature, follow these steps:

  i. In the left-side navigation pane of the **Development** page, click **Storage**.

  ii. In the upper-right corner of the **Storage** tab, click **+Registration and Connection**.

  iii. In the **Register Data Store and Test Connection** dialog box, turn on **Test Connection**.



Reference data stores owned by another level-1 organization

You can only register and use data stores that are owned by your level-1 organization. To use data stores that are owned by another level-1 organization, write DDL statements to create a reference to these data stores. For example, if a user from Organization A wants to use the data stores owned by Organization B, the user can enter the following DDL statements:

```
CREATE TABLE in_stream(
 a varchar,
 b varchar,
 c timeStamp
) with (
 type='datahub',
 endPoint='http://dh-cn-hangzhou.aliyuncs.com',
 project='blink_test',
 topic='ip_count02',
 accessId='<The AccessKey ID that is authorized by Organization B users>',
 accessKey='<The AccessKey secret that is authorized by Organization B users>'
);
```

3.4.3. Register a DataHub data store

DataHub is a streaming data processing platform. This platform allows you to publish, subscribe to, and distribute streaming data. The solution provides efficient methods to analyze streaming data and build streaming data applications. Realtime Compute often uses DataHub to store source tables and result tables that contain streaming data.

Register a DataHub project

1. Log on to the Realtime Compute console.
2. In the top navigation bar, click **Development**.
3. In the left-side navigation pane, click the **Storage** tab.
4. Right-click **DataHub Data Storage** and select **Register Data Store** to register a DataHub project in Realtime Compute.

Parameters

Parameter	Description
Test Connection	Specifies whether to enable the network connection test feature. Network connection tests are automatically performed on data stores that can be registered in Realtime Compute. To test the connection between Realtime Compute and data stores that cannot be registered, turn on the **Test Connection** switch.
Storage Type	The type of the data store. **DataHub Data Storage** is selected by default.

Parameter	Description
Endpoint	The endpoint of DataHub. The endpoint of DataHub varies with region. For information about the endpoint, contact your administrator. **Note** To specify this parameter for Apsara Stack, contact your Apsara Stack administrator to obtain the DataHub endpoint.
Project	The name of the DataHub project. **Note** You can only register DataHub projects that are owned by your level-1 organization. For example, if DataHub Project A is owned by Organization A, a user from Organization B cannot register Project A in Realtime Compute.
AccessKey ID	The AccessKey ID of the current account.
AccessKey Secret	The AccessKey secret of the current account. The AccessKey secret enables Realtime Compute to access the DataHub project.

Scenarios

DataHub is a streaming data storage system that can be used to store source and result tables. However, it cannot be used to store dimension tables for Realtime Compute.

FAQ

Q: Why am I unable to register a DataHub project in Realtime Compute?

A: Realtime Compute uses a storage software development kit (SDK) to access different data stores. The **Storage** tab in the Realtime Compute console only helps you manage data from different data stores. You can perform the following operations to troubleshoot registration errors:

- Check whether you have created the DataHub project and have the required permissions to access the project. To perform the check, log on to the DataHub console, and check whether you can access the project.
- Check whether you are the project owner. You can only register DataHub projects that are owned by your level-1 organization. For example, if DataHub Project A is owned by Organization A, a user from Organization B cannot register Project A in Realtime Compute.
- Check whether you have specified the correct DataHub endpoint and project name.
- Check whether you have specified a classic network endpoint for the Endpoint parameter. If you specify a VPC endpoint, the DataHub project fails to be registered.
- Check whether you have registered the DataHub project. Realtime Compute provides a registration check mechanism that prevents duplicate registration.

Q: Why does Realtime Compute support only time-based sampling?

A: DataHub stores streaming data, and you can only specify time parameters in the API. Therefore, Realtime Compute supports only time-based sampling.

3.4.4. Register a Log Service data store

Log Service (previously known as SLS) provides an end-to-end solution for log management. You can use this solution to easily collect, subscribe to, ship, and query large amounts of log data. If you use Log Service to manage Elastic Compute Service (ECS) logs, Realtime Compute can integrate with Log Service to process ECS logs. This eliminates the need to transfer data between these systems.

Register a Log Service project

1. Log on to the Realtime Compute console.
2. In the top navigation bar, click **Development**.
3. In the left-side navigation pane, click the **Storage** tab.
4. Right-click **LogService Data Storage** and select **Register Data Store** to register a Log Service project in Realtime Compute.

Parameters

Parameter	Description
Test Connection	Specifies whether to enable the network connection test feature. Network connection tests are automatically performed on data stores that can be registered in Realtime Compute. To test the connection between Realtime Compute and data stores that cannot be registered, turn on the **Test Connection** switch.
Storage Type	The type of the data store. **LogService Data Storage** is selected by default.
Endpoint	The endpoint of Log Service. The endpoint of Log Service varies with region. **Note** For information about the endpoint for Log Service, contact the Apsara Stack system administrator.
Project	The name of the Log Service project. **Note** You can only register Log Service projects that are owned by your level-1 organization. For example, if Log Service Project A is owned by Organization A, a user from Organization B cannot register Project A in Realtime Compute.
AccessKey ID	The AccessKey ID of the current account.
AccessKey Secret	The AccessKey secret of the current account. The AccessKey secret enables Realtime Compute to access the Log Service project.

Scenarios

Log Service is a streaming data storage system that can be used to store source tables and result tables. However, it cannot be used to store dimension tables for Realtime Compute.

FAQ

- Q: Why am I unable to register a Log Service project in Realtime Compute?

  A: Realtime Compute uses a storage software development kit (SDK) to access different data stores. The **Storage** tab in the Realtime Compute console only helps you manage data from different data stores. You can perform the following operations to troubleshoot registration errors:

  - Check whether you have created the Log Service project and have the required permissions to access the project. To perform the check, log on to the Log Service console, and check whether you can access the project.
  - Check whether you are the project owner. You can only register Log Service projects that are owned by your level-1 organization. For example, if Log Service Project A is owned by Organization A, a user from Organization B cannot register Project A in Realtime Compute.
  - Check whether you have specified the correct Log Service endpoint and project name.

    > **Note** The endpoint must start with http and cannot end with a forward slash (/). For example, `http://cn-hangzhou.log.aliyuncs.com` is correct, and `http://cn-hangzhou.log.aliyuncs.com/` is incorrect.

  - Check whether you have registered the Log Service project. Realtime Compute provides a registration check mechanism that prevents duplicate registration.

- Q: Why does Realtime Compute support only time-based sampling?

  A: Log Service stores streaming data, and you can only specify time parameters in the API. Therefore, Realtime Compute supports only time-based sampling.

  > **Note** To use the search feature of Log Service, log on to the Log Service console.

3.4.5. Register a Tablestore data store

Tablestore is a NoSQL database service that is based on the Apsara distributed system. Tablestore allows you to store and access large amounts of structured data in real time. Tablestore features massive data storage and low access delays, which makes it suitable to store dimension tables and result tables for Realtime Compute.

Register a Tablestore instance

1. Log on to the Realtime Compute console.
2. In the top navigation bar, click **Development**.
3. In the left-side navigation pane, click the **Storage** tab.
4. Right-click **TableStore Data Storage** and select **Register Data Store**. In the dialog box that appears, register a Tablestore instance in Realtime Compute.

Parameters

Parameter	Description

Parameter	Description
Test Connection	Specifies whether to enable the network connection test feature. Network connection tests are automatically performed on data stores that can be registered in Realtime Compute. To test the connection between Realtime Compute and data stores that cannot be registered, turn on the **Test Connection** switch.
Storage Type	The type of the data store. **TableStore Data Storage** is selected by default.
Endpoint	The endpoint of the Tablestore instance. You must enter the internal endpoint of the Tablestore instance. You can log on to the Tablestore console to view the internal endpoint of the instance.
Instance Name	The name of the Tablestore instance.
AccessKey ID	The AccessKey ID of the current account.
AccessKey Secret	The AccessKey secret of the current account. The AccessKey secret enables Realtime Compute to access the Tablestore instance.

3.4.6. Register an RDS data store

This topic describes how to register and use an ApsaraDB for RDS data store in Realtime Compute.

RDS overview

RDS offers a stable, reliable, and scalable online database service. Based on the Apsara distributed system and high performance SSD storage, RDS supports a wide range of engines, such as MySQL, PostgreSQL, and Postgres Plus Advanced Server (PPAS, highly compatible with Oracle). Realtime Compute supports the following RDS engines: MySQL and PostgreSQL.

The performance of Tablestore in high concurrency scenarios where large amounts of data need to be processed is higher than that of RDS. The performance of RDS is restricted by the limits of relational models. Therefore, RDS is often used to store result tables for Realtime Compute. In low concurrency scenarios where a small number of data needs to be processed, RDS can be used to store dimension tables.

> **Note** Realtime Compute uses relational databases, such as ApsaraDB RDS for MySQL, to store result data. Distributed Relational Database Service (DRDS) and RDS connectors are used. If Realtime Compute frequently writes data into a DRDS or RDS table, deadlocks may occur. In scenarios that require high queries per second (QPS), high transactions per second (TPS), or highly concurrent write operations, we recommend that you do not use DRDS or RDS to store the result tables of Blink jobs. To prevent deadlocks, we recommend that you use Tablestore to store result tables.

Register an RDS instance

1. Log on to the Realtime Compute console.
2. In the top navigation bar, click **Development**.
3. In the left-side navigation pane, click the **Storage** tab.

4. Right-click **RDS Data Storage**, and select **Register Data Store**. In the dialog box that appears, register an RDS instance in Realtime Compute.

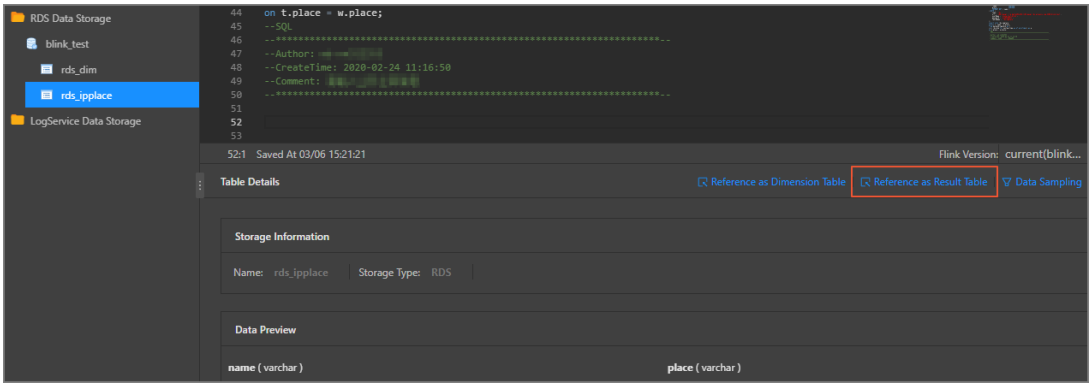
Parameters

Parameter	Description
Test Connection	Specifies whether to enable the network connection test feature. Network connection tests are automatically performed on data stores that can be registered in Realtime Compute. To test the connection between Realtime Compute and data stores that cannot be registered, turn on the **Test Connection** switch.
Storage Type	The type of the data store. **RDS Data Storage** is selected by default.
URL	The connection URL of the RDS database.
DBName	The name of the RDS database to be accessed by Realtime Compute. **Note** This parameter specifies the RDS database name instead of the RDS instance name. RDS uses whitelists for access control to ensure system security. The IP addresses of the Realtime Compute console and worker nodes must be added to RDS whitelists. Otherwise, Realtime Compute may fail to connect to RDS. For more information, see Specify whitelist settings.
User Name	The username that you use to log on to the RDS database.
Password	The password that you use to log on to the RDS database.
Engine	The type of the RDS database. Valid values: ○ **mysql** ○ **postgresql** ○ **sqlserver**

Reference an RDS table as a result table

After you register an RDS data store, double-click the RDS database, double-click the RDS table that you want to reference as a result table, and then click **Reference as Result Table**.

Reference an RDS table as a result table



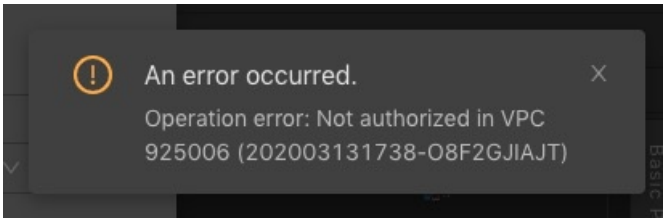
After you click **Reference as Result Table**, Realtime Compute automatically generates the corresponding DDL statements on the current page.

Result

```
    place             VARCHAR,
    PRIMARY KEY (`name`)
) WITH (
    type= 'rds',
    url = '',
    userName = '',
    password = '',
    tableName = ''
);
```

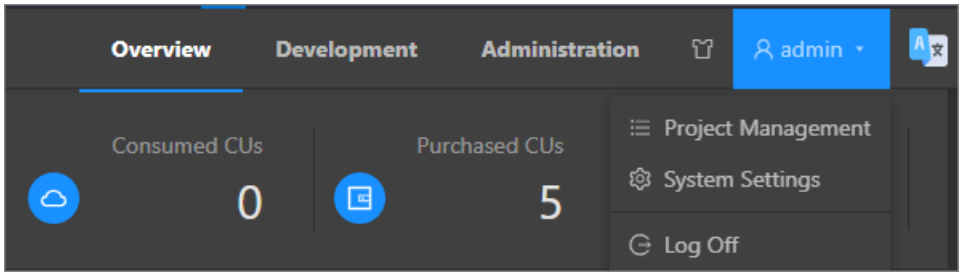
If the following error message appears, troubleshoot and rectify the fault as follows.

Error message



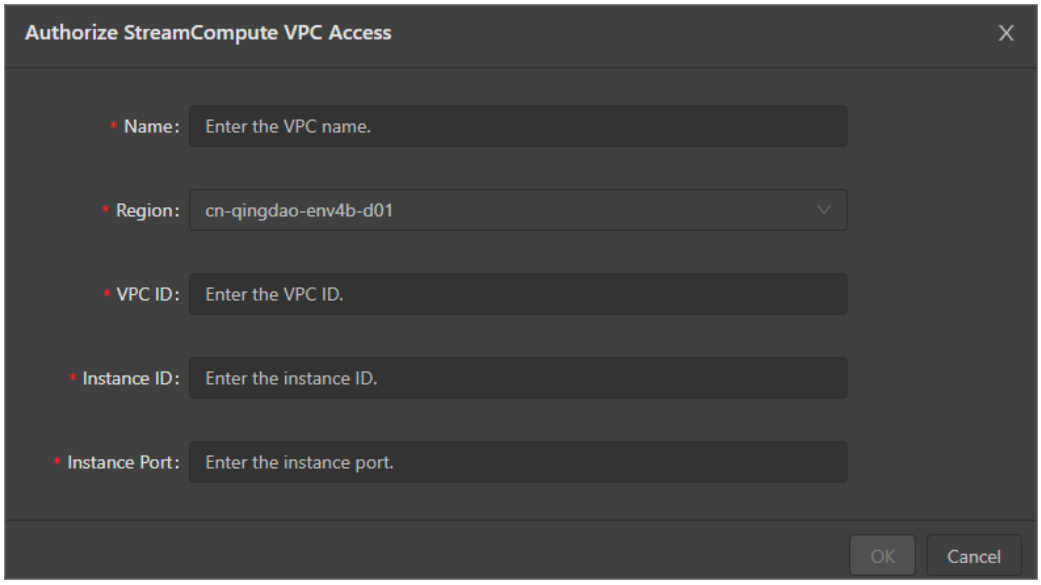
The error occurs because a VPC (not a classic network) was selected when you created the RDS instance. To rectify this fault, follow these steps:

1. Move the pointer over the administrator icon, as shown in the following figure.

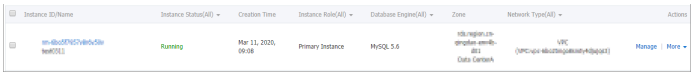


2. Click **System Settings**.
3. In the left-side navigation pane, click **VPC Access Authorization**.
4. Click **Add Authorization**. The **Authorize StreamCompute VPC Access** page appears.

Authorization



Parameters

Parameter	Description
Name	The name of the VPC.
Region	The region where RDS resides.
VPC ID	The ID of the VPC.
Instance ID	The ID of the RDS instance. You can log on to the RDS console and view the instance ID. Instance information 
Instance Port	The access port for the RDS instance. To view the internal port number, log on to the RDS console, click the target instance ID or name in the **Instance ID/Name** column. On the page that appears, view the internal port number in the Basic Information section.

5. Register the target RDS instance. You must specify the required parameters during the registration.

You can only register data storage resources that are owned by your level-1 organization. For example, if RDS Instance A is owned by Organization A, a user from Organization B cannot register RDS Instance A in the Realtime Compute console. To use Instance A in a stream processing job, the user from Organization B must use SQL code to create a reference to Instance A.

> **Note** If you want to use the RDS storage resources owned by your level-1 organization, we recommend that you do not use SQL code to create a reference to these resources.

The user from Organization B must also specify the following parameters in the WITH clause based on the information of Instance A: url, userName, password, and tableName.

Configuration

```
CREATE TABLE datahub_output (
    id            varchar
) WITH (
    type= 'rds',
    url = '                ',
    userName = '          n',
    password = '          3',
    tableName = 'datahub_output'
);
```

To use RDS storage resources by writing SQL code, the user from Organization B must specify whitelist settings.

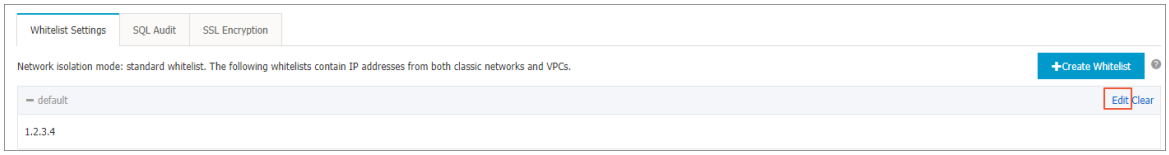
Specify whitelist settings

Some data stores use whitelists for access control to ensure high-level security. These data stores allow access only from the IP addresses that are added to the whitelists. This prevents unauthorized Apsara Stack services from accessing data in these data stores. For example, a newly created RDS database denies all access. You must add IP addresses to the RDS database whitelists to allow access to the database.

RDS can be accessed from both external and internal networks. To enable Realtime Compute to access RDS, you must add the CIDR blocks of Realtime Compute to RDS whitelists.

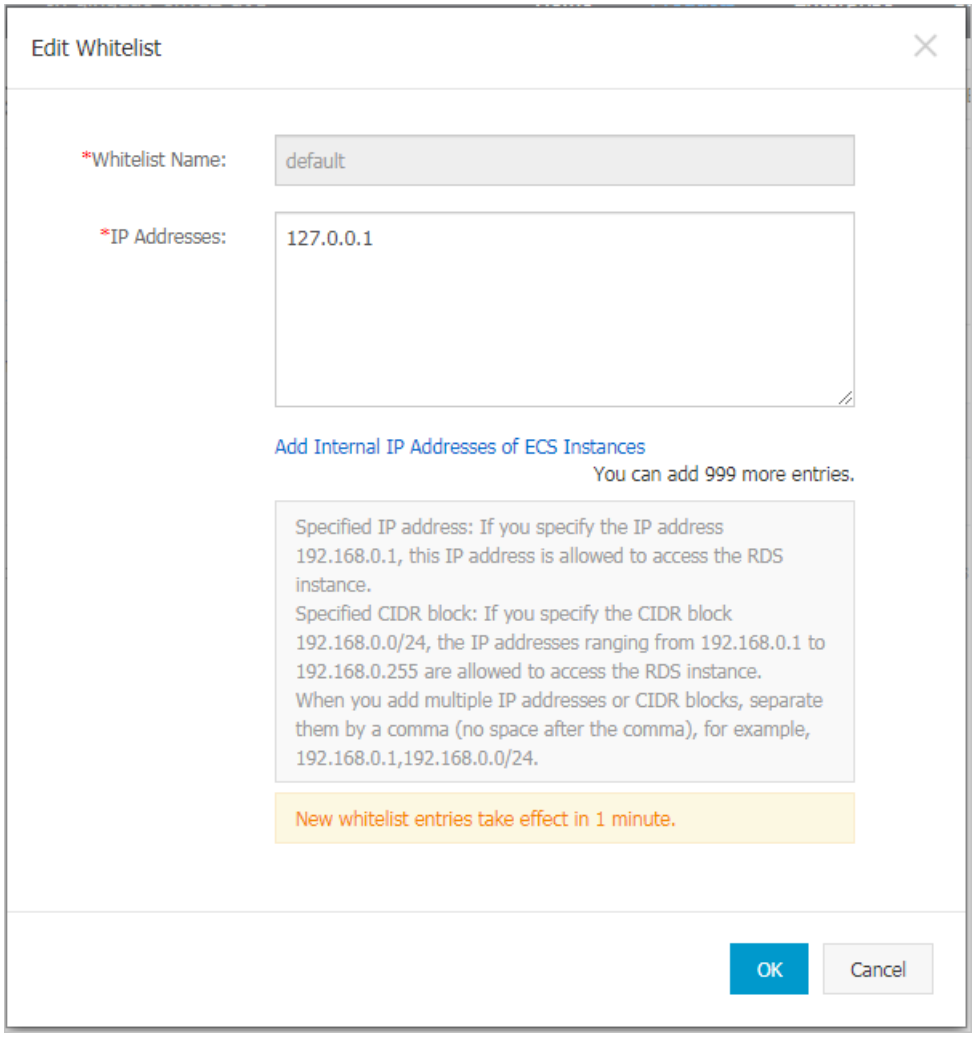
To do this, follow these steps:

1. Log on to the ApsaraDB for RDS console.
2. On the **Instances** page, click the ID of an instance in the **Instance ID/Name** column.
3. In the left-side navigation pane, click **Data Security**.
4. On the **Whitelist Settings** tab, click **Edit** corresponding to the **default** whitelist.



> **Note**
>
> - To connect an ECS instance to an RDS instance by using an internal endpoint, you must make sure that the two instances are in the same region and have the same network type. Otherwise, the connection fails.
> - You can also click **Create Whitelist** to create a new whitelist.

5. In the **Edit Whitelist** dialog box that appears, specify the IP addresses or CIDR blocks that are used to access the instance, and then click **OK**.



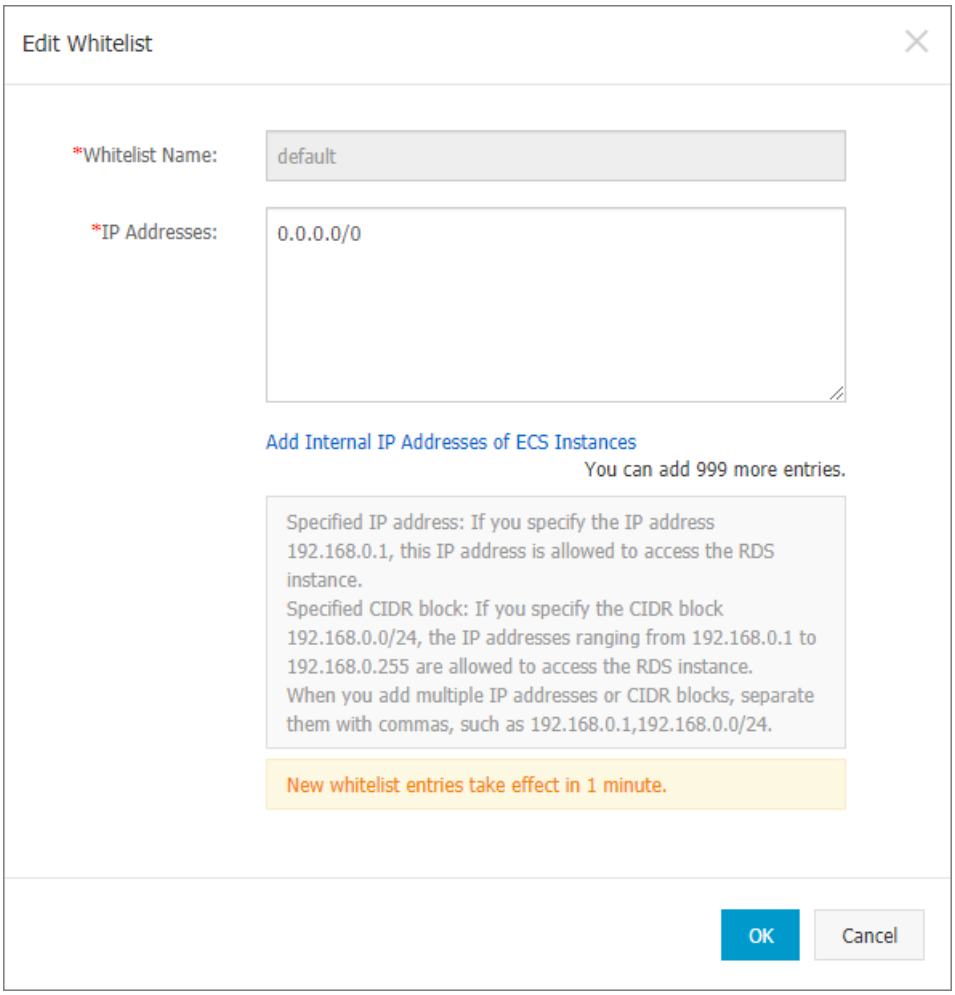
- If you specify the 10.10.10.0/24 CIDR block, IP addresses in the 10.10.10.X format are allowed to access the RDS instance.
- If you want to add multiple IP addresses or CIDR blocks, separate entries with commas (without spaces), such as 192.168.0.1,172.16.213.9.
- After you click **Add Internal IP Addresses of ECS Instances**, the IP addresses of all the ECS instances under your Apsara Stack account are displayed. You can select the required IP addresses to add to the whitelist.

> **Note** If you add a new IP address or CIDR block to the **default** whitelist, the default address 127.0.0.1 is automatically deleted.

Troubleshooting

- Fault description

A stack exception occurs while the system is running, as shown in the following figure.



- Solution

  Add the IP address of your region to an RDS whitelist. For more information, see Specify whitelist settings.

3.5. Data development

3.5.1. Create a job

This topic describes how to create a Realtime Compute job.

Procedure

1. Log on to the Realtime Compute console.
2. Click **Development Platform**.
3. Click **Development** in the top navigation bar.
4. Click **Create File** in the toolbar.
5. In the **Create File** dialog box, specify the required fields.

Field	Description
File Name	The name of the file. The specified name must be 3 to 64 characters in length and can contain lowercase letters, digits, and underscores (_). It must start with a lowercase letter.
File Type	The type of the file. Valid values: FLINK_STREAM/SQL and FLINK_STREAM/DATASTREAM.
Storage Path	The folder of the file. You can click the icon on the right side of an existing folder and create a subfolder.

6. Click **OK**.

3.5.2. Development

3.5.2.1. SQL code assistance

The development platform of Realtime Compute offers a complete set of SQL tools in the integrated development environment (IDE). These tools provide the following features to help you with Flink SQL-based development:

- Syntax check

  On the **Development** page of Realtime Compute, the revised script is automatically saved. When the script is saved, an SQL syntax check is automatically performed. If a syntax error is detected, the **Development** page shows the row and column where the error is located, and the cause of the error.

- Intelligent code completion

  When you enter SQL statements on the **Development** page of Realtime Compute, auto completion popups about keywords, built-in functions, tables, or fields are automatically displayed.

- Syntax highlighting

  Flink SQL keywords are highlighted in different colors to differentiate data structures.

3.5.2.2. SQL code version management

Realtime Compute provides key features that help you complete development tasks, such as coding assistance and code version management. A new code version is generated each time you publish a job SQL file. The code version management feature allows you to track code changes and roll back to an earlier version if required.

- Manage code versions

  On the **Development** page, you can manage Flink SQL code versions. A new code version is generated each time you publish a job SQL file. You can use the code version management feature to track versions, modify the code, and roll the code back to an earlier version.

  On the **Versions** tab on the right side of the **Development** page, click **More** in the **Actions** column to manage code versions.

  - **Compare**: Check the differences between the current version and an earlier version.
  - **Rollback**: Roll back to an earlier version.

- **Delete**: Delete an earlier version.
- **Locked**: Lock the current version.

> **Note** You cannot submit a new version before you unlock the SQL file.

- Delete code versions

  A snapshot of a code version is created each time you submit an SQL file for publishing a job. This allows you to track code changes. The maximum number of code versions has been specified. If you use Apsara Stack, a maximum of 20 code versions can be published. To find out the maximum number of code versions in other environments, contact the system administrator. If the number of code versions reaches the upper limit, an error message is displayed to alert you to delete one or more earlier versions.

  In this scenario, you must delete one or more earlier versions before you publish new versions. To do this, click the **Versions** tab on the right side of the **Development** page, click **More** in the **Actions** column, and select **Delete** to delete expired versions that are no longer needed.

3.5.2.3. Data store management

The Development page of the Realtime Compute console provides an easy and effective method to manage data stores. For example, you can register external data stores to reference the data stores.

- Data preview

  The **Development** page of Realtime Compute allows you to preview data from a wide range of data stores. Data preview allows you to analyze the characteristics of upstream and downstream data, identify key business logic, and complete development tasks with high efficiency.

- Auto DDL generation

  Realtime Compute provides the auto DDL generation feature. The system can automatically generate DDL statements to reference data stores that can be registered in Realtime Compute. This feature provides a simple method to edit SQL statements for stream processing jobs. This improves overall efficiency and reduces errors when you manually enter SQL statements.

3.5.3. Debug job code

The Realtime Compute development platform provides a simulated running environment where you can customize uploaded data, simulate operations, and check outputs.

After you write the SQL code that implements the computing logic, follow these steps to debug the code:

1. Log on to the Realtime Compute console.
2. In the top navigation bar, click **Development**.
3. In the left-side navigation pane, click **Development**.
4. On the **Development** tab, double-click the target folder and file name to open the job file.
5. In the top menu bar, click **Syntax Check**.

> **Note** You can use the syntax check feature to check whether the SQL file includes syntax errors. Error messages are displayed for syntax errors.

6. In the top menu bar, click **Debug**. On the **Debug File** page, debug your SQL code.

   The test data for debugging can be acquired by using either of the following two methods:

   - Upload local data.
     a. Click **Download Template**.
     b. Prepare test data based on the template.
     c. Click **Upload**. After the file is uploaded, you can view the uploaded data in the data preview section.
   - Sample online data.
     a. Click **Random Online Data Sampling** or **Sequential Online Data Sampling**.
     b. View the sampled data in the data preview section.

7. Click **OK**.
8. In the output window, view the debugging result.

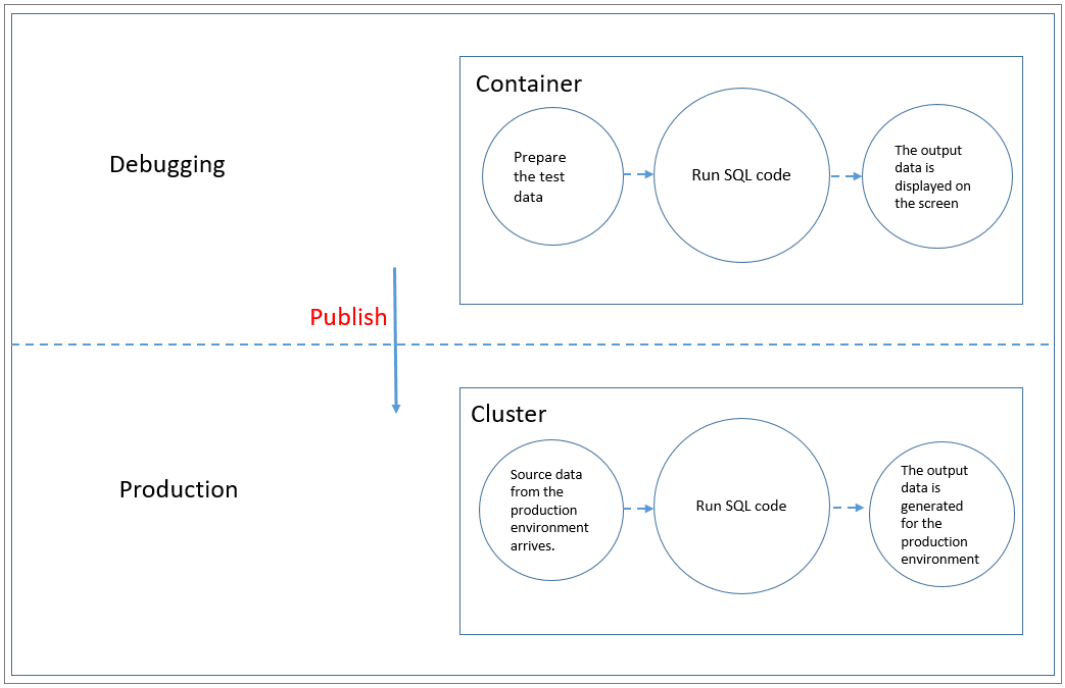
The debugging feature of Realtime Compute provides the following functions:

- Enables isolation between debugging and production environments.

  In the debugging environment, the Flink SQL code runs in a separate container, and computing result data is only displayed on the screen of the **Development** page. In this way, the debugging does not affect the running jobs and data stores in the production environment.

  In the debugging phase, result data is not written to external data stores. In the production environment, failures may occur due to format errors when result data is written to the target data stores. Such failures cannot be identified or prevented in the debugging phase, and can be detected only while jobs are running. For example, failures may occur in the production environment if your result data is too long. This occurs when the result data is written to a result table in ApsaraDB for RDS and the length of character strings reaches the upper limit for an RDS table. The Realtime Compute team is working on support for writing result data to external data stores in the production environment. This allows you to effectively simulate the production environment and resolve more issues in the debugging phase.

  Isolation between debugging and production environments



- Supports the customization of test data.

  In the debugging environment, Realtime Compute does not read data from source data stores, such as DataHub topics that store source tables and RDS instances that store dimension tables. You must create a set of test data and upload the test data on the **Development** page.

  To make the debugging feature easy to use, Realtime Compute provides a template of test data for each type of job. You can download the template and enter your test data.

  > **Note** We recommend that you use the templates to prevent errors.

- Specifies a separator.

  A comma (,) is used as the separator in files for debugging by default. An example of a file for debugging is described as follows:

  ```
  id,name,age
  1,alicloud,13
  2,stream,1
  ```

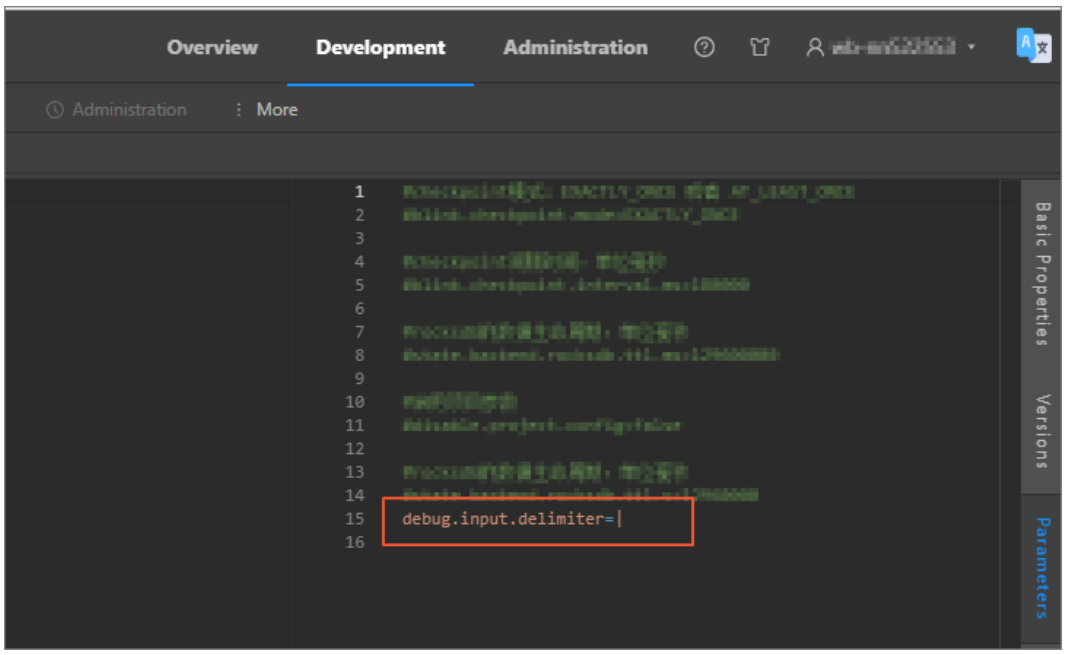
  If the separator is not specified, a comma (,) is used to separate fields. If you need to use a JSON string as the field data and the string contains commas (,), you must specify another character as the separator.

  > **Note** Realtime Compute allows you to specify a character as the separator, but not a multi-character string, such as aaa.

  ```
  id|name|age
  1|alicloud|13
  2|stream|1
  ```

In this example, specify the debug.input.delimiter parameter as follows: `debug.input.delimiter=|`.

Specify a separator



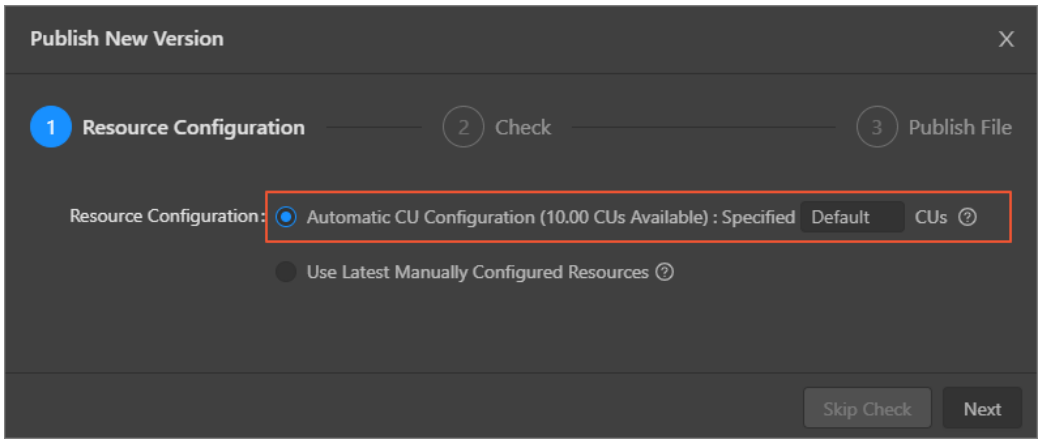
3.5.4. Publish a job SQL file

After you have created and debugged a job Flink SQL file, you can publish the SQL file and manage the job in the production environment.

Procedure

1. Log on to the Realtime Compute console.
2. In the top navigation bar, Click **Development**.
3. In the top menu bar, click **Publish**.
4. In the dialog box that appears, select **Automatic CU Configuration**. If you are performing automatic configuration for the first time, we recommend that you use the default number of CUs. Click **Next**.

Configure resources



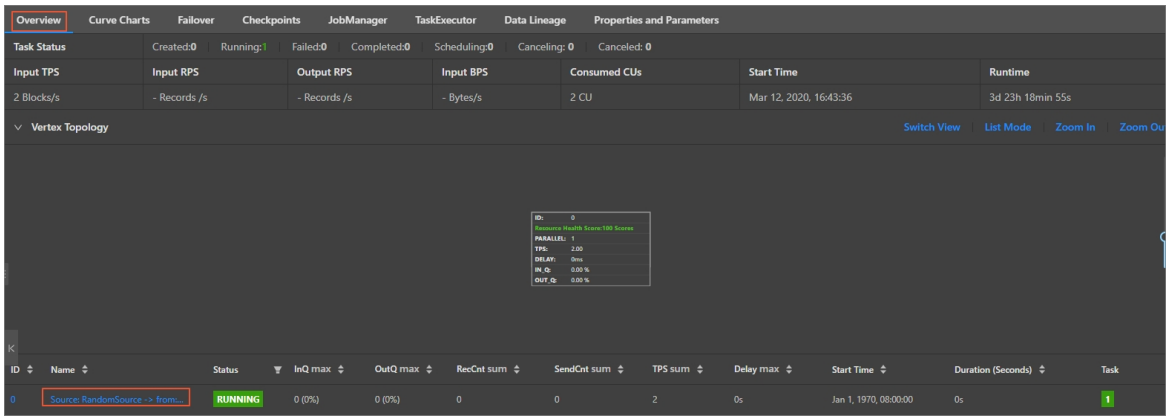
5. Check the data. After the check is completed, click **Next**.
6. Click **Publish**.
7. Go to the **Administration** page to start the job.
   i. In the top navigation bar, click **Administration**.
   ii. On the **Administration** page, find the target job, and click **Start** in the **Actions** column.

3.5.5. View logs

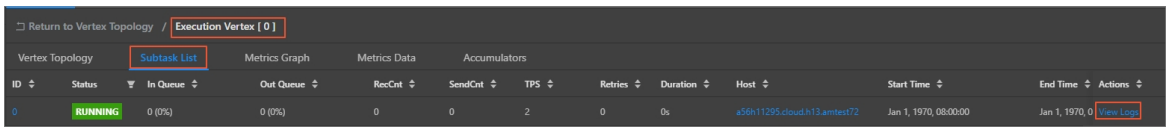
You can view job logs to check the job run information. This topic describes how to view job logs.

Procedure

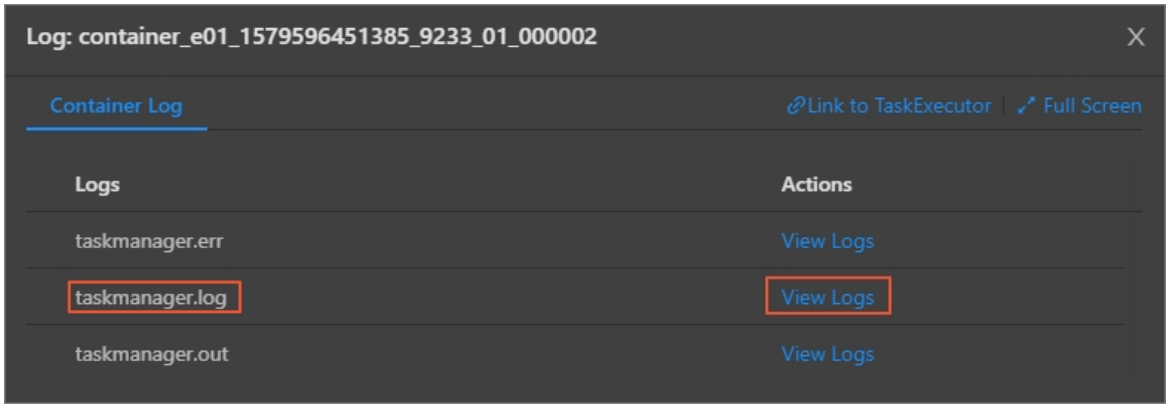
1. Go to the **Administration** page in Realtime Compute.
   i. Log on to the Realtime Compute console.
   ii. In the top navigation bar, click **Administration**.
   iii. On the **Jobs** page that appears, click the target job name in the **Job Name** column.
2. At the bottom of the **Overview** page, click the name of the target vertex.



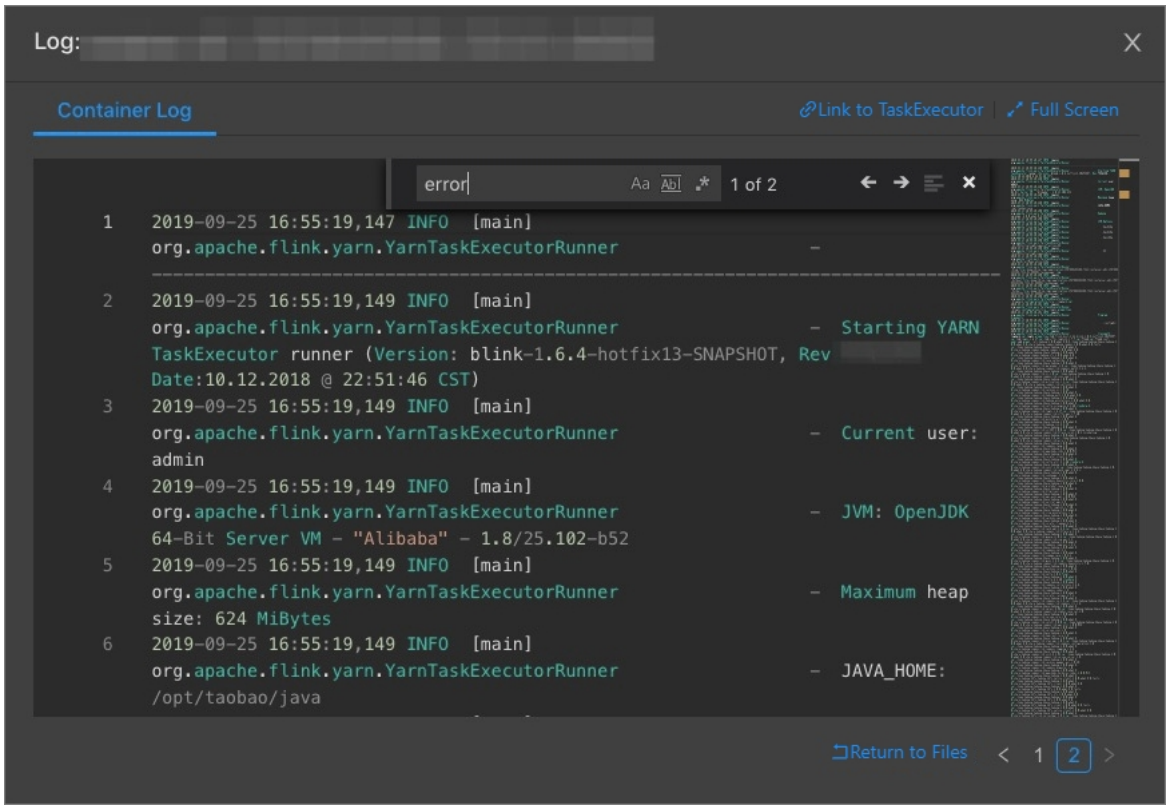
3. On the **Execution Vertex** page, click the **Subtask List** tab, and click **View Logs** in the **Actions** column.



4. In the **Log** dialog box that appears, click **View Logs** for **taskmanager.log** in the **Actions** column.



5. On the **Container Log** tab, view the log entries.



Note You can press **Ctrl+F** for Windows or **Cmd+F** for MacOS to search for specified log entries. We recommend that you view the logs from the last page. The first `error` log entry describes the root cause of the job error.

4.Machine Learning Platform for AI

4.1. What is machine learning?

Machine learning is a process of using statistical algorithms to learn large amounts of historical data and generate an empirical model to provide business strategies.

Apsara Stack Machine Learning Platform for AI is a set of data mining, modeling, and prediction tools. It is developed based on MaxCompute (also known as ODPS). Machine Learning Platform for AI supports the following functions:

- Provides an all-in-one algorithm service covering algorithm development, sharing, model training, deployment, and monitoring.
- Allows you to complete the entire procedure of an experiment either through the GUI or by running PAI commands. This function is typically intended for data mining personnel, analysts, algorithm developers, and data explorers.
- In Apsara Stack, Machine Learning Platform for AI runs on MaxCompute. Machine Learning Platform for AI allows you to call algorithms to decouple the applications and compute engines after you have deployed algorithm packages in MaxCompute clusters.
- Provides various algorithms and reliable technical support, providing more options to resolve service issues. In the Data Technology (DT) era, you can use Machine Learning Platform for AI to implement data-driven services.

Machine Learning Platform for AI can be applied in the following scenarios:

- Marketing: commodity recommendations, user profiling, and precise advertising.
- Finance: loan delivery prediction, financial risk control, stock trend prediction, and gold price prediction.
- Social network sites (SNSs): microblog leader analysis and social relationship chain analysis.
- Text: news classification, keyword extraction, text summarization, and text analysis.
- Unstructured data processing: image classification and image text extraction through OCR.
- Other prediction cases: rainfall forecast and football match result prediction.

Machine learning can be divided into three types:

- Supervised learning: Each sample has an expected value. You can create a model and map input feature vectors to target values. Typical examples of this learning mode include regression and classification.
- Unsupervised learning: No samples have a target value. This learning mode is used to discover potential regular patterns from data. Typical examples of this learning mode include simple clustering.
- Reinforcement learning: This learning mode is complex. A system constantly interacts with the external environment to obtain external feedback and determines its own behavior to achieve a long-term optimization of targets. Typical examples of this learning mode include AlphaGo and driverless vehicles.

4.2. Quick start

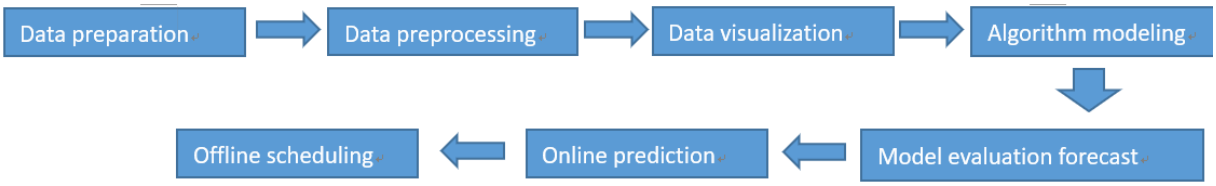
4.2.1. Overview

This topic describes how to perform data preparation, data preprocessing, data visualization, algorithm modeling, model prediction and evaluation, online prediction, and DataWorks task scheduling to set up a machine learning experiment.

> **Note** This document covers Apsara Stack Machine Learning Platform for AI, online model service, and deep learning framework. The online model service and deep learning framework are not basic functions of Apsara Stack Machine Learning Platform for AI and must be purchased separately.

For more information, see Machine learning experiment creation flowchart.

Machine learning experiment creation flowchart



1. Data preparation

   Import target data into the Apsara Stack Machine Learning Platform for AI console.

2. Data preprocessing

   Perform data processing, including SQL-based conversion, normalization, and standardization, to ensure that all data has the same dimensions.

3. Data visualization

   Display data in charts to view the features of the data and the distribution of the values. This serves as the basis for model algorithm selection.

4. Algorithm modeling

   Use machine learning algorithms to train data and ultimately build a model.

5. Model evaluation forecast

   Make predictions from and evaluate the model, and use the prediction results to create business development strategies.

6. Online prediction

   Use online prediction to deploy the generated model and adjust your business strategy based on the prediction results.

7. Offline scheduling

   Deploy experiments in DataStudio and run them on a regular basis.

4.2.2. Log on to Apsara Stack Machine Learning Platform for AI

This topic describes how to log on to Apsara Stack Machine Learning Platform for AI.

Prerequisites

- Before logging on to the ASCM console, make sure that you have obtained the IP address or domain name of the ASCM console from the deployment personnel. The URL used to access the ASCM console is in the following format: https://[IP address or domain name of the ASCM console].
- We recommend that you use the Google Chrome browser.

Procedure

1. Enter the address into the address bar of your web browser, and then press Enter.
2. Enter your username and password. Obtain the username and password for logging on to the console from the operations administrator.

   > **Note** The first time you are logging on to ASCM, you must follow the instructions to change the password of your account. For security concerns, your password must meet the minimum complexity requirements: The password must be 8 to 20 characters in length and must contain two or more types of the following characters: letters, digits, and special characters such as exclamation points (!), at signs (@), number signs (#), dollar signs ($), and percent signs (%).

3. Click **Login** to log on to ASCM.
4. In the top menu bar, choose **Products > Machine Learnig Platform for AI** to open the portal of Machine Learning Platform for AI.
5. Select an organization, and then click **PAI**.

   > **Note** If this is the first time that you log on to the Machine Learning Platform for AI console, you must perform the following tasks:
   >
   > i. Add an organization
   >
   > Create an organization to manage resource sets and resources in the resource sets.
   >
   > ii. Create a user
   >
   > Administrators can create users and attach different roles to users for permission control.
   >
   > iii. Create a resource set
   >
   > Create a resource set before you apply for resources.
   >
   > iv. Add a member to a resource set
   >
   > Add users to the resource set as members.
   >
   > v. In the top menu bar of ASCM, choose **Products > Big Data > MaxCompute**, and then create a **task account** and **MaxCompute project**.
   >
   > a. Create a task account: set the **Organization** to the one created in step 1.
   >
   > b. Create a MaxCompute project: set the **Organization** to the one created in step 1, set the **Resource Set** to the one created in step 2, and set the **Task Account** to the one that you have created.
   >
   > vi. Create a DataWorks workspace. In the **Advanced Settings** section, set **MaxCompute Project Name** to the project created in the preceding step.

4.2.3. Data preparation

This topic describes how to import data into the Apsara Stack Machine Learning Platform for AI console for modelling.

Prerequisites

Make sure that you have created a MaxCompute project and imported table data into the project. You can download the data from .

Procedure

1. Log on to the Apsara Stack Machine Learning Platform for AI console and click **Experiments** in the left-side navigation pane.
2. On the **Experiments** page, right-click **My Experiments** and choose **New Experiment** from the shortcut menu. In the dialog box that appears, enter the experiment name and description. Click **Create** to go to the **Components** page.
3. In the **Components** list, click **Data Source/Target**, and drag and drop the **Read MaxCompute Table** onto the canvas.
4. Click the **Read MaxCompute Table** component and configure its parameters. Enter the MaxCompute table name in **Table Name** in the right-side configuration pane.
5. In the right-side parameter setting pane, click **Column Information** to view the column name, data type, and the first 100 rows of data in the input table.

4.2.4. Data preprocessing

This topic describes how to perform data preprocessing by using methods such as normalization, SQL scripts, and data splitting.

Prerequisites

Before data preprocessing, make sure that you have completed data preparation.

Procedure

1. Log on to the Apsara Stack Machine Learning Platform for AI console and click **Components** in the left-side navigation pane.
2. In the **Components** list, click **Tools**. Drag and drop the **SQL Script** component onto the canvas. Click **Data Preprocessing**. Drag and drop the **Normalization** component onto the canvas, and connect the components.
3. Click the **SQL Script** component and click the right-side **Parameters** tab. In the **SQL Script** input box, enter the following SQL scripts to convert the features from string type to numeric type.

```
select age,
(case sex when 'male' then 1 else 0 end) as sex,
(case cp when 'angina' then 0  when 'notang' then 1 else 2 end) as cp,
trestbps,
chol,
(case fbs when 'true' then 1 else 0 end) as fbs,
(case restecg when 'norm' then 0  when 'abn' then 1 else 2 end) as restecg,
thalach,
(case exang when 'true' then 1 else 0 end) as exang,
oldpeak,
(case slop when 'up' then 0  when 'flat' then 1 else 2 end) as slop,
ca,
(case thal when 'norm' then 0  when 'fix' then 1 else 2 end) as thal,
(case status  when 'sick' then 1 else 0 end) as ifHealth
from  ${t2};
```

4. Click the **Normalization** component and select all fields to normalize the numeric features to values ranging from 0 to 1.
5. Click **Data Preprocessing**. Drag and drop the **Split** component onto the canvas and set **Split Ratio** to **0.7**.

> **Note** This step splits data into two parts: 70% of the data is used as the model training set, and 30% of the data is used as the model prediction set.

4.2.5. Data visualization

This topic describes how to view the features and value distribution by using statistical analysis components.

Prerequisites

Before data visualization, make sure that you have completed data preprocessing.

Procedure

1. Log on to the Apsara Stack Machine Learning Platform for AI console and click **Components** in the left-side navigation pane.
2. In the **Components** list, click **Statistical Analysis**. Drag and drop the **Whole Table Statistics** component onto the canvas. Connect the components, and click **Run** at the bottom of the canvas.
3. After the experiment stops running, right-click **Whole Table Statistics** and choose **View Data** from the shortcut menu. The analysis report is displayed.

4.2.6. Algorithm modeling

This topic describes how to perform feature training and generate models by using the machine learning components.

Prerequisites

Before algorithm modeling, ensure that you have completed data preprocessing and learned the data characteristics and value distribution through data visualization.

Procedure

1. Log on to the Apsara Stack Machine Learning Platform for AI console and click **Components** in the left-side navigation pane.
2. In the **Components** list, choose **Machine Learning > Binary Classification**. Drag and drop the **Binary Logistic Regression** component onto the canvas, and connect the corresponding components and data streams.
3. Click the component, and select 13 feature columns from **Training Feature Columns** in the right-side **Column Settings** pane. All parameters use the default settings.
4. Click **Run**.
5. Click **Models** in the left-side navigation pane to view the generated model.

4.2.7. Model prediction evaluation

This topic describes how to use a model to make predictions and evaluate its results by using the prediction and evaluation components.

Prerequisites

Before evaluating the prediction, make sure that you have completed algorithm modeling and generated a machine learning model from the experiment.

Procedure

1. Log on to the Apsara Stack Machine Learning Platform for AI console and click **Components** in the left-side navigation pane.
2. In the **Components** list, click **Machine Learning**. Drag and drop the **Prediction** component onto the canvas, and connect the corresponding components and data streams.
3. Choose **Machine Learning > Evaluation**. Drag and drop the **Binary Classification Evaluation** component onto the canvas and connect the corresponding components and data streams.
4. Click **Run** in the upper-left corner of the canvas. During the running process, select a component and click the **Developer Tool (**  **)** icon in the lower-right corner of the canvas to view the running status of the component.
5. Right-click the **Binary Classification Evaluation** component and choose **View Evaluation Report** from the shortcut menu to generate the ROC curve of the LR model trained with different parameters.

4.2.8. DataWorks task scheduling

After you have run all nodes in an experiment, you can deploy the experiment to DataWorks and schedule DataWorks to periodically run the experiment. This topic uses air quality prediction as an example scenario.

Prerequisites

Before scheduling an experiment, you must make sure that you have successfully run all nodes in the experiment and that the experiment is deployed to DataWorks.

Procedure

1. Log on to the Apsara Stack Machine Learning Platform for AI console. Click **Experiments** in the left-side navigation pane.
2. Click the **My Experiments** tab and select an experiment to navigate to the canvas.

   > **Notice** Make sure all components have been run in the experiment. A green check means that the component is running correctly.

3. In the upper-left corner of the canvas, choose **Deploy > Schedule DataWorks Tasks** to go to DataStudio.
4. In the DataStudio console, choose **Create > Algorithm > Machine Learning Platform for AI**, and then create a Machine Learning experiment node.
5. In the **Create Node** dialog box, enter the node name, select the target folder, and click **Submit**.

   > **Notice** You must select a target folder for the algorithm type.

   After the experiment node is created.
6. Select the experiment from the drop-down list.
7. Configure task scheduling parameters, including the recurrence, input, and output parameters.
8. Click **Submit**. The task will be executed the next day.
9. Click **Administration** in the upper-right corner to go to the administration page. You can view the status of the machine learning task and the system log. You can also perform other operations such as adding retroactive data and testing the experiment.

4.3. Online model service (must be activated separately)

4.3.1. Deploy an online model service

This topic describes how to deploy the generated experiment model through the online model service. You can adjust your business strategy anytime based on predicted results.

Prerequisites

Before deploying the online model service, make sure that the preceding steps are completed and the components are running properly. A green check means that the component is running correctly.

Procedure

1. Log on to the Apsara Stack Machine Learning for AI console and click **Experiments** in the left-side navigation pane.
2. Click the **My Experiments** tab and select an experiment to navigate to the canvas.

> **Notice** Make sure that the selected experiment is running properly. A green check means that the component is running correctly.

3. In the upper-left corner of the canvas, choose **Deploy > Online Model Service**.
4. Select the model to deploy and click **Next**.
5. Select a deployment mode. You can select one of the following modes:
   - New Service
   - Add Existing Service Version
   - Create Blue-green Deployment

4.3.2. Create a service

This topic describes how to use the **New Service** mode to deploy online prediction services.

Procedure

1. Complete Preparations for online model prediction.
2. Set **Processes** and **Quota**.

   > **Note** **Processes** determines the maximum number of concurrently running programs. **Quota** determines the running speed and the parameters such as RT and QPS.

3. Click **Deploy**. It takes several minutes to create the model.
4. After the model is created, click the model name to view information about the model invocation.
5. Click the icons under **Monitor** to view statistics about QPS, response, RT, traffic, CPU utilization, memory usage, and daily invocation.
6. > **Note** Perform this step when resources are insufficient and need to be expanded.

   Click **Update** to expand resources.
7. Click **Online Debugging** in the upper-right corner of the page and select the current model.

4.3.3. Add an existing service version

This topic describes how to use the **Add Existing Service Version** mode to deploy online prediction services.

Prerequisites

Before you use the **Add Existing Service Version** mode to deploy online prediction services, ensure that you have deployed one version of online prediction services through the New Service mode.

Procedure

1. Complete Preparations for online model prediction.
2. Select **Add Existing Service Version**.
3. Select a deployed model. It takes several minutes to add a version.

4. After the model is deployed, select the added version from the **Current Version** drop-down list.

4.3.4. Create a blue-green deployment

This topic describes how to use the **Create Blue-green Deployment** mode to deploy online prediction services.

Prerequisites

Before you use the **Create Blue-green Deployment** mode to deploy online prediction services, ensure that you have deployed two versions of online prediction services through the New Service and Add Existing Service Version modes.

Context

In the blue-green deployment mode, you can deploy and test the target version without stopping the source version. After confirming that the target version is running normally, switch all traffic to the target version. Blue-green deployment is safe and does not interrupt services.

Procedure

1. Complete Preparations for online model prediction.
2. Select the deployed model service and click **Deploy**. The deployment may take several minutes.
3. Click **Switch Traffic** and adjust the ratio of traffic forwarded to the two models. The initial ratio is 100% for both models.
4. Perform online debugging.
   i. Click **Online Debugging** in the upper-right corner of the page and select the deployed model.
   ii. Enter data (feature input) in **Body**. For example, the body information of the logistic regression model for heart disease prediction is as follows:

   ```
   [{"sex":0,"cp":0,"fbs":0,"restecg":0,"exang":0,"slop":0,"thal":0,"age":0,"trestbps":0,"chol":0,"thalach":0,"oldpeak":0,"ca":0}]
   ```

   iii. Click **Run** and check the result.

4.4. Components

4.4.1. Overview

This topic describes how to use and configure machine learning components. When building a machine learning experiment, you can select components based on the features of existing data to generate a model and make accurate predictions for your business.

Each component has one or more input or output ports. You can move the pointer over the ports to view their descriptions and connect the components.

4.4.2. Data source and target

This topic describes components in the **Data Source/Target** category, such as the Read MaxCompute Table and Write MaxCompute Table components.

Read MaxCompute tables

You can use the Read MaxCompute Table component to read MaxCompute tables. By default, this component reads data of the current project. If you want to read data from tables in another project for which you have access, you can prefix the table name with the project name in the `project name.table name` format. For example, `tianchi_project.weibo_data`. After you specify the input table, the system reads the structural data of the table. You can click the **Column Information** tab to view the data. This component does not support views.

If the selected input table is a partitioned table, the back end automatically selects the Partition checkbox. You can select or configure partition parameters. Only one partition can be selected. If you do not select the Partition checkbox or do not specify the partition parameters, the whole table is selected. If the input table is non-partitioned, the Partition checkbox cannot be selected.

Write MaxCompute tables

You can use the Write MaxCompute Table component to write data to tables in the current project or tables in other projects. This component can write data to partitions. Partitions must be created for the table in the MaxCompute console before this component can write data to the partitions. You can set the table lifecycle measured in days.

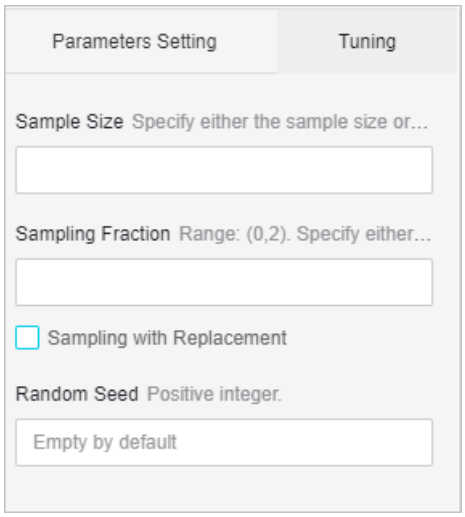
4.4.3. Data preprocessing

4.4.3.1. Sampling and filtering

4.4.3.1.1. Random sampling

Data is sampled randomly and independently. You can specify a ratio or quantity of samples to be taken and choose whether to enable sampling with replacement.

Parameter settings



PAI command

```
Pai –name sample
–project algo_public
-DinputTableName=wbpc
-DoutputTableName=wpbc_sample
-Dratio=0.3;
```

Algorithm parameters

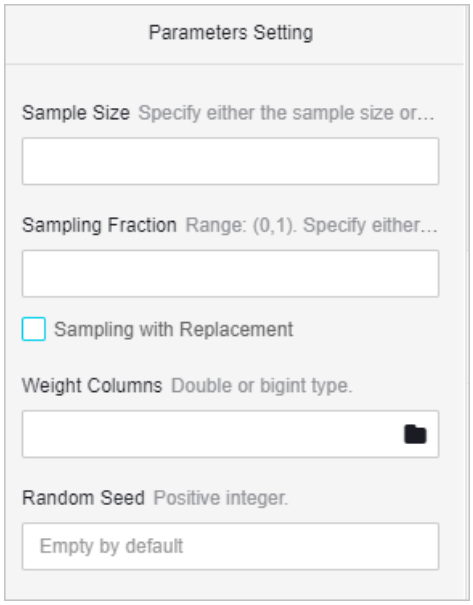
Parameters

Parameter	Description	Valid values	Default value
inputTableName	Required. The name of the input table.	-	-
inputTablePartitions	Optional. The partitions selected from the input table for training, in the format of `partition_name=value`. To specify multiple partitions, use the following format: `name1=value1/name2=value2`. Separate multiple partitions with commas (,).	-	All partitions in the input table are selected by default.
ratio	Required. The sampling fraction.	(0, 1)	-
outputTableName	Required. The name of the output table.	-	-
outputTablePartition	Optional. The partition of the output table.	-	The output table is a non-partitioned table by default.
lifecycle	Optional. The lifecycle of the output table.	A positive integer in the range of [1, 3650]	No lifecycle is set by default.

4.4.3.1.2. Weighted sampling

Sample data is collected based on weights. The weight column must be of double or int type. Data is sampled based on the value of its corresponding weight. For example, data with a col value of 1.2 has a higher probability to be sampled than data with a col value of 1.0.

Parameter settings



Parameter settings

Parameter	Description
Sample Size	You can specify the number of samples to be taken, which is 10,000 by default. For sampling without replacement, the number of samples cannot be greater than the number of data entries.
Sampling Fraction	You can use either the Sample Size or Sampling Fraction parameter. You can choose sampling with or without replacement, the latter of which is used by default. Select the checkbox to enable sampling with replacement.
Weight Columns	You can select a weight column from the drop-down list. The weight column can be of the double or bigint type.
Random Seed	The random seed, which is a positive integer. This parameter is empty by default.

- You can choose sampling with or without replacement, the latter of which is used by default. Select the checkbox to enable sampling with replacement.
- You can specify the number of samples to be taken, which is 10,000 by default.

  > **Note** For sampling without replacement, the number of samples cannot be greater than the number of data entries.

- You can select a weight column from the drop-down list. The weight column can be of the double or bigint type.

PAI command

```
PAI –name WeightedSample
–project algo_public
-DprobCol="previous"
-DsampleSize="500"
-DoutputTableName="test2"
-DinputPartitions="pt=20150501"
-DinputTableName="bank_data_partition";
```

Parameters

Parameter	Description
name	The name of the component.
project	The name of the project. This parameter is used to specify the workspace of the algorithm. The default value is algo_public. If you change the name, the system reports an error.
replace	Indicates whether sampled data is replaced. If this parameter is set to true, data is replaced after it is sampled. If this parameter is set to false, data is not replaced after it is sampled.
probCol	The columns to be weighted. Each value indicates the weight of an entry. Normalization is not required.
sampleSize	The number of samples to be taken. For sampling without replacement, the number of samples cannot be greater than the number of data entries.
outputTableNames	The name of the output table. Separate multiple table names with commas (,).
inputPartitions	Optional. The partitions selected from the input table for training. If no partitions are specified, the entire table is selected.
inputTableName	The name of the input table.
replace	Optional. This parameter indicates whether sampled data is replaced. If this parameter is set to true, data is replaced after it is sampled. If this parameter is set to false, data is not replaced after it is sampled.

4.4.3.1.3. Filtering and mapping

You can filter data based on filtering expressions and rename columns.

Parameter settings

1. Use the WHERE condition to filter data similar to how it would function in an SQL statement.

   Filtering conditions: Operators available include the equal (=), not equal (!=), greater than (>), less than (<), greater than or equal to (>=), less than or equal to (<=) signs, as well as like and rlike.

2. Rename columns.

PAI command

```
PAI –name Filter
–project algo_public
-DoutTableName="test_9"
-DinputPartitions="pt=20150501"
-DinputTableName="bank_data_partition"
-Dfilter="age>=40";
```

Parameters

Parameter	Description
name	The name of the component.
project	The name of the project. This parameter is used to specify the workspace of the algorithm. The default value is algo_public. If you change the name, the system reports an error.
outTableName	The name of the output table.
inputPartitions	Optional. The partitions selected from the input table for training. If no partitions are specified, the entire table is selected.
inputTableName	The name of the input table.
filter	The WHERE condition to filter data. Operators available include the equal (=), not equal (!=), greater than (>), less than (<), greater than or equal to (>=), less than or equal to (<=) signs, as well as like and rlike.

4.4.3.1.4. Stratified sampling

Stratified sampling is a statistical computing method. It works by dividing a population into several strata based on specified features, performing random sampling at each stratum, and creating a sample collection.

Parameter settings

Parameter	Description
Column Settings	Stratification Column: Required. Samples are stratified based on this column.
Parameter Settings	Sampling Fraction/Sample Size: Required. A value less than 1 represents the sampling fraction per stratum. A value greater than 1 represents the number of samples at each stratum.
	Other Sampling Configurations: Optional. This parameter allows you to collect different numbers of samples at different strata.
	Random Seed: Optional. Valid values: 1, 2, 3, 4, 5, 6, and 7.

PAI command

```
Pai –name sample
–project algo_public
-DinputTableName=wbpc
-DoutputTableName=wpbc_sample
-DstrataColName="label"
-DsampleSize="A:200,B:300,C:500"
-DrandomSeed=1007
-Dlifecycle=30
```

Algorithm parameters

Parameters

Parameter	Description	Valid values	Default value
inputTableName	Required. The name of the input table.	-	-
inputTablePartitions	Optional. The partitions selected from the input table for training, in the format of `partition_name=value`. To specify multiple partitions, use the following format: `name1=value1/name2=value2`. Separate multiple partitions with commas (,).	-	All partitions in the input table are selected by default.
strataColName	Required. The stratification column.	-	-
outputTableName	Required. The name of the output table.	-	-

Parameter	Description	Valid values	Default value
sampleSize	Optional. An integer value that specifies the number of samples taken from each stratum. A string value must be in the `strata0:n0,strata1:n1...` format. Each item in the string represents the number of samples to be taken from the corresponding stratum.	-	
sampleRatio	Optional. A decimal value from 0 to 1 that represents the ratio of data for each stratum to be sampled. A string value must be in the `strata0:r0,strata1:r1...` format. Each item in the string represents the sampling fraction for the corresponding stratum.	-	-
randomSeed	Optional. The number of random seeds.	-	0
lifecycle	Optional. The lifecycle of the output table.	A positive integer in the range of [1, 3650]	No lifecycle is set by default.
coreNum	Optional. The number of cores.	-	Automatically calculated.
memSizePerCore	Optional. The memory size of each core.	-	Automatically calculated.

4.4.3.2. Data merge

4.4.3.2.1. Join

This component merges two tables by associating the information in the tables and outputting the specified columns. This component is similar to the JOIN statement of SQL.

Parameter settings

- Join types: left join, internal join, right join, and full join.
- Only the equation condition is supported.

- You can manually add or delete join conditions.

PAI command

No PAI command is available.

4.4.3.2.2. Merge columns

You can merge data of two tables by column. The two tables must have the same number of rows.

Parameter settings

Procedure

1. Select input columns from the left table.
2. Select input columns from the right table.

   When merging columns:

   - The two tables must have the same number of rows.
   - The names of output columns selected from the left and right tables cannot be the same.
   - When selecting an output column, you can change its name.
   - If no output columns are selected from the left or right table, the whole table is selected. In this case, if **Automatically Rename Output Columns** is selected, the duplicate columns are renamed and then output.

PAI command

```
PAI –name AppendColumns
–project algo_public
-DoutputTableColNames="petal_length,petal_width,petal_length2,petal_width2"
-DautoRenameCol="false"
-DoutputTableName="pai_temp_770_6840_1"
-DinputTableNames="iris_twopartition,iris_twopartition"
-DinputPartitionsInfoList="dt=20150125/dp=20150124;dt=20150124/dp=20150123"
-DselectedColNamesList="petal_length,petal_width;sepal_length,sepal_width";
```

Parameters

Parameter	Description
name	The name of the component.
project	The name of the project. This parameter is used to specify the workspace of the algorithm. The default value is algo_public. If you change the name, the system reports an error.

Parameter	Description
outputTableColNames	The names of the columns in the new table. The column names must be separated with commas (,). If autoRenameCol is set to true, this parameter is ignored.
autoRenameCol	Optional. This parameter specifies whether to automatically rename the columns in the output table. If the value is true, the columns are renamed. If the value is false, the columns are not renamed. Default value: false.
outputTableName	The name of the output table.
inputTableNames	The name of the input table. Separate multiple table names with commas (,).
inputPartitionsInfoList	Optional. A list of partitions selected from the corresponding input tables. Partitions of the same table must be separated with commas (,) and partitions of different tables must be separated with semicolons (;).
selectedColNamesList	The names of selected columns. The names of columns in the same table must be separated with commas (,) and the names of columns in different tables must be separated with semicolons (;).

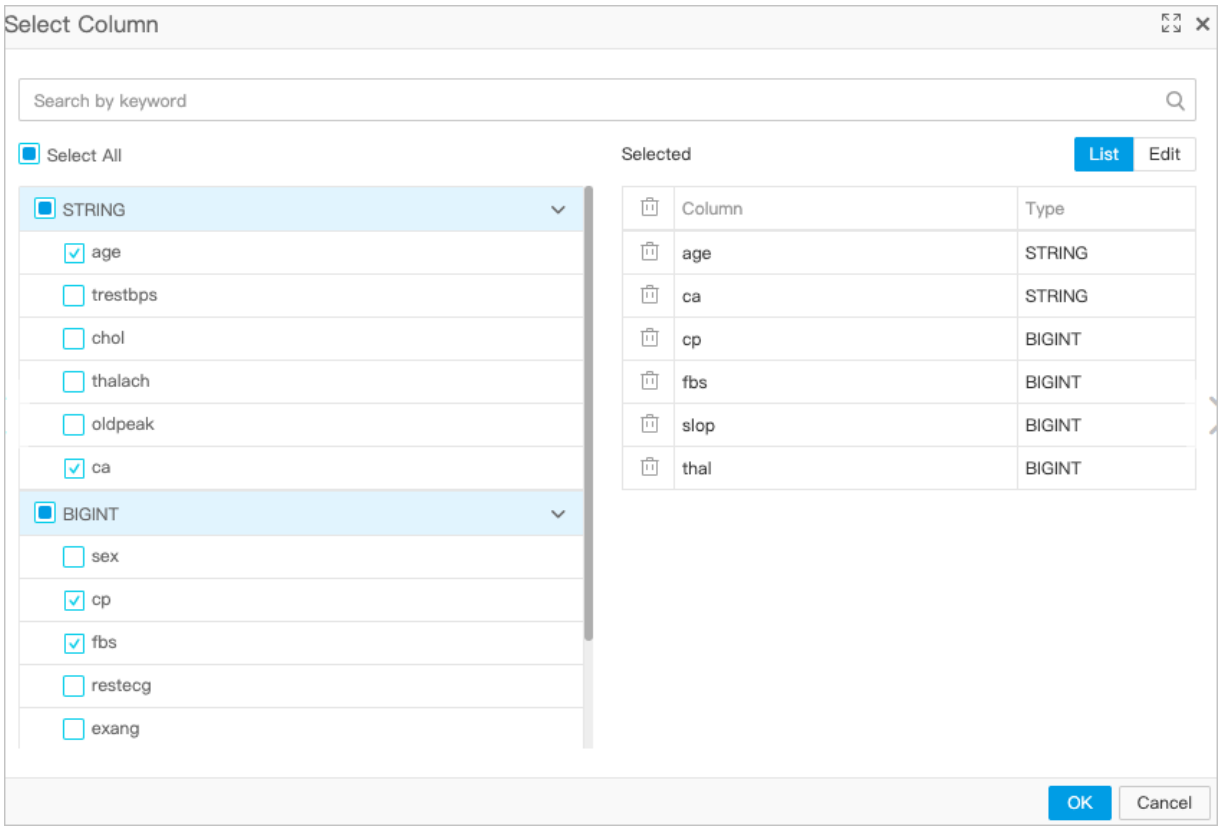
4.4.3.2.3. Merge rows (UNION)

To merge the data of two tables by row, the quantity and data type of the output columns selected from the left and right tables must be the same. The function is integrated with the UNION and UNION ALL functions.

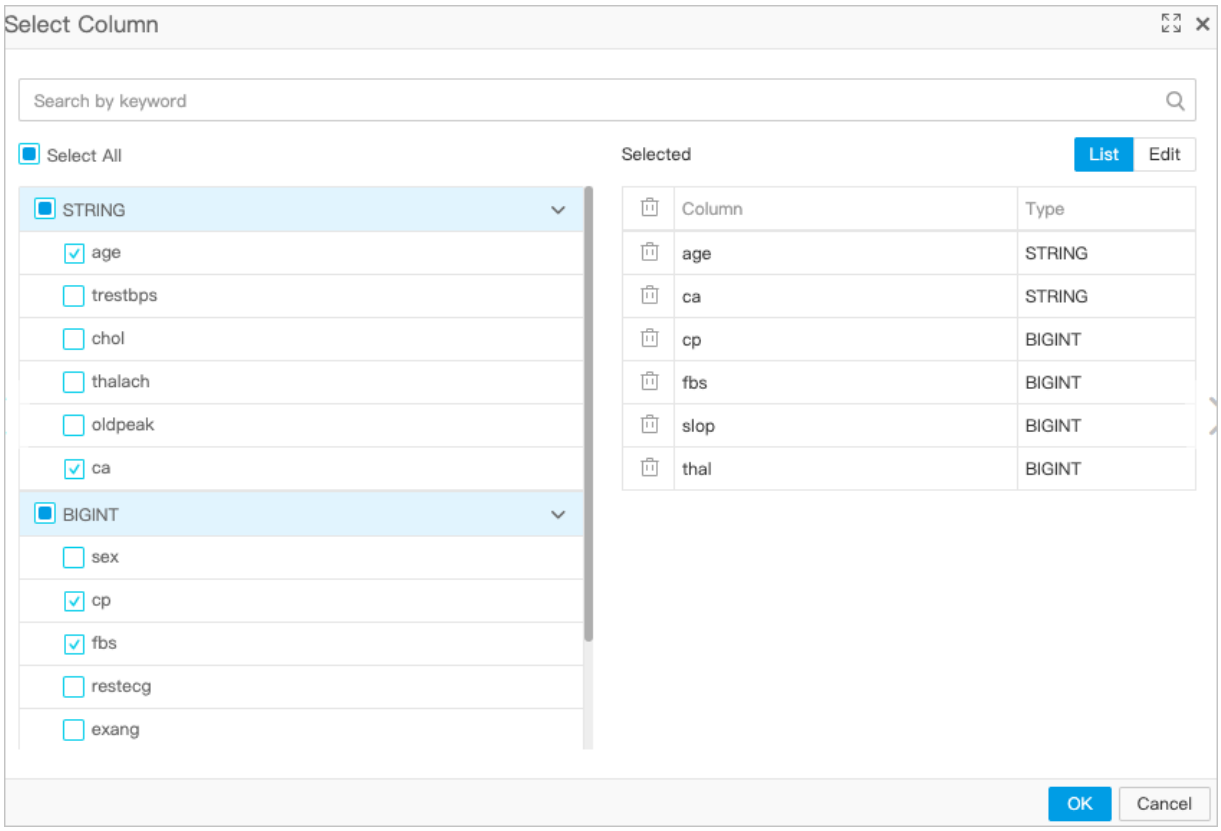
Parameter settings

- During the merge process, the numbers of columns selected from the left and right tables must be the same, and the data types of the corresponding columns must be the same.
- You can enter conditions in the text box by which to filter and select columns. The whole table is selected by default. Operators available include the equal (=), not equal (!=), greater than (>), less than (<), greater than or equal to (>=), and less than or equal to (<=) signs, as well as like and rlike.
- **Remove Duplicates** is selected by default. When this option is selected, duplicate rows in the output table are removed.

The following figure shows the union columns selected from the left table.



The following figure shows the union columns selected from the right table.



PAI command

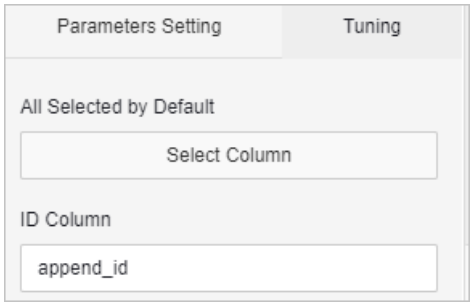
No PAI command is available.

4.4.3.3. Others

4.4.3.3.1. Add ID column

You can append an ID column to a table as the first column and save the table as a new table.

Parameter settings



PAI command

```
PAI –name AppendId
–project algo_public
-DIDColName="append_id"
-DoutputTableName="test_11"
-DinputTableName="bank_data"
-DselectedColNames="age,campaign,cons_conf_idx,cons_price_idx,emp_var_rate,euribor3m,nr_employed,
pdays,poutcome,previous,y";
```

Parameters

Parameter	Description
name	The name of the component.
project	The name of the project. This parameter is used to specify the workspace of the algorithm. The default value is algo_public. If you change the name, the system reports an error.
IDColName	The name of the appended ID column. ID numbers start from 0 and increment by one. Example: 0, 1, 2, 3, ...
outputTableName	The name of the output table.
inputTableName	The name of the input table.

Parameter	Description
selectedColNames	The names of the columns to be retained. Separate multiple columns with commas (,).

4.4.3.3.2. Split

This component is used to split an input table or a partition based on a specified ratio, and output two tables from two output ports.

Algorithm component

Parameter settings

- The Split component has two output ports.
- In Parameter settings, if the splitting fraction is set to 0.7, the left output port outputs 70% of the data and the right output port outputs 30% of the data.

PAI command

```
pai -name split -project algo_public
    -DinputTableName=wbpc
     -Doutput1TableName=wpbc_split1
    -Doutput2TableName=wpbc_split2
    -Dfraction=0.25;
```

Parameter settings

Parameter	Description	Valid values	Default value
inputTableName	Required. The name of the input table.	-	-
inputTablePartitions	Optional. The partitions selected from the input table for training, in the format of `partition_name=value`. To specify multiple partitions, use the following format: `name1=value1/name2=value2`. Separate multiple partitions with commas (,).	-	All partitions in the input table are selected by default.
output1TableName	Required. The name of output table 1.	-	-

Parameter	Description	Valid values	Default value
output1TablePartition	Optional. The partitions in output table 1.	-	Output table 1 is a non-partitioned table by default.
output2TableName	Required. The name of output table 2.	-	-
output2TablePartition	Optional. The partitions in output table 2.	-	Output table 2 is a non-partitioned table by default.
fraction	Required. The portion of data diverted to output table 1.	(0, 1)	-
lifecycle	Optional. The lifecycle of the output table.	A positive integer in the range of [1, 3650]	No lifecycle is set by default.

4.4.3.3.3. Missing value imputation

This component replaces a null value or a specified value with the maximum, minimum, average, or custom value. A list of values is defined to impute the missing values in an input table with the specified values.

- This component can replace a numeric null value with the maximum, minimum, average, or custom value.
- This component can also replace a null string, empty string, null and empty string, or specified value with a custom value.
- The missing values to be imputed can be null strings, empty strings, or custom values. If you choose empty strings, the data type of the target column must be string.

The parameters for the two input ports are as follows:

- inputTableName: the name of the input table for which to replace missing data.
- inputParaTableName: the name of the input configuration table that contains parameters generated by the missing value imputation node. Based on this parameter, configuration parameters in one table can be applied to a new table.

Parameters for the two output ports are as follows:

- outputTableName: the name of the imputed output table.
- outputParaTableName: the name of the output configuration table, which can be applied to other datasets.
- Columns to Impute: the names of the columns for which to replace missing values.
- Original Value: the values to be replaced.
- Replaced With: the replacement values.

PAI command

```
PAI -name FillMissingValues
  -project algo_public
  -Dconfigs="poutcome,null-empty,testing" \
  -DoutputTableName="test_3"
  -DinputPartitions="pt=20150501"
  -DinputTableName="bank_data_partition";
```

Algorithm parameters

Parameter	Description	Valid value	Default value
inputTableName	Required. The name of the input table.	Table name	N/A
inputTablePartitions	Optional. The partitions selected from the input table for training.	Partition name	The whole table is selected by default.
outputTableName	Required. The name of the output table.	Table name	N/A
configs	Required. The configurations for missing value imputation. Example: `col1, null, 3.14; col2, empty, hello; col3, empty-null, world`, where *null* indicates a null value and *empty* indicates an empty string. If you choose to use empty strings to fill the target columns, the data type of the target column must be string. The variables used to specify the replacement value as maximum, minimum, and average are max, min, and mean respectively. If you want to impute a custom value to the target column, use a user-defined variable in the `col4,user-defined,str,str123` format.	N/A	N/A

Parameter	Description	Valid value	Default value
outputParaTableName	Required. The name of the output configuration table.	Table name	N/A
inputParaTableName	Optional. The name of the input configuration table.	Table name	No input configuration table is set by default.
lifecycle	Optional. The lifecycle of the output table.	A positive integer	No lifecycle is set by default.
coreNum	Optional. The number of cores.	A positive integer	Automatically calculated.
memSizePerCore	Optional. The memory size of each core.	A positive integer	Automatically calculated.

Examples

Test data

- SQL statement to generate data:

```
drop table if exists fill_missing_values_test_input;
create table fill_missing_values_test_input(
  col_string string,
  col_bigint bigint,
  col_double double,
  col_boolean boolean,
  col_datetime datetime);
insert overwrite table fill_missing_values_test_input
select
  *
from
(
  select
    '01' as col_string,
    10 as col_bigint,
    10.1 as col_double,
    True as col_boolean,
    cast('2016-07-01 10:00:00' as datetime) as col_datetime
  from dual
  union all
    select
      cast(null as string) as col_string,
```

```
        11 as col_bigint,
        10.2 as col_double,
        False as col_boolean,
        cast('2016-07-02 10:00:00' as datetime) as col_datetime
      from dual
    union all
      select
        '02' as col_string,
        cast(null as bigint) as col_bigint,
        10.3 as col_double,
        True as col_boolean,
        cast('2016-07-03 10:00:00' as datetime) as col_datetime
      from dual
    union all
      select
        '03' as col_string,
        12 as col_bigint,
        cast(null as double) as col_double,
        False as col_boolean,
        cast('2016-07-04 10:00:00' as datetime) as col_datetime
      from dual
    union all
      select
        '04' as col_string,
        13 as col_bigint,
        10.4 as col_double,
        cast(null as boolean) as col_boolean,
        cast('2016-07-05 10:00:00' as datetime) as col_datetime
      from dual
    union all
      select
        '05' as col_string,
        14 as col_bigint,
        10.5 as col_double,
        True as col_boolean,
        cast(null as datetime) as col_datetime
      from dual
  ) tmp;
```

- Input description

```
+------------+------------+------------+------------+--------------+
| col_string | col_bigint | col_double | col_boolean | col_datetime |
+------------+------------+------------+------------+--------------+
| 04         | 13         | 10.4       | NULL       | 2016-07-05 10:00:00 |
| 02         | NULL       | 10.3       | true       | 2016-07-03 10:00:00 |
| 03         | 12         | NULL       | false      | 2016-07-04 10:00:00 |
| NULL       | 11         | 10.2       | false      | 2016-07-02 10:00:00 |
| 01         | 10         | 10.1       | true       | 2016-07-01 10:00:00 |
| 05         | 14         | 10.5       | true       | NULL         |
+------------+------------+------------+------------+--------------+
```

PAI command

```
drop table if exists fill_missing_values_test_input_output;
drop table if exists fill_missing_values_test_input_model_output;
PAI -name FillMissingValues
-project algo_public
-Dconfigs="col_double,null,mean;col_string,null-empty,str_type_empty;col_bigint,null,max;col_boolean,n
ull,true;col_datetime,null,2016-07-06 10:00:00"
-DoutputParaTableName="fill_missing_values_test_input_model_output"
-Dlifecycle="28"
-DoutputTableName="fill_missing_values_test_input_output"
-DinputTableName="fill_missing_values_test_input";
drop table if exists fill_missing_values_test_input_output_using_model;
drop table if exists fill_missing_values_test_input_output_using_model_model_output;
PAI -name FillMissingValues
-project algo_public
-DoutputParaTableName="fill_missing_values_test_input_output_using_model_model_output"
-DinputParaTableName="fill_missing_values_test_input_model_output"
-Dlifecycle="28"
-DoutputTableName="fill_missing_values_test_input_output_using_model"
-DinputTableName="fill_missing_values_test_input";
```

Output

- fill_missing_values_test_input_output

```
+------------+------------+------------+------------+--------------+
| col_string | col_bigint | col_double | col_boolean | col_datetime |
+------------+------------+------------+------------+--------------+
| 04         | 13         | 10.4       | true       | 2016-07-05 10:00:00 |
| 02         | 14         | 10.3       | true       | 2016-07-03 10:00:00 |
| 03         | 12         | 10.3       | false      | 2016-07-04 10:00:00 |
| str_type_empty | 11     | 10.2       | false      | 2016-07-02 10:00:00 |
| 01         | 10         | 10.1       | true       | 2016-07-01 10:00:00 |
| 05         | 14         | 10.5       | true       | 2016-07-06 10:00:00 |
+------------+------------+------------+------------+--------------+
```

- fill_missing_values_test_input_model_output

```
+------------+------------+
| feature    | json       |
+------------+------------+
| col_string | {"name": "fillMissingValues", "type": "string", "paras":{"missing_value_type": "null-empty", "replaced_value": "str_type_empty"}} |
| col_bigint | {"name": "fillMissingValues", "type": "bigint", "paras":{"missing_value_type": "null", "replaced_value": 14}} |
| col_double | {"name": "fillMissingValues", "type": "double", "paras":{"missing_value_type": "null", "replaced_value": 10.3}} |
| col_boolean | {"name": "fillMissingValues", "type": "boolean", "paras":{"missing_value_type": "null", "replaced_value": 1}} |
| col_datetime | {"name": "fillMissingValues", "type": "datetime", "paras":{"missing_value_type": "null", "replaced_value": 1467770400000}} |
+------------+------------+
```

- fill_missing_values_test_input_output_using_model

```
+------------+------------+------------+------------+--------------+
| col_string | col_bigint | col_double | col_boolean | col_datetime |
+------------+------------+------------+------------+--------------+
| 04         | 13         | 10.4       | true       | 2016-07-05 10:00:00 |
| 02         | 14         | 10.3       | true       | 2016-07-03 10:00:00 |
| 03         | 12         | 10.3       | false      | 2016-07-04 10:00:00 |
| str_type_empty | 11     | 10.2       | false      | 2016-07-02 10:00:00 |
| 01         | 10         | 10.1       | true       | 2016-07-01 10:00:00 |
| 05         | 14         | 10.5       | true       | 2016-07-06 10:00:00 |
+------------+------------+------------+------------+--------------+
```

- fill_missing_values_test_input_output_using_model_model_output

```
+------------+------------+
| feature    | json       |
+------------+------------+
| col_string | {"name": "fillMissingValues", "type": "string", "paras":{"missing_value_type": "null-empty", "replaced_value": "str_type_empty"}} |
| col_bigint | {"name": "fillMissingValues", "type": "bigint", "paras":{"missing_value_type": "null", "replaced_value": 14}} |
| col_double | {"name": "fillMissingValues", "type": "double", "paras":{"missing_value_type": "null", "replaced_value": 10.3}} |
| col_boolean | {"name": "fillMissingValues", "type": "boolean", "paras":{"missing_value_type": "null", "replaced_value": 1}} |
| col_datetime | {"name": "fillMissingValues", "type": "datetime", "paras":{"missing_value_type": "null", "replaced_value": 1467770400000}} |
+------------+------------+
```

4.4.3.3.4. Normalization

You can normalize one or more columns in a table and save the generated data to a new table.

Linear function transformation is supported. The transformation expression is `y=(x-MinValue)/(MaxValue-MinValue)`.

MaxValue and *MinValue* indicate the maximum and minimum values of the sample respectively.

- Click **Columns** to select the columns to be normalized. Double and bigint types are supported.
- You can choose whether to retain the original columns. If you select the corresponding checkbox, the original columns will be retained. Processed columns will be renamed.

PAI command

```
PAI -name normalize_wf
-project algo_public
-DkeepOriginal="true"
-DoutputTableName="test_4"
-DinputPartitions="pt=20150501"
-DinputTableName="bank_data_partition"
-DselectedColNames="emp_var_rate,euribor3m";
```

Algorithm parameters

Parameters

Parameter	Description	Default value

Parameter	Description	Default value
inputTableName	Required. The name of the input table.	N/A
selectedColNames	Optional. The names of columns selected from the input table.	All columns are selected by default.
inputTablePartitions	Optional. The partitions selected from the input table for training.	The whole table is selected by default.
outputTableName	Required. The name of the output table.	N/A
outputParaTableName	Required. The name of the output configuration table.	N/A
inputParaTableName	Optional. The name of the input configuration table.	No input configuration table is set by default.
outputPMMLTableName	Required. The name of the output PMML table.	N/A
keepOriginal	Optional. This parameter specifies whether to retain the original columns. If `keepOriginal` is set to true, processed columns are renamed with the `normalized_` prefix and the original columns are retained and their data overwritten. If `keepOriginal` is set to false, all columns are retained but not renamed.	false
lifecycle	Optional. The lifecycle of the output table.	No lifecycle is set by default.
coreNum	Optional. The number of cores.	Automatically calculated.
memSizePerCore	Optional. The memory size of each core.	Automatically calculated.

4.4.3.3.5. Standardization

You can standardize one or more columns in a table and save the generated data to a new table.

- The formula used for standardization is `(X - Mean)/(Standard deviation)`.
  - Mean: The mean of samples.

- Standard deviation: The standard deviation of samples. This variable is used when samples are used to calculate the total deviation. To make the calculated value closer to the mean, you must moderately increase the calculated standard deviation by using the formula $\frac{1}{N-1}$.
- The formula for calculating the standard deviation of samples:

$$S = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(X_i - \bar{X})^2}$$

$\bar{X}$ represents the mean of samples X1, X2, ..., Xn.

- You can choose whether to retain the original columns. If you select the corresponding checkbox, the original columns will be retained. Processed columns will be renamed.
- Click **Columns** and select columns to be standardized. Double and bigint types are supported.

PAI command

```
PAI -name Standardize
-project algo_public
-DkeepOriginal="false"
-DoutputTableName="test_5"
-DinputTablePartitions="pt=20150501"
-DinputTableName="bank_data_partition"
-DselectedColNames="euribor3m,pdays"
```

Standardization component

Parameters for the two input ports are as follows:

- inputTableName: the name of the input table to be standardized.
- inputParaTableName: the name of the input configuration table that contains the parameters generated by the standardization node. You can use an input configuration table to apply the configuration parameters of one table to a new table.

Parameters for the two output ports are as follows:

- outputTableName: the name of the standardized output table.
- outputParaTableName: the name of the output parameter table, which can be applied to other datasets.

Standardization parameters

The corresponding algorithm parameter for Reserve Original Columns is `keepOriginal`.

Algorithm parameters

Parameters

Parameter	Description	Valid values	Default value
inputTableName	Required. The name of the input table.	-	-
selectedColNames	Optional. The names of columns selected from the input table.	-	All columns are selected by default.
inputTablePartitions	Optional. The partitions selected from the input table for training, in the format of `partition_name=value`. To specify multiple partitions, use the following format: `name1=value1/name2=value2`. Separate multiple partitions with commas (,).	-	All partitions in the input table are selected by default.
outputTableName	Required. The name of the output table.	-	-
outputParaTableName	Required. The name of the output configuration table.	-	-
outputPartition	Optional. The partitions in the output table.	-	-
inputParaTableName	Optional. The name of the input configuration table.	-	No input configuration table is set by default.
keepOriginal	Optional. This parameter specifies whether to retain the original columns. If this parameter is set to true, the original columns are retained and the column name is suffixed with `_orig`.	true and false	false
lifecycle	Optional. The lifecycle of the output table.	-	No lifecycle is set by default.
coreNum	Optional. The number of cores.	-	Automatically calculated.
memSizePerCore	Optional. The memory size of each core.	-	Automatically calculated.

Examples

```
drop table if exists standardize_test_input;
create table standardize_test_input(
col_string string,
col_bigint bigint,
col_double double,
col_boolean boolean,
col_datetime datetime);
insert overwrite table standardize_test_input  select    * from  (
select      '01' as col_string,
10 as col_bigint,
10.1 as col_double,
True as col_boolean,
cast('2016-07-01 10:00:00' as datetime) as col_datetime    from dual    union all
select        cast(null as string) as col_string,
11 as col_bigint,
10.2 as col_double,
False as col_boolean,
cast('2016-07-02 10:00:00' as datetime) as col_datetime      from dual    union all
select
'02' as col_string,
cast(null as bigint) as col_bigint,
10.3 as col_double,
True as col_boolean,
cast('2016-07-03 10:00:00' as datetime) as col_datetime      from dual    union all
select        '03' as col_string,
12 as col_bigint,
cast(null as double) as col_double,
False as col_boolean,
cast('2016-07-04 10:00:00' as datetime) as col_datetime      from dual    union all
select        '04' as col_string,
13 as col_bigint,
10.4 as col_double,
cast(null as boolean) as col_boolean,
cast('2016-07-05 10:00:00' as datetime) as col_datetime      from dual    union all
select        '05' as col_string,
14 as col_bigint,
10.5 as col_double,
True as col_boolean,
cast(null as datetime) as col_datetime      from dual ) tmp;
```

PAI command

```
drop table if exists standardize_test_input_output;
drop table if exists standardize_test_input_model_output;
PAI -name Standardize
-project algo_public
-DoutputParaTableName="standardize_test_input_model_output"
-Dlifecycle="28"
-DoutputTableName="standardize_test_input_output"
-DinputTableName="standardize_test_input"
-DselectedColNames="col_double,col_bigint"
-DkeepOriginal="true";
drop table if exists standardize_test_input_output_using_model;
drop table if exists standardize_test_input_output_using_model_model_output;
PAI -name Standardize
-project algo_public
-DoutputParaTableName="standardize_test_input_output_using_model_model_output"
-DinputParaTableName="standardize_test_input_model_output"
-Dlifecycle="28"
 -DoutputTableName="standardize_test_input_output_using_model"
-DinputTableName="standardize_test_input"
```

Input description

standardize_test_input

col_string	col_bigint	col_double	col_boolean	col_datetime
01	10	10.1	true	2016-07-01 10:00:00
NULL	11	10.2	false	2016-07-02 10:00:00
02	NULL	10.3	true	2016-07-03 10:00:00
03	12	NULL	false	2016-07-04 10:00:00
04	13	10.4	NULL	2016-07-05 10:00:00
05	14	10.5	true	NULL

Output description

standardize_test_input_output

col_string	col_bigint	col_double	col_boolean	col_datetime	stdized_col_bigint	stdized_col_double
01	10	10.1	true	2016-0	-1.264911064	-1.264911064
NULL	11	10.2	false	2016-07-02 10:00:00	-0.6324555320336759	-0.6324555320341972
02	NULL	10.3	true	2016-07-03 10:00:00	NULL	0.0
03	12	NULL	false	2016-07-04 10:00:00	0.0	NULL
04	13	10.4	NULL	2016-07-05 10:00:00	0.6324555320336759	0.6324555320341859
05	14	10.5	true	NULL	1.2649110640673518	1.2649110640683718

standardize_test_input_model_output

Feature	json
col_bigint	{"name": "standardize", "type":"bigint", "paras": {"mean":12, "std": 1.58113883008419}}
col_double	{"name": "standardize", "type":"double", "paras": {"mean":10.3, "std": 0.1581138830082909}}

standardize_test_input_output_using_model

col_string	col_bigint	col_double	col_boolean	col_datetime
01	-1.2649110640673515	-1.2649110640683833	true	2016-07-01 10:00:00
NULL	-0.6324555320336758	-0.6324555320341971	false	2016-07-02 10:00:00
02	NULL	0.0	true	2016-07-03 10:00:00
03	0.0	NULL	false	2016-07-04 10:00:00

col_string	col_bigint	col_double	col_boolean	col_datetime
04	0.6324555320336758	0.6324555320341858	NULL	2016-07-05 10:00:00
05	1.2649110640673515	1.2649110640683716	true	NULL

standardize_test_input_output_using_model_model_output

feature	json
col_bigint	{"name": "standardize", "type":"bigint", "paras": {"mean":12, "std": 1.58113883008419}}
col_double	{"name": "standardize", "type":"double", "paras": {"mean":10.3, "std": 0.1581138830082909}}

4.4.3.3.6. KV to Table

This component is used to convert KV pairs to a table. The key is converted to a table column, while the value is converted to a column value in the corresponding row.

KV table format definition:

- A key is the index of a column. Key values can be of the bigint or double types.
- A KV table can be input in the sparse format to algorithm components such as logistic and linear regression.
- Keys must be of the string type. You can input a key_map table to the KV to Table component to map keys to columns. This component outputs a key_map table that contains all key-column mappings after conversion, regardless of whether you input a key_map table.

kv
1:10;2:20;3:30

key_map table format definition: a table that contains index-to-column mappings and data type information. The data types of the col_name, col_index, and col_datatype columns must be string. The default data type of the col_datatype column is double if not specified.

col_name	col_index	col_datatype
col1	1	bigint
col2	2	double

PAI command

```
PAI -name KVToTable
  -project algo_public
  -DinputTableName=test
  -DoutputTableName=test_out
  -DoutputKeyMapTableName=test_keymap_out
  -DkvColName=kv;
```

Parameters

Parameter	Description	Valid values	Default value
inputTableName	Required. The name of the input table.	Table name	The table cannot be empty.
kvColName	Required. The name of the KV column.	Only one column can be selected.	-
outputTableName	Required. The name of the output table.	Table name	-
outputKeyMapTableName	Required. The name of the output index table.	Table name	-
inputKeyMapTableName	Optional. The name of the input index table.	Table name	No input index table is set by default.
appendColName	Optional. The name of the appended column.	Multiple columns can be selected.	No column is appended by default.
inputTablePartitions	Optional. The partitions selected from the input table.	Partition name	No partition is specified by default.
kvDelimiter	Optional. The delimiter used to separate keys and values.	Symbol	The default delimiter is a semicolon (;).
itemDelimiter	Optional. The delimiter used to separate key-value pairs.	Symbol	The default delimiter is a comma (,).
top1200	Optional. This parameter specifies whether to output the first 1,200 columns.	true and false	Default value: true. If the value is false, an error is returned when the number of columns reaches the upper limit.
lifecycle	Optional. The lifecycle of the output table.	An integer greater than or equal to -1.	Default value: -1. This value indicates that no lifecycle is set.

Parameter	Description	Valid values	Default value
coreNum	Optional. The number of cores.	An integer greater than 0.	Default value: -1. This value indicates that the number of instances is determined by the amount of input data.
memSizePerCore	Optional. The memory size of each core.	(100, 65536)	Default value: -1. This value indicates that the memory size is determined by the amount of input data.

Examples

SQL statement to generate data:

```
drop table if exists test;
  create table test as
   select
    *
   from
   (
    select '1:1,2:2,3:-3.3' as kv from dual
    union all
    select '1:10,2:20,3:-33.3' as kv from dual
   ) tmp;
```

PAI command

```
PAI -name KVToTable
  -project algo_public
  -DinputTableName=test
  -DoutputTableName=test_out
  -DoutputKeyMapTableName=test_keymap_out
  -DkvColName=kv;
```

Output

The output table is shown as follows.

```
+------------+------------+------------+
| kv_1     | kv_2     | kv_3     |
+------------+------------+------------+
| 1.0      | 2.0      | -3.3     |
| 10.0     | 20.0     | -33.3    |
+------------+------------+------------+
```

The output mapping table is shown as follows.

```
+------------+------------+------------+
| col_name  | col_index | col_type  |
+------------+------------+------------+
| kv_1     | 1        | double    |
| kv_2     | 2        | double    |
| kv_3     | 3        | double    |
+------------+------------+------------+
```

Input and output restrictions

Converted columns include appended columns and columns converted from KV pairs. The KV columns are output before the appended columns. MaxCompute supports a maximum of 1,200 columns. When the number of columns exceeds the maximum value, and top1200 is set to true, only the first 1,200 columns are output. If top1200 is set to false, an error is returned. The number of input data entries cannot exceed 100 million.

Restrictions and guidelines

- If a key_map table is input, columns are converted from the keys that exist in both the key_map and key-value tables.
- The converted column type can only be numeric.
- If a key_map table is input, the data type of the converted key column is the same as that of the key_map table. If no key_map table is input, the data type of the converted key column is double.
- If a key_map table is not input, the name of the converted key column is in the format of 'kv column name+""+key'. An error is returned if the key contains any of the following characters: %&()*+-. /; <>=?
- If an appended column is specified and the name of the appended column is the same as that of the converted key column, an error is returned indicating a column name conflict.
- If a row contains multiple keys, the values are added.
- A column name can contain up to 128 characters. If more than 128 characters are entered, only the first 128 characters are kept.

4.4.3.3.7. Table to KV

This component is used to convert data tables to KV tables. Null values in the table to be converted are not displayed in the KV table. You can specify columns to be retained in the new table. These columns will remain unchanged.

PAI command

```
PAI -name TableToKV
  -project algo_public
  -DinputTableName=maple_tabletokv_basic_input
  -DoutputTableName=maple_tabletokv_basic_output
  -DselectedColNames=col0,col1,col2
  -DappendColNames=rowid;
```

Parameters

Parameter	Description	Valid values	Default value
inputTableName	Required. The name of the input table.	Table name	-
inputTablePartitions	Optional. The partitions selected from the input table for training, in the format of `partition_name=value`. To specify multiple partitions, use the following format: `name1=value1/name2=value2`. Separate multiple partitions with commas (,).	Partition name	All partitions are selected by default.
selectedColNames	Optional. The names of selected columns from the input table.	The column type must be bigint or double.	The whole table is selected by default.
appendColNames	Optional. The names of columns to remain unchanged. These columns are written in the output table without any changes.	Multiple columns can be selected.	-
outputTableName	Required. The name of the output KV table.	Table name	-
kvDelimiter	Optional. The delimiter used to separate keys and values.	Symbol	The default delimiter is a colon (:).

Parameter	Description	Valid values	Default value
itemDelimiter	Optional. The delimiter used to separate key-value pairs.	Symbol	The default delimiter is a comma (,).
convertColToIndexId	Optional. This parameter specifies whether to convert columns into IDs.	0 and 1	0
inputKeyMapTableName	Optional. The name of the input index table. This parameter takes effect only in the case of `convertColToIndexId=1`. If this parameter is not specified, IDs are automatically generated.	Table name	No input index table is set by default.
outputKeyMapTableName	The name of the output index table. This parameter is required only in the case of `convertColToIndexId=1`.	Table name	The default value is determined by convertColToIndexId.
lifecycle	Optional. The lifecycle of the output table.	A positive integer	No lifecycle is set by default.
coreNum	Optional. The number of cores.	This parameter is used with memSizePerCore. The value must be a positive integer in the range of [1, 9999].	Automatically calculated.
memSizePerCore	Optional. The memory size of each core. Unit: MB.	A positive integer in the range of [1024, 65536]	Automatically calculated.

Example 1

Data generation

rowid	kv
0	col0:1,col1:1.1,col2:2
1	col0:0,col1:1.2,col2:3
2	col0:1,col1:2.3

rowid	kv
3	col0:1,col1:0.0,col2:4

PAI command

```
PAI -name TableToKV
  -project algo_public
  -DinputTableName=maple_tabletokv_basic_input
  -DoutputTableName=maple_tabletokv_basic_output
  -DselectedColNames=col0,col1,col2
  -DappendColNames=rowid;
```

Output

The output table is shown as follows.

maple_tabletokv_basic_output

rowid:bigint	kv:string
0	1:1.1,2:2
1	1:1.2,2:3
2	1:2.3
3	1:0.0,2:4

Example 2

PAI command

```
PAI -name TableToKV
  -project projectxlib4 -DinputTableName=maple_tabletokv_basic_input
  -DoutputTableName=maple_tabletokv_basic_output
  -DselectedColNames=col0,col1,col2 -DappendColNames=rowid
  -DconvertColToIndexId=1
  -DinputKeyMapTableName=maple_test_tabletokv_basic_map_input
  -DoutputKeyMapTableName=maple_test_tabletokv_basic_map_output;
```

Output

The output table is shown as follows.

maple_test_tabletokv_basic_map_output

col_name:string	col_index:string	col_datatype:string
col1	1	bigint
col2	2	double

Restrictions and guidelines

- If a key_map table is input, columns are converted from the keys that exist in both the key_map and key-value tables.
- If a key_map table is input and its type is different from the input table, the output key_map table uses the type specified by the user.
- The type of the columns that need to be converted into KV pairs in the input table must be bigint or double.

4.4.4. Feature engineering

4.4.4.1. Feature transformation

4.4.4.1.1. PCA

You can use principal component analysis (PCA) to reduce dimensionality.

- For more information about the PCA algorithm, see Wikipedia.
- This component supports the dense data format.

PAI command

```
PAI -name PrinCompAnalysis
–project algo_public
-DinputTableName=bank_data
-DeigOutputTableName=pai_temp_2032_17900_2
-DprincompOutputTableName=pai_temp_2032_17900_1
-DselectedColNames=pdays,previous,emp_var_rate,cons_price_idx,cons_conf_idx,euribor3m,nr_employed

-DtransType=Simple
-DcalcuType=CORR
-DcontriRate=0.9;
```

Algorithm parameters

Parameters

Parameter	Description	Default value
inputTableName	Required. The name of the input table for PCA.	-

Parameter	Description	Default value
eigOutputTableName	Required. The name of the output table that contains eigenvectors and eigenvalues.	-
princompOutputTableName	Required. The name of the output table after PCA dimensionality reduction.	-
selectedColNames	Required. The names of feature columns that are involved in the PCA procedure.	-
transType	Optional. The method used to transform the original table to the principal component table. Valid values: Simple, Sub-Mean, and Normalization.	Simple
calcuType	Optional. The eigendecomposition mode of the original table. Valid values: CORR, COVAR_SAMP, and COVAR_POP.	CORR
contriRate	Optional. The ratio of information to be retained after dimensionality reduction.	0.9
remainColumns	Optional. The columns retained from the original table after dimensionality reduction.	-

Sample PCA output

Table after dimensionality reduction,shows a sample table after dimensionality reduction.

Eigenvalues and eigenvectors,shows the eigenvalues and eigenvectors.

4.4.4.2. Feature importance evaluation

4.4.4.2.1. Linear model feature importance

You can evaluate the quality of a linear algorithm model based on the predicted and actual output results such as the indicators and residual histogram. Indicators include SST, SSE, SSR, R2, R, MSE, RMSE, MAE, MAD, MAPE, count, yMean, and predictMean.

PAI command

```
pai -name regression_evaluation
-project algo_public
-DinputTableName=input_table
-DyColName=y_col
-DpredictionColName=prediction_col
-DindexOutputTableName=index_output_table
-DresidualOutputTableName=residual_output_table
```

Parameters

Parameter	Description	Valid values	Default value
inputTableName	Required. The name of the input table.	-	-
inputTablePartitions	Optional. The partitions selected from the input table for training.	-	All partitions in the input table are selected by default.
yColName	Required. The name of the expected dependent variable column in the input table. It must be a numerical value.	-	-
predictionColName	Required. The name of the predicted dependent variable column. It must be a numerical value.	-	-
indexOutputTableName	Required. The name of the regression indicator output table.	-	-
residualOutputTableName	Required. The name of the residual histogram output table.	-	-
intervalNum	Optional. The number of intervals to divide the histogram over.	-	100
lifecycle	Optional. The lifecycle of the output table.	A positive integer	No lifecycle is set by default.
coreNum	Optional. The number of cores.	-	Automatically calculated.
memSizePerCore	Optional. The memory size of each core.	-	Automatically calculated.

Output

The output table is in JSON format. Field description describes the JSON fields.

Field description

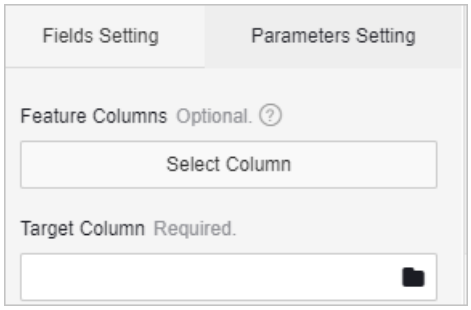
Field	Description
SST	Total sum of squares.
SSE	Sum of squared errors.

Field	Description
SSR	Sum of squares due to regression.
R2	Coefficient of determination.
R	Coefficient of multiple correlation.
MSE	Mean squared error.
RMSE	Root-mean-square error.
MAE	Mean absolute error.
MAD	Mean absolute difference.
MAPE	Mean absolute percentage error.
count	Number of rows.
yMean	Mean of expected dependent variables.
predictionMean	Mean of prediction results.

4.4.4.2.2. Random forest feature importance

You can calculate the importance of features in a random forest model.

Column settings



PAI command

```
pai -name feature_importance
-project algo_public
-DinputTableName=input
-DoutputTableName=output
-Dlabel=label
-DmodelName=model
```

Algorithm parameters

Parameters

Parameter	Description	Default value
inputTableName	Required. The name of the input table.	-
outputTableName	Required. The name of the output table.	-
labelColName	Required. The name of the label column.	-
modelName	Required. The name of the input model.	-
featureColNames	Optional. The names of feature columns selected from the input table.	All columns except the label column are selected by default.
inputTablePartitions	Optional. The partitions selected from the input table.	The whole table is selected by default.
lifecycle	Optional. The lifecycle of the output table.	No lifecycle is set by default.
coreNum	Optional. The number of cores.	Automatically calculated.
memSizePerCore	Optional. The memory size of each core.	Automatically calculated.

4.4.5. Statistical analysis

4.4.5.1. Data pivoting

This component allows you to view the distributions of feature values, feature columns, and label columns. Data can be analyzed more efficiently when you know its features. This component supports dense and sparse formats.

PAI command

```
PAI -name fe_meta_runner -project algo_public
-DinputTable="pai_dense_10_10"
-DoutputTable="pai_temp_2263_20384_1"
-DmapTable="pai_temp_2263_20384_2"
-DselectedCols="pdays,previous,emp_var_rate,cons_price_idx,cons_conf_idx,euribor3m,nr_employed,age,
campaign,poutcome"
-DlabelCol="y"
-DcategoryCols="previous"
-Dlifecycle="28"-DmaxBins="5" ;
```

Algorithm parameters

Parameter	Description	Required	Default value
inputTable	The name of the input table.	Yes	N/A
inputTablePartitions	The partitions selected from the input table.	No	N/A
outputTable	The name of the output table.	Yes	N/A
mapTable	The output mapping table. The Data Pivoting component maps String and Int type data for machine learning to use for training.	Yes	N/A
selectedCols	The columns selected from the input table.	Yes	N/A
categoryCols	The columns specified to process Int or Double type columns as enumeration features.	No	null
maxBins	The maximum number of intervals for equal-distance division of continuous features.	No	100
isSparse	Indicates whether the features are in sparse format.	No	false
itemSpliter	The delimiter used to separate sparse feature items.	No	","

Parameter	Description	Required	Default value
kvSpliter	The delimiter used to separate keys and values.	No	":"
lifecycle	The lifecycle of the output table. Unit: days.	No	28

4.4.5.2. Whole table statistics

This component analyzes a table or selected columns of a table.

Parameter settings

In the Input Columns box, select the columns of the table to be analyzed. By default, all columns are selected. You can enter filtering conditions for the selected columns in the condition text box. Operators available include the equal (=), not equal (!=), greater than (>), less than (<), greater than or equal to (>=), and less than or equal to (<=) signs, as well as like and rlike.

PAI command

```
PAI –name SimpleSummary
–project algo_public
-DsummaryColNames="euribor3m,pdays"
-DoutputTableNames="pai_temp_667_6017_1"
-DinputTableName="bank_data"
-Dfilter="age>40";
```

Parameters

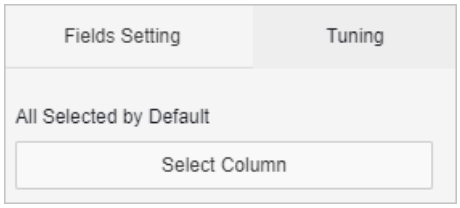
Parameter	Description
name	The name of the component.
project	The name of the project. This parameter is used to specify the workspace of the algorithm. The default value is algo_public. If you change the name, the system reports an error.
summaryColNames	The columns that require analysis. Separate the columns with commas(,).

Parameter	Description
outputTableNames	The names of the output tables generated after the system performs the whole table statistics operation.
inputTableName	The name of the input table.
filter	The filtering conditions. Operators available include the equal (=), not equal (!=), greater than (>), less than (<), greater than or equal to (>=), and less than or equal to (<=) signs, as well as like and rlike.

4.4.5.3. Correlation coefficient matrix

The correlation coefficient is a measure of the correlation between columns in a matrix. The valid range of values for this parameter is [-1, 1]. The count equals the number of non-zero elements in two successive columns.

Column settings



PAI command

```
PAI -name corrcoef
-project algo_public
-DinputTableName=maple_test_corrcoef_basic12x10_input
-DoutputTableName=maple_test_corrcoef_basic12x10_output
-DcoreNum=1
-DmemSizePerCore=110
```

Parameters

Parameter	Description	Valid values	Default value
inputTableName	Required. The name of the input table.	Table name	-

Parameter	Description	Valid values	Default value
inputTablePartition	Optional. The partitions selected from the input table for training, in the format of `partition_name=value`. To specify multiple partitions, use the following format: `name1=value1/name2=value2`. Separate multiple partitions with commas (,).	-	All partitions are selected by default.
outputTableName	Required. A list of output table names.	Table name	-
selectedColNames	Optional. The names of columns selected from the input table.	Column name	All columns are selected by default.
lifecycle	Optional. The lifecycle of the output table.	A positive integer	No lifecycle is set by default.
coreNum	Optional. The number of cores.	This parameter is used with memSizePerCore. The value must be a positive integer in the range of [1, 9999].	Automatically calculated.
memSizePerCore	Optional. The memory size of each node. Unit: MB.	A positive integer in the range of [1024, 65536]	Automatically calculated.

Examples

Data generation describes the data generation result.

Data generation

col0:double	col1:bigint	col2:double	col3:bigint	col4:double	col5:bigint	col6:double	col7:bigint	col8:double	col9:double
19	95	33	52	115	43	32	98	76	40
114	26	101	69	56	59	116	23	109	105
103	89	7	9	65	118	73	50	55	81
79	20	63	71	5	24	77	31	21	75
87	16	66	47	25	14	42	99	108	57
11	104	38	37	106	51	3	91	80	97

col0:double	col1:bigint	col2:double	col3:bigint	col4:double	col5:bigint	col6:double	col7:bigint	col8:double	col9:double
84	30	70	46	8	6	94	22	45	48
35	17	107	64	10	78	53	34	90	96
13	61	39	1	29	117	112	2	82	28
62	4	102	88	100	36	67	54	12	85
49	27	44	93	68	110	60	72	86	58
92	119	0	113	41	15	74	83	18	111

PAI command

```
PAI -name corrcoef
-project algo_public
-DinputTableName=maple_test_corrcoef_basic12x10_input
-DoutputTableName=maple_test_corrcoef_basic12x10_output
-DcoreNum=1
-DmemSizePerCore=110
```

Output description

Output table

columnsnames	col0	col1	col2
col0	1	-0.2115657251820724	0.0598306259706561
col1	-0.2115657251820724	1	-0.8444477377898585
col2	0.0598306259706561	-0.8444477377898585	1
col3	0.2599903570684693	-0.17507636221594533	0.18518346647293102
col4	-0.3483249188225586	0.40943384150571377	-0.20934839228057014
col5	-0.28716254396809926	0.09135976026101403	-0.1896417512389659
col6	0.47880162127435116	-0.3018506374626574	0.1799377498863213
col7	-0.13646519484213326	0.40733726912808044	-0.3858885676469948
col8	-0.19500158764680092	-0.11827739124590071	0.20254569203773892
col9	0.3897390240949085	0.12433851389455183	0.13476160753756655

4.4.5.4. Covariance

In probability theory and statistics, covariance is a measure of the joint variability of two random variables. Variance is a special case of covariance where the two measured variables are the same. If the expected values are E(X) = μ and E(Y) = v, the covariance between real-number random variables X and Y is cov(X, Y) = E((X - μ) (Y - v)).

PAI command

```
PAI -name cov
  -project algo_public
  -DinputTableName=maple_test_cov_basic12x10_input
  -DoutputTableName=maple_test_cov_basic12x10_output
  -DcoreNum=6
  -DmemSizePerCore=110;
```

Parameters

Parameter	Description	Valid values	Default value
inputTableName	Required. The name of the input table.	Table name	-
inputTablePartitions	Optional. The partitions selected from the input table for training, in the format of `partition_name=value`. To specify multiple partitions, use the following format: `name1=value1/name2=value2`. Separate multiple partitions with commas (,).	Partition name	All partitions are selected by default.
outputTableName	Required. A list of output table names.	Table name	-
selectedColNames	Optional. The names of columns selected from the input table.	Column name	All columns are selected by default.
lifecycle	Optional. The lifecycle of the output table.	A positive integer	No lifecycle is set by default.

Parameter	Description	Valid values	Default value
coreNum	Optional. The number of cores.	This parameter is used with memSizePerCore. The value must be a positive integer in the range of [1, 9999].	Automatically calculated.
memSizePerCore	Optional. The memory size of each node. Unit: MB.	A positive integer in the range of [1024, 65536]	Automatically calculated.

4.4.5.5. Empirical probability density chart

An empirical distribution is an estimated non-parametric distribution of probability in scenarios where accurate parametric distributions cannot be made.

The algorithm uses kernel distribution to estimate the probability density of sample data. Similar to a histogram, the algorithm generates functions to describe the distribution of sample data. However, kernel distribution is different in that it overlays the contributions of all parts to generate a smooth and continuous distribution curve, while a histogram only generates discrete descriptions. When kernel distribution is used, the probability density of non-sample data points is not 0, but an overlay of weighted probability density of all sampling points in a certain kernel distribution. In this document, the kernel distribution used is Gaussian distribution.

- For more information about kernel distribution, see Wikipedia.
- For more information about empirical distribution, see Wikipedia.

PAI command

```
PAI -name empirical_pdf
-project algo_public
-DinputTableName="test_data"
-DoutputTableName="test_epdf_out"
-DfeatureColNames="col0,col1,col2"
-DinputTablePartitions="ds='20160101'"
-Dlifecycle=1
-DintervalNum=100
```

Parameters

Parameter	Description	Valid values	Default value
inputTableName	Required. The name of the input table.	Table name	-
outputTableName	Required. The name of the output table.	Table name	-

Parameter	Description	Valid values	Default value
featureColNames	Required. The names of input columns.	Multiple columns of the double or bigint type can be selected.	-
labelColName	Optional. The name of the input label column.The feature column is stratified based on the label values in the label column.	Only one column of the bigint or string type can be selected. The number of label values cannot exceed 100.	No input label column is set by default.
inputTablePartitions	Optional. The partitions selected from the input table.	Partition name	All partitions are selected by default.
intervalNum	The number of calculation intervals. The larger the number, the higher the accuracy.	[1, 1E14)	Default value: -1. This value indicates that the number of intervals is determined based on the range of data values for each column.
lifecycle	The lifecycle of the output table.	A positive integer	Default value: -1. This value indicates that no lifecycle is set.
coreNum	Optional. The number of cores.	A positive integer	Default value: -1. This value indicates that the number of instances is determined based on the volume of input data.
memSizePerCore	Optional. The memory size of each core.	A positive integer in the range of [1024, 65536]	Default value: -1. This value indicates that the memory size is determined based on the volume of input data.

Examples

SQL statement to generate data:

```
drop table if exists epdf_test;
create table epdf_test as
select
 *
from
(
 select 1.0 as col1 from dual
  union all
 select 2.0 as col1 from dual
  union all
 select 3.0 as col1 from dual
  union all
 select 4.0 as col1 from dual
  union all
 select 5.0 as col1 from dual
) tmp;
```

PAI command

```
PAI -name empirical_pdf
-project algo_public
-DinputTableName=epdf_test
-DoutputTableName=epdf_test_out
-DfeatureColNames=col1;
```

Input description

You can select multiple columns to be calculated. You can select a label column and stratify the columns by label. For example, if the label column contains labels 0 and 1, the columns that need to be calculated are stratified into two groups. One group only contains columns with label 0 and the other group only contains columns with label 1. The probability density for each group is then calculated. If no label column is selected, all feature columns are calculated.

Output description

This component outputs a diagram and a result table. The columns in the result table are as follows. If no label column is selected, NULL is output in the label column.

Column name	Data type
colName	string
label	string
x	double

Column name	Data type
pdf	double

Output table:

```
+------------+------------+------------+------------+
| colname    | label      | x          | pdf        |
+------------+------------+------------+------------+
| col1       | NULL       | 1.0        | 0.12775155176809325 |
| col1       | NULL       | 1.0404050505050506 | 0.1304256933829622 |
| col1       | NULL       | 1.0808101010101012 | 0.13306325897429525 |
| col1       | NULL       | 1.1212151515151518 | 0.1356613897616418 |
| col1       | NULL       | 1.1616202020202024 | 0.1382173796574596 |
| col1       | NULL       | 1.202025252525253 | 0.1407286844875733 |
| col1       | NULL       | 1.2424303030303037 | 0.14319293014274642 |
| col1       | NULL       | 1.2828353535353543 | 0.14560791960033242 |
| col1       | NULL       | 1.3232404040404049 | 0.14797163876379316 |
| col1       | NULL       | 1.3636454545454555 | 0.1502822610772349 |
| col1       | NULL       | 1.404050505050506 | 0.1525381508819247 |
| col1       | NULL       | 1.4444555555555567 | 0.1547378654919243 |
| col1       | NULL       | 1.4848606060606073 | 0.1568801559764068 |
| col1       | NULL       | 1.525265656565658 | 0.15896396664681753 |
| col1       | NULL       | 1.5656707070707085 | 0.16098843325768245 |
| col1       | NULL       | 1.6060757575757592 | 0.1629528799404685 |
| col1       | NULL       | 1.6464808080808098 | 0.16485681490034038 |
| col1       | NULL       | 1.6868858585858604 | 0.16669992491584543 |
| col1       | NULL       | 1.727290909090911 | 0.16848206869138338 |
| col1       | NULL       | 1.7676959595959616 | 0.17020326912168932 |
| col1       | NULL       | 1.8081010101010122 | 0.17186370453638117 |
| col1       | NULL       | 1.8485060606060628 | 0.17346369900080946 |
| col1       | NULL       | 1.8889111111111134 | 0.17500371175692428 |
| col1       | NULL       | 1.929316161616164 | 0.17648432589456017 |
| col1       | NULL       | 1.9697212121212146 | 0.17790623634938396 |
| col1       | NULL       | 2.0101262626262653 | 0.1792702373286898 |
| col1       | NULL       | 2.050531313131316 | 0.18057720927022053 |
| col1       | NULL       | 2.0909363636363665 | 0.18182810544221673 |
| col1       | NULL       | 2.131341414141417 | 0.18302393829491406 |
| col1       | NULL       | 2.1717464646464677 | 0.18416576567472337 |
| col1       | NULL       | 2.2121515151515183 | 0.1852546770123305 |
| col1       | NULL       | 2.252556565656569 | 0.18629177959496213 |
| col1       | NULL       | 2.2929616161616195 | 0.18727818503109434 |
```

col1	NULL	2.33336666666667	0.18821499601297229
col1	NULL	2.3737717171717208	0.18910329347850022
col1	NULL	2.4141767676767714	0.18994412426940221
col1	NULL	2.454581818181822	0.19073848937711185
col1	NULL	2.4949868686868726	0.19148733286168018
col1	NULL	2.535391919191923	0.1921915315221827
col1	NULL	2.575796969696974	0.19285188538972659
col1	NULL	2.6162020202020244	0.19346910910630113
col1	NULL	2.656607070707075	0.19404382424446043
col1	NULL	2.6970121212121256	0.1945765526142701
col1	NULL	2.7374171717171762	0.19506771059517916
col1	NULL	2.777822222222227	0.19551760452158667
col1	NULL	2.8182272727272775	0.19592642714194602
col1	NULL	2.858632323232328	0.1962942551623821
col1	NULL	2.8990373737373787	0.1966210478770638
col1	NULL	2.9394424242424293	0.1969066468790639
col1	NULL	2.97984747474748	0.19715077683721793
col1	NULL	3.0202525252525305	0.19735304731663747
col1	NULL	3.060657575757581	0.19751295561309964
col1	NULL	3.1010626262626317	0.19762989056457925
col1	NULL	3.1414676767676823	0.19770313729675995
col1	NULL	3.181872727272733	0.19773188285349683
col1	NULL	3.2222777777777836	0.19771522265793107
col1	NULL	3.262682828282834	0.19765216774530828
col1	NULL	3.303087878787885	0.19754165270453194
col1	NULL	3.3434929292929354	0.19738254426210697
col1	NULL	3.383897979797986	0.19717365043938664
col1	NULL	3.4243030303030366	0.19691373021193162
col1	NULL	3.4647080808080872	0.1966015035982942
col1	NULL	3.505113131313138	0.19623566210464843
col1	NULL	3.5455181818181885	0.19581487945135703
col1	NULL	3.585923232323239	0.19533782250778076
col1	NULL	3.6263282828282897	0.1948031623623475
col1	NULL	3.6667333333333403	0.1942095854560816
col1	NULL	3.707138383838391	0.19355580470939734
col1	NULL	3.7475434343434415	0.19284057057394655
col1	NULL	3.787948484848492	0.19206268194364004
col1	NULL	3.8283535353535427	0.19122099686158253
col1	NULL	3.8687585858585933	0.19031444296253852
col1	NULL	3.909163636363644	0.1893420275936375
col1	NULL	3.9495686868686946	0.18830284755928747

```
| col1    | NULL    | 3.989973737373745 | 0.1871960984396676 |
| col1    | NULL    | 4.030378787878796 | 0.18602108343567092 |
| col1    | NULL    | 4.070783838383846 | 0.18477722169674377 |
| col1    | NULL    | 4.111188888888897 | 0.1834640560916829 |
| col1    | NULL    | 4.151593939393948 | 0.1820812603860928 |
| col1    | NULL    | 4.191998989898998 | 0.18062864579383914 |
| col1    | NULL    | 4.232404040404049 | 0.179106166873458 |
| col1    | NULL    | 4.272809090909099 | 0.17751392674406796 |
| col1    | NULL    | 4.31321414141415 | 0.17585218159888508 |
| col1    | NULL    | 4.353619191919201 | 0.17412134449794325 |
| col1    | NULL    | 4.394024242424251 | 0.1723219884250765 |
| col1    | NULL    | 4.434429292929302 | 0.17045484859762067 |
| col1    | NULL    | 4.4748343434343525 | 0.16852082402064342 |
| col1    | NULL    | 4.515239393939403 | 0.1665209782808102 |
| col1    | NULL    | 4.555644444444454 | 0.16445653957824907 |
| col1    | NULL    | 4.596049494949504 | 0.16232889999798905 |
| col1    | NULL    | 4.636454545454555 | 0.16013961402571825 |
| col1    | NULL    | 4.6768595959596055 | 0.1578903963157465 |
| col1    | NULL    | 4.717264646464656 | 0.15558311872216193 |
| col1    | NULL    | 4.757669696969707 | 0.1532198066072439 |
| col1    | NULL    | 4.798074747474757 | 0.1508026344442397 |
| col1    | NULL    | 4.838479797979808 | 0.14833392073462115 |
| col1    | NULL    | 4.878884848484859 | 0.14581612226291346 |
| col1    | NULL    | 4.919289898989909 | 0.1432518277151203 |
| col1    | NULL    | 4.95969494949496 | 0.1406437506896507 |
| col1    | NULL    | 5.00010000000001 | 0.13799472213247665 |
+---------+---------+-------------------+--------------------+
```

Input and output restrictions

The maximum number of label columns that can be specified is 100.

4.4.5.6. Chi-square goodness of fit test

This component is used to determine the differences between the observed frequencies and the expected frequencies for each classification of a single multiclass classification nominal variable. The null hypothesis assumes that the observed frequencies and the expected frequencies are consistent.

PAI command

```
PAI -name chisq_test
  -project algo_public
  -DinputTableName=pai_chisq_test_input
  -DcolName=f0
  -DprobConfig=0:0.3,1:0.7
  -DoutputTableName=pai_chisq_test_output0
  -DoutputDetailTableName=pai_chisq_test_output0_detail
```

Parameters

Parameter	Description	Valid values	Default value
inputTableName	Required. The name of the input table.	Table name	-
colName	Required. The name of the column that requires a chi-square test.	Column name	-
outputTableName	Required. The name of the output table.	Table name that has not been used	-
outputDetailTableName	Required. The name of the output detail table.	Table name that has not been used	-
inputTablePartitions	Optional. The partitions selected from the input table.	Partition list	All partitions are selected by default.
probConfig	Optional. The class probability configuration.	The configuration is stored in a key-value pair format: `class:probability`. The sum of all probabilities is 1.	All classes have the same probability by default.

Examples

Testing data

```
create table pai_chisq_test_input as
select * from
(
 select '1' as f0,'2' as f1 from dual
 union all
 select '1' as f0,'3' as f1 from dual
 union all
 select '1' as f0,'4' as f1 from dual
 union all
 select '0' as f0,'3' as f1 from dual
 union all
 select '0' as f0,'4' as f1 from dual
)tmp;
```

PAI command

```
PAI -name chisq_test
  -project algo_public
  -DinputTableName=pai_chisq_test_input
  -DcolName=f0
  -DprobConfig=0:0.3,1:0.7
  -DoutputTableName=pai_chisq_test_output0
  -DoutputDetailTableName=pai_chisq_test_output0_detail
```

Output description

Output table outputTableName is a JSON array containing only one row and one column.

```
{
  "Chi-Square": {
    "comment": "Pearsons chi-square test",
    "df": 1,
    "p-value": 0.75,
    "value": 0.2380952380952381
  }
}
```

Output table outputDetailTableName includes the following columns: data source class (**f0** or **f1**), observed frequency (**observed**), expected frequency (**expected**), and standard residuals (`residuals = (observed - expected)/sqrt (expected)`).

f0	f1	observed	expected	residuals
0	2	0.0	0.4	-0.6324555320336759
0	3	1.0	0.8	0.22360679774997894
0	4	1.0	0.8	0.22360679774997894
1	2	1.0	0.6000000000000001	0.5163977794943221
1	3	1.0	1.2000000000000002	-0.1825741858350555
1	4	1.0	1.2000000000000002	-0.1825741858350555

4.4.5.7. Chi-square test of independence

This component verifies whether two factors (each having two or more classes) are mutually independent. The null hypothesis is that two factors are independent of each other.

PAI command

```
PAI -name chisq_test
  -project algo_public
  -DinputTableName=pai_chisq_test_input
  -DxColName=f0
  -DyColName=f1
  -DoutputTableName=pai_chisq_test_output2
  -DoutputDetailTableName=pai_chisq_test_output2_detail
```

Parameters

Parameter	Description	Valid values	Default value
inputTableName	Required. The name of the input table.	Table name	-
xColName	Required. The name of the column that requires a chi-square test.	Column name	-
yColName	Required. The name of the column that require a chi-square test.	Column name	-
outputTableName	Required. The name of the output table.	Table name that has not been used	-
outputDetailTableName	Required. The name of the output detail table.	Table name that has not been used	-

Parameter	Description	Valid values	Default value
inputTablePartitions	Optional. The partitions selected from the input table.	Partition list	All partitions are selected by default.
lifecycle	Optional. The lifecycle of the output table.	A positive integer	No lifecycle is set by default.

Examples

- Testing data

```
create table pai_chisq_test_input as
select * from
(
select '1' as f0,'2' as f1 from dual
union all
select '1' as f0,'3' as f1 from dual
union all
select '1' as f0,'4' as f1 from dual
union all
select '0' as f0,'3' as f1 from dual
union all
select '0' as f0,'4' as f1 from dual
)tmp;
```

- PAI command

```
PAI -name chisq_test
 -project algo_public
 -DinputTableName=pai_chisq_test_input
 -DxColName=f0
 -DyColName=f1
 -DoutputTableName=pai_chisq_test_output2
 -DoutputDetailTableName=pai_chisq_test_output2_detail
```

- Output description

  Output table outputTableName is a JSON array containing only one row and one column.

```
{
  "Chi-Square": {
    "comment": "Pearsons chi-square test",
    "df": 2,
    "p-value": 0.75,
    "value": 0.8333333333333334
  }
}
```


Output table outputDetailTableName has the following columns:

Column name	Description
xColName	Class
yColName	Class
observed	Observed frequency
expected	Expected frequency
residuals	Residuals = (observed - expected)/sqrt (expected)

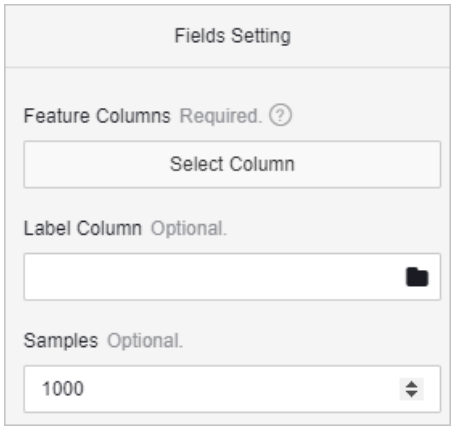
Data:

f0	f1	observed	expected	residuals
0	2	0.0	0.4	-0.6324555320336759
0	3	1.0	0.8	0.22360679774997894
0	4	1.0	0.8	0.22360679774997894
1	2	1.0	0.6000000000000001	0.5163977794943221
1	3	1.0	1.2000000000000002	-0.1825741858350555
1	4	1.0	1.2000000000000002	-0.1825741858350555

4.4.5.8. Scatter plot

In regression analysis, this component outputs a scatter plot that shows the distribution of data points in a Cartesian coordinate system.

Column settings



PAI command

```
PAI -name scatter_diagram
-project algo_public
-DselectedCols=emp_var_rate,cons_price_rate,cons_conf_idx,euribor3m
-DsampleSize=1000
-DlabelCol=y
-DmapTable=pai_temp_2447_22859_2
-DinputTable=scatter_diagram
-DoutputTable=pai_temp_2447_22859_1
```

Parameters

Parameter	Description	Default value
inputTable	Required. The name of the input table.	-
inputTablePartitions	Optional. The partitions selected from the input table.	-
outputTable	Required. The name of the output table that stores the samples.	-
mapTable	Required. The name of the output table that stores the maximum value, minimum value, and enumeration values of each feature.	-
selectedCols	Required. The columns selected from the input table from which to draw a scatter plot. A maximum of five features can be selected.	-
labelCol	Optional. An Int or String column to serve as the enumeration label column.	No enumeration label column is set by default.

Parameter	Description	Default value
sampleSize	Optional. The number of samples to collect from the input data.	1000
lifecycle	Optional. The lifecycle of the output table measured in days.	28

Examples

Input data

```
create table scatter_diagram as select emp_var_rate,cons_price_rate, cons_conf_idx,euribor3m,y from pai_bank_data limit 10
```

Parameters

emp_var_rate	cons_price_rate	cons_conf_idx	euribor3m	y
1.4	93.918	-42.7	4.962	0
-0.1	93.2	-42.0	4.021	0
-1.7	94.055	-39.8	0.729	1
-1.8	93.075	-47.1	1.405	0
-2.9	92.201	-31.4	0.869	1
1.4	93.918	-42.7	4.961	0
-1.8	92.893	-46.2	1.327	0
-1.8	92.893	-46.2	1.313	0
-2.9	92.963	-40.8	1.266	1
-1.8	93.075	-47.1	1.41	0
1.1	93.994	-36.4	4.864	0
1.4	93.444	-36.1	4.964	0
1.4	93.444	-36.1	4.965	1
-1.8	92.893	-46.2	1.291	0
1.4	94.465	-41.8	4.96	0
1.4	93.918	-42.7	4.962	0
-1.8	93.075	-47.1	1.365	1

emp_var_rate	cons_price_rate	cons_conf_idx	euribor3m	y
-0.1	93.798	-40.4	4.86	1
1.1	93.994	-36.4	4.86	0
1.4	93.918	-42.7	4.96	0
-1.8	93.075	-47.1	1.405	0
1.4	94.465	-41.8	4.967	0
1.4	93.918	-42.7	4.963	0
1.4	93.918	-42.7	4.968	0
1.4	93.918	-42.7	4.962	0
-1.8	92.893	-46.2	1.344	0
-3.4	92.431	-26.9	0.754	0
-1.8	93.075	-47.1	1.365	0
-1.8	92.893	-46.2	1.313	0
1.4	93.918	-42.7	4.961	0
1.4	94.465	-41.8	4.961	0
-1.8	92.893	-46.2	1.327	0
-1.8	92.893	-46.2	1.299	0
-2.9	92.963	-40.8	1.268	1
1.4	93.918	-42.7	4.963	0
-1.8	92.893	-46.2	1.334	0
1.4	93.918	-42.7	4.96	0
-1.8	93.075	-47.1	1.405	0
1.4	94.465	-41.8	4.96	0
1.4	93.444	-36.1	4.962	0
1.1	93.994	-36.4	4.86	0
1.1	93.994	-36.4	4.857	0
1.4	93.918	-42.7	4.961	0

emp_var_rate	cons_price_rate	cons_conf_idx	euribor3m	y
-3.4	92.649	-30.1	0.715	1
1.4	93.444	-36.1	4.966	0
-0.1	93.2	-42.0	4.076	0
1.4	93.444	-36.1	4.965	0
-1.8	92.893	-46.2	1.354	0
1.4	93.444	-36.1	4.967	0
1.4	94.465	-41.8	4.959	0
-1.8	92.893	-46.2	1.354	0
1.4	94.465	-41.8	4.958	0
-1.8	92.893	-46.2	1.354	0
1.4	94.465	-41.8	4.864	0
1.1	93.994	-36.4	4.859	0
1.1	93.994	-36.4	4.857	0
-1.8	92.893	-46.2	1.27	0
1.1	93.994	-36.4	4.857	0
1.1	93.994	-36.4	4.859	0
1.4	94.465	-41.8	4.959	0
1.1	93.994	-36.4	4.856	0
-1.8	93.075	-47.1	1.405	0
-1.8	92.843	-50.0	1.811	1
-0.1	93.2	-42.0	4.021	0
-2.9	92.469	-33.6	1.029	0
1.4	93.918	-42.7	4.962	0
-1.8	93.075	-47.1	1.365	0
1.1	93.994	-36.4	4.857	0
-1.8	92.893	-46.2	1.259	0

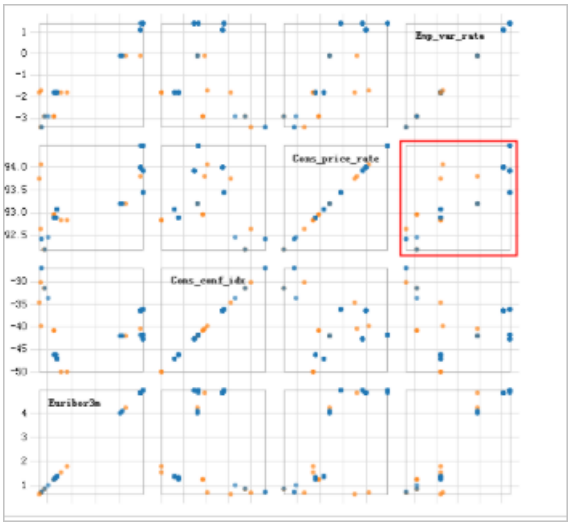
emp_var_rate	cons_price_rate	cons_conf_idx	euribor3m	y
1.1	93.994	-36.4	4.857	0
1.4	94.465	-41.8	4.866	0
-2.9	92.201	-31.4	0.883	0
-0.1	93.2	-42.0	4.076	0
1.1	93.994	-36.4	4.857	0
1.4	93.918	-42.7	4.96	0
1.4	93.444	-36.1	4.962	0
1.1	93.994	-36.4	4.858	0
1.1	93.994	-36.4	4.857	0
1.1	93.994	-36.4	4.856	0
1.4	93.918	-42.7	4.968	0
1.4	93.444	-36.1	4.966	0
1.4	94.465	-41.8	4.962	0
1.4	93.444	-36.1	4.963	0
-1.8	92.843	-50.0	1.56	1
1.4	93.918	-42.7	4.96	0
1.4	93.444	-36.1	4.963	0
-3.4	92.431	-26.9	0.74	0
1.1	93.994	-36.4	4.856	0
1.4	93.918	-42.7	4.962	0
1.1	93.994	-36.4	4.856	0
-0.1	93.2	-42.0	4.245	1
1.1	93.994	-36.4	4.857	0
-1.8	93.075	-47.1	1.405	0
-1.8	92.893	-46.2	1.327	0
-0.1	93.2	-42.0	4.12	0

emp_var_rate	cons_price_rate	cons_conf_idx	euribor3m	y
1.4	94.465	-41.8	4.958	0
-1.8	93.749	-34.6	0.659	1
1.1	93.994	-36.4	4.858	0
1.1	93.994	-36.4	4.858	0
1.4	93.444	-36.1	4.963	0

Parameter settings

Scatter plot configuration: select **select emp_var_rate**, **cons_price_rate**, **cons_conf_idx**, and **euribor3m** as the feature columns, and select **y** as the label column.

Output



You can view the distribution of classification tags between every two features in the scatter plot.

4.4.5.9. Two-sample T-test

A two-sample T-test is composed of an independent sample T-test and a paired sample T-test. Two samples independent of each other are called independent samples. An independent sample T-test checks whether two samples are significantly different from each other. The T-test is based on the premise that two samples are independent of each other and come from two normally distributed populations. A paired sample T-test checks whether the mean values from two paired populations are significantly different from each other.

PAI command

```
PAI -name t_test
  -project algo_public
  -DxTableName=pai_t_test_all_type
  -DxColName=col1_double
  -DxTablePartitions=ds=2010/dt=1
  -DyTableName=pai_t_test_all_type
  -DyColName=col1_double
  -DyTablePartitions=ds=2010/dt=1
  -DoutputTableName=pai_t_test_out
  -Dalternative=less
  -Dmu=47
  -DconfidenceLevel=0.95
  -Dpaired=False
  -DvarEqual=True
```

Parameters

Parameter	Description	Valid values	Default value
xTableName	Required. The name of input table x.	Table name	-
xTablePartitions	Optional. The partitions selected from input table x for testing, in the format of `Partition_name=value`. To specify multiple partitions, use the following format: `name1=value1/name2=value2`. Separate multiple partitions with commas (,).	Partition name	All partitions are selected by default.
xColName	Required. The column selected from table x for testing.	Column name. The type must be double or bigint.	-
yTableName	Required. The name of input table y.	Table name	-
yTablePartitions	Optional. The partitions selected from input table y for testing, in the format of `Partition_name=value`. To specify multiple partitions, use the following format: `name1=value1/name2=value2`. Separate multiple partitions with commas (,).	Partition name	All partitions are selected by default.
yColName	Required. The name of the column selected from table y for testing.	Column name. The type must be double or bigint.	-

Parameter	Description	Valid values	Default value
paired	Optional. A value of True indicates that it is a paired sample T-test. A value of False indicates that it is an independent sample T-test.	True and False	False
alternative	Optional. The alternative hypothesis.	two.sided, less, and greater	two.sided
mu	Optional. The hypothesized mean.	double	0
varEqual	Optional. This parameter indicates whether two population variances are equal.	True and False	False
confidenceLevel	Optional. The confidence level.	0.8, 0.9, 0.95, 0.99, 0. 995, and 0.999	0.95
coreNum	Optional. The number of cores.	This parameter is used with memSizePerCore. The value must be a positive integer in the range of [1, 9999].	Automatically calculated.
memSizePerCore	Optional. The memory size of each node. Unit: MB.	A positive integer in the range of [1024, 65536].	Automatically calculated.
lifecycle	Optional. The lifecycle of the output table.	A positive integer	No lifecycle is set by default.

Custom resources

Note

- For a regular table, we recommend that you do not set coreNum and memSizePerCore, and instead allow the default values to be used automatically.
- If you do not have sufficient compute resources, use the following code to calculate the amount of compute resources needed:

```
def CalcCoreNumAndMem(row, centerCount, kOneCoreDataSize=1024):
  """Calculates the number of nodes and memory size needed for each node.
    Args:
      row: the number of rows in the input table.
      col: the number of columns in the input table.
      kOneCoreDataSize: the amount of data needed to be calculated per node. Unit: MB. The value must be
a positive integer. Default value: 1024.
    Return:
      coreNum, memSizePerCore
    Example:
      coreNum, memSizePerCore = CalcCoreNumAndMem(1000,99, 100, kOneCoreDataSize=2048)
  """
  kMBytes = 1024.0 * 1024.0
  #Number of compute nodes
  coreNum = max(1, int(row * 2 * 8 / kMBytes / kOneCoreDataSize))
  #Memory size per node = Data volume
  memSizePerCore = max(1024,  int(kOneCoreDataSize*2))
  return coreNum,  memSizePerCore
```

Examples

- SQL statement to generate data:

```
create table pai_test_input as
select * from
(
 select 1 as f0,2 as f1 from dual
 union all
 select 1 as f0,3 as f1 from dual
 union all
 select 1 as f0,4 as f1 from dual
 union all
 select 0 as f0,3 as f1 from dual
 union all
 select 0 as f0,4 as f1 from dual
)tmp;
```

- PAI command

```
PAI -name t_test
  -project algo_public
  -DxTableName=pai_test_input
  -DxColName=f0
  -DyTableName=pai_test_input
  -DyColName=f1
  -DyTablePartitions=ds=2010/dt=1
  -DoutputTableName=pai_t_test_out
  -Dalternative=less
  -Dmu=47
  -DconfidenceLevel=0.95
  -Dpaired=False
  -DvarEqual=True
```

- Output description

  The output table is a JSON array containing only one row and one column.

```
{
  "AlternativeHypthesis": "difference in means not equals to 0",
  "ConfidenceInterval": "(-2.5465, -0.4535)",
  "ConfidenceLevel": 0.95,
  "alpha": 0.05000000000000004,
  "df": 19,
  "mean of the differences": -1.5,
  "p": 0.008000000000000007,
  "t": -3
}
```

Input and output restrictions

The input and output are not limited.

4.4.5.10. One-sample T-test

A one-sample T-test verifies whether the mean of a normally distributed population differs significantly from a target value. A T-test is performed based on the condition that the sample population is normally distributed.

PAI command

```
PAI -name t_test -project algo_public
  -DxTableName=pai_t_test_all_type
  -DxColName=col1_double
  -DoutputTableName=pai_t_test_out
  -DxTablePartitions=ds=2010/dt=1
  -Dalternative=less
  -Dmu=47
  -DconfidenceLevel=0.95
```

Algorithm parameters

Parameter	Description	Valid values	Default value
xTableName	Required. The name of input table x.	Table name	-
xColName	Required. The column selected from table x for testing.	Column name. The type must be double or bigint.	-
outputTableName	Required. The name of the output table.	Table name that has not been used	-
xTablePartitions	Optional. The partitions selected from input table x.	Partition list	All partitions are selected by default.
alternative	Optional. The alternative hypothesis.	two.sided, less, and greater	two.sided
mu	Optional. The hypothesized mean.	double	0
confidenceLevel	Optional. The confidence level.	0.8, 0.9, 0.95, 0.99, 0.995, and 0.999	0.95

Output description

The output table is a JSON array containing only one row and one column.

```
{
  "AlternativeHypthesis": "mean not equals to 0",
  "ConfidenceInterval": "(44.72234194006504, 46.27765805993496)",
  "ConfidenceLevel": 0.95,
  "alpha": 0.05,
  "df": 99,
  "mean": 45.5,
  "p": 0,
  "stdDeviation": 3.919647479510927,
  "t": 116.081867662439
}
```


4.4.5.11. Lorenz curve

The Lorenz curve is a graph to illustrate the distribution of wealth across a population. The X axis represents the total population arranged from least wealthy to most wealthy, while the Y axis represents the total wealth. If this graph is a straight line, it indicates perfectly equal distribution of wealth. The Gini coefficient is calculated by taking the area between the equal distribution curve and the actual Lorenz curve for a population as a fraction of the total area beneath the equal distribution curve. As the distribution of wealth becomes less equal, the Gini coefficient will increase, whereas a population with equal distribution of wealth will have a Gini coefficient of 0.

To study the distribution of income among a population, American statistician Max Otto Lorenz proposed the famous Lorenz curve in 1905. In 1921, Italian economist Corrado Gini defined the Gini coefficient as a measure of inequality in a population based on the Lorenz curve.

PAI command

```
PAI -name LorenzCurve
  -project algo_public
  -DinputTableName=maple_test_lorenz_basic10_input
  -DcolName=col0
  -DoutputTableName=maple_test_lorenz_basic10_output -DcoreNum=20
  -DmemSizePerCore=110;
```

Parameters

Parameter	Description	Valid value	Default value
inputTableName	Required. The name of the input table.	Table name	N/A
outputTableName	Required. The name of the output table.	Table name that has not been used	N/A

Parameter	Description	Valid value	Default value
colName	Optional. The column name. Separate multiple columns with commas (,).	Column name	The whole table is selected by default.
N	The number of quantiles.	N/A	100
inputPartitions	Optional. The partitions selected from the input table for training, in the `partition_name=value` format. To specify multiple partitions, use the following format: `name1=value1/name2=value2`. Separate multiple partitions with commas (,).	Partition name	All partitions are selected by default.
lifecycle	Optional. The lifecycle of the output table.	A positive integer	No lifecycle is set by default.
coreNum	Optional. The number of cores.	This parameter is used with memSizePerCore. The value must be a positive integer in the range of [1, 9999].	Automatically calculated.
memSizePerCore	Optional. The memory size of each core. Unit: MB.	A positive integer in the range of [1024, 65536]	Automatically calculated.

Examples

Data generation

col0:double
4
7
2
8
6
3

col0:double
9
5
0
1
10

PAI command

```
PAI -name LorenzCurve
  -project algo_public
  -DinputTableName=maple_test_lorenz_basic10_input
  -DcolName=col0
  -DoutputTableName=maple_test_lorenz_basic10_output
  -DcoreNum=20
  -DmemSizePerCore=110;
```

Output

Quantile	col0
0	0
1	0.01818181818181818
2	0.01818181818181818
3	0.01818181818181818
4	0.01818181818181818
5	0.01818181818181818
6	0.01818181818181818
7	0.01818181818181818
8	0.01818181818181818
9	0.01818181818181818
10	0.01818181818181818
11	0.05454545454545454
12	0.05454545454545454

Quantile	col0
13	0.05454545454545454
14	0.05454545454545454
...	...
85	0.8181818181818182
86	0.8181818181818182
87	0.8181818181818182
88	0.8181818181818182
89	0.8181818181818182
90	1
91	1
92	1
93	1
94	1
95	1
96	1
97	1
98	1
99	1
100	1

4.4.5.12. Normality test

This component is used to determine whether observed values are normally distributed.

This component consists of three test methods: Anderson-Darling test (see Wikipedia), Kolmogorov-Smirnov test (see Wikipedia), and Q-Q plot (see Wikipedia). You can use one or more methods as needed.

Algorithm description:

- Original hypothesis H0: The observed values are normally distributed. H1: The observed values are not normally distributed.
- The KS p-value calculation method progressively calculates CDF of KS distribution regardless of the

sample size. For more information, see Wikipedia.

- If the sample size is greater than 1000, the Q-Q plot method collects samples to calculate and output plots. This means that the data points in plots do not necessarily cover all samples.

PAI command

```
PAI -name normality_test
  -project algo_public
  -DinputTableName=test
  -DoutputTableName=test_out
  -DselectedColNames=col1,col2
  -Dlifecycle=1;
```

Parameters

Parameter	Description	Valid values	Default value
inputTableName	Required. The name of the input table.	Table name	-
outputTableName	Required. The name of the output table.	Table name that has not been used	-
selectedColNames	Optional. The names of selected columns.	Multiple double or bigint type columns can be selected.	-
inputTablePartitions	Optional. The partitions selected from the input table.	Partition name	All partitions are selected by default.
enableQQplot	Optional. This parameter specifies whether to use the Q-Q plot.	true and false	true
enableADtest	Optional. This parameter specifies whether to perform the Anderson-Darling test.	true and false	true
enableKStest	Optional. This parameter specifies whether to perform the Kolmogorov-Smirnov test.	true and false	true
lifecycle	Optional. The lifecycle of the output table.	An integer greater than or equal to -1	Default value: -1. This value indicates that no lifecycle is set.

Parameter	Description	Valid values	Default value
coreNum	Optional. The number of cores.	An integer greater than 0	Default value: -1. This value indicates that the number of instances is determined by the amount of input data.
memSizePerCore	Optional. The memory size of each core.	(100, 65536)	Default value: -1. This value indicates that the memory size is determined by the amount of input data.

Examples

- SQL statement to generate data:

```
drop table if exists normality_test_input;
  create table normality_test_input as
  select
   *
  from
  (
   select 1 as x from dual
    union all
   select 2 as x from dual
    union all
   select 3 as x from dual
    union all
   select 4 as x from dual
    union all
   select 5 as x from dual
    union all
   select 6 as x from dual
    union all
   select 7 as x from dual
    union all
   select 8 as x from dual
    union all
   select 9 as x from dual
    union all
   select 10 as x from dual
  ) tmp;
```

- PAI command

```
PAI -name normality_test
  -project projectxlib4
  -DinputTableName=normality_test_input
  -DoutputTableName=normality_test_output
  -DselectedColNames=x
  -Dlifecycle=1;
```

- Input description

  Input format: select the columns that need to be calculated. The columns must be of the double or bigint type.

- Output description

  A diagram and a result table are output. The columns in the result table are as follows. The result table has two partitions:

  - `p='test'` shows the result of the AD or KS test. Data is output when *enableADtest* or *enableKStest* is set to true.
  - `p='plot'` shows the Q-Q plot data. When *enableQQplot* is set to true, data is output and the columns that meet the `p='test'` condition are reused. In the case of `p='plot'`, the *testvalue* column records the original observed data (x axis of the Q-Q plot), and the *pvalue* column records the expected data that is normally distributed (y axis of the Q-Q plot).

  Output table:

```
+------------+------------+------------+------------+------------+
| colname    | testname   | testvalue  | pvalue     | p          |
+------------+------------+------------+------------+------------+
| x          | NULL       | 1.0        | 0.8173291742279805 | plot       |
| x          | NULL       | 2.0        | 2.470864450785345 | plot       |
| x          | NULL       | 3.0        | 3.5156067948020056 | plot       |
| x          | NULL       | 4.0        | 4.3632330349313095 | plot       |
| x          | NULL       | 5.0        | 5.128868067945126 | plot       |
| x          | NULL       | 6.0        | 5.871131932054874 | plot       |
| x          | NULL       | 7.0        | 6.6367669650686905 | plot       |
| x          | NULL       | 8.0        | 7.4843932051979944 | plot       |
| x          | NULL       | 9.0        | 8.529135549214654 | plot       |
| x          | NULL       | 10.0       | 10.182670825772018 | plot       |
| x          | Anderson_Darling_Test | 0.1411092332197832 | 0.9566579606430077 | test       |
| x          | Kolmogorov_Smirnov_Test | 0.09551932503797644 | 0.9999888659426232 | test       |
+------------+------------+------------+------------+------------+
```

Column name	Data type	Definition
colName	string	Column name
testname	string	Test name
testvalue	double	Test value on the x axis of the Q-Q plot
pvalue	double	Test p value on the y axis of the Q-Q plot
p	double	Partition name

4.4.5.13. Percentile

This component calculates the percentile of the values in a column.

Parameter settings

Select the column to be analyzed. Only the double and bigint types are supported.

PAI command

```
PAI –name Percentile
–project algo_public
-DoutputTableName="pai_temp_666_6014_1"
-DcolName="euribor3m"
-DinputTableName="bank_data";
```

Parameters

Parameter	Description
name	The name of the component.
project	The name of the project. This parameter is used to specify the workspace of the algorithm. The default value is algo_public. If you change the name, the system reports an error.
outputTableName	The name of the output table automatically generated after the system performs the percentile calculation.
colName	The column selected for percentile calculation. Only the numeric type is supported.
inputTableName	The name of the input table.

4.4.5.14. Pearson coefficient

This component calculates the Pearson correlation coefficient of two numeric columns in an input table or a partition, and saves the result to the output table.

Component description

- The component has only two parameters: input column 1 and input column 2. Enter the names of the two columns for which the Pearson correlation coefficient is calculated.
- After you run the component, right-click the component and choose **View Analytics Report** from the shortcut menu.
- The Pearson correlation coefficient is listed in the row.

PAI command

```
pai –name pearson
–project algo_test
-DinputTableName=wpbc
-Dcol1Name=f1
-Dcol2Name=f2
-DoutputTableName=wpbc_pear;
```

Algorithm prameters

Parameters

Parameter	Description	Valid values	Default value
inputTableName	Required. The name of the input table.	Table name	-
inputTablePartitions	The partitions selected from the input table for calculation.	The parameter value must be in the `partition_name=value` format. To specify multiple partitions, use the following format: `name1=value1/name2=value2`. Separate multiple partitions with commas (,).	All partitions in the input table are selected by default.
col1Name	Required. The name of input column 1.	Column name	-
col2Name	Required. The name of input column 2.	Column name	-
outputTableName	Required. The name of the output table.	Table name	-

4.4.5.15. Histogram

This component analyzes data in a column and outputs a histogram.

Parameter settings

- Select the columns to be analyzed. Only the double and bigint types are supported.
- View the analysis report.
- You can adjust the step and move the slider to view the entire histogram.

4.4.6. Machine learning

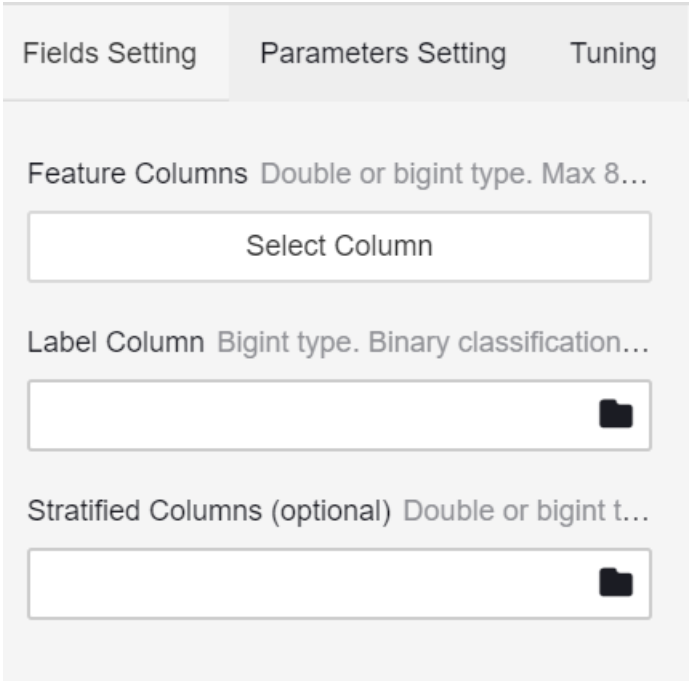
4.4.6.1. Binary classification

4.4.6.1.1. GBDT binary classification

This component is used for binary classification based on GBDT regression and sorting. Values greater than the threshold value are considered positive samples, while values that are less than or equal to the threshold value are considered negative samples.

Procedure

1. Drag and drop the GBDT Binary Classification component onto the canvas for training and set the parameters, as shown in the following figure.



Parameters

Parameter	Description
Feature Columns	The double and bigint types are supported. A maximum of 800 columns can be specified.
Label Column	You can select all columns except the input column. The values must be of the binary type.

Parameter	Description
Stratification Column	Optional. The whole table is selected by default. The double and bigint types are supported.

2. You can change the data type of the input columns.

   The input columns of GBDT binary classification only support the continuous type and are processed in the same way as the discrete type.

3. Set the parameters.

Parameters

Parameter	Description
Metric Type	The normalized discounted cumulative gain (NDCG) and discounted cumulative gain (DCG).
Trees	Valid values: [1,10000]. Default value: 500.
Learning Rate	Valid values: (0, 1). Default value: 0.05.
Training Sample Fraction	Valid values: (0, 1). Default value: 0.6.
Training Feature Fraction	Valid values: (0, 1). Default value: 0.6.
Maximum Leaves	The value must be an integer in the range of [2, 1000]. Default value: 32.
Testing Data Fraction	Valid values: [0, 1]. Default value: 0.0.
Maximum Tree Depth	The value must be an integer in the range of [1, 11]. Default value: 11.
Minimum Samples per Leaf Node	The value must be an integer in the range of [100, 1000]. Default value: 500.
Random Seed	The value must be an integer in the range of [0, 10]. Default value: 0.
Maximum Splits per Feature	Valid values: [1, 1000]. Default value: 500.

4. View the output. For more information, see the description of the Random forest component.

> Note
>
> - GBDT and GBDT_LR have different default types of loss functions. The default loss function of GBDT is regression loss:mean squared error loss. The default loss function of GBDT_LR is logistic regression loss. The system automatically writes the default loss function for GBDT_LR.
> - For GBDT binary classification, the label column must be of the binary type. String type data is not supported.
> - When connecting the ROC curve component, set the prediction component parameters and select a base value.

PAI command (F/L setup settings are not used)

```
PAI -name GBDT_LR
-project algo_public
-DfeatureSplitValueMaxSize="500"
-DrandSeed="0"
-Dshrinkage="0.5"
-DmaxLeafCount="32"
-DlabelColName="y"
-DinputTableName="bank_data_partition"
-DminLeafSampleCount="500"
-DgroupIDColName="nr_employed"
-DsampleRatio="0.6"
-DmaxDepth="11"
-DmodelName="xlab_m_GBDT_LR_21208"
-DmetricType="2"
-DfeatureRatio="0.6"
-DinputTablePartitions="pt=20150501"
-DtestRatio="0.0"
-DfeatureColNames="age,previous,cons_conf_idx,euribor3m"
-DtreeCount="500";
```

Parameters

Parameter	Description
name	The name of the component.
project	The name of the project. This parameter is used to specify the workspace of the algorithm. The default value is algo_public. If you change the name, the system reports an error.

Parameter	Description
featureSplitValueMaxSize	Optional. The maximum number of splits per feature. Valid values: [1, 1000]. Default value: 500.
randSeed	Optional. The number of random seeds. The value must be an integer in the range of [0, 10]. Default value: 0.
shrinkage	Optional. The learning rate. Valid values: (0, 1). Default value: 0.05.
maxLeafCount	Optional. The maximum number of leaves. The value must be an integer in the range of [2, 1000]. Default value: 32.
labelColName	The name of the label column selected from the input table.
inputTableName	The name of the input table for training.
minLeafSampleCount	Optional. The minimum number of samples per leaf node. The value must be an integer in the range of [100, 1000]. Default value: 500.
groupIDColName	Optional. The name of the stratification column. The whole table is considered as a stratum by default.
sampleRatio	Optional. The fraction of samples collected for training. Valid values: (0, 1). Default value: 0.6.
maxDepth	Optional. The maximum depth of a tree. The value must be an integer in the range of [1, 11]. Default value: 11.
modelName	The name of the output model.
metricType	Optional. The type of a metric. Valid values: 0 and 1. 0 represents normalized discounted cumulative gain (NDCG) and 1 represents discounted cumulative gain (DCG).
featureRatio	Optional. The fraction of features collected for training. Valid values: (0, 1). Default value: 0.6.
inputTablePartitions	Optional. The partitions selected from the input prediction table. If no partitions are specified, the whole table is selected.
testRatio	Optional. The fraction of testing samples. Valid values: [0, 1]. Default value: 0.0.
featureColNames	The names of feature columns selected from the input table for training.
treeCount	Optional. The number of trees. Valid values: [1, 10000]. Default value: 500.

4.4.6.1.2. Linear SVM

Support-vector machines (SVMs) are developed based on the VC dimension theory and the structural risk minimization principle.

This linear SVM version is not implemented using the kernel function. For more information, see Trust Region Method for L2-SVM at http://www.csie.ntu.edu.tw/~cjlin/papers/logistic.pdf. This algorithm only supports binary classification.

Procedure

1. Configure column settings.
   - Feature Columns: You can select a feature column of the bigint or double type.
   - Label Column: The data type of the label column can be bigint, double, or string. This component only supports binary classification.
2. Set parameters.

Parameters

Parameter	Description
Positive Sample Label	Optional. The value of the positive sample. If this parameter is not specified, the system randomly selects a value. We recommend that you specify this parameter when the positive and negative samples are significantly different.
Positive Penalty Factor	Optional. The weight of the positive sample. Valid values: (0, +∞). Default value: 1.0.
Negative Penalty Factor	Optional. The weight of the negative sample. Valid values: (0, +∞). Default value: 1.0.
Convergence Coefficient	Optional. The convergence deviation. Valid values: (0, 1). Default value: 0.001. **Note** If no base value is specified, Positive Penalty Factor and Negative Penalty Factor must be set to the same value.

3. View the output. For more information, see the description of the Random Forest component.

PAI command (F/L setup settings are not used)

```
PAI –name LinearSVM
–project algo_public
-DnegativeCost="1.0"
-DmodelName="xlab_m_LinearSVM_6143"
-DpositiveCost="1.0"
-Depsilon="0.001"
-DlabelColName="y"
-DfeatureColNames="pdays,emp_var_rate,cons_conf_idx"
-DinputTableName="bank_data"
-DpositiveLabel="0";
```

Parameters

Parameter	Description
name	The name of the component.
project	The name of the project. This parameter is used to specify the workspace of the algorithm. The default value is algo_public. If you change the name, the system reports an error.
negativeCost	Optional. The weight of the negative sample. It is the penalty factor of the negative sample. Valid values: (0, +∞). Default value: 1.0.
modelName	The name of the output model.
positiveCost	Optional. The weight of the positive sample. It is the penalty factor of the positive sample. Valid values: (0, +∞). Default value: 1.0.
epsilon	Optional. The convergence coefficient. Valid values: (0, 1). Default value: 0.001.
labelColName	The name of the label column.
featureColNames	The names of feature columns selected from the input table for training.
inputTableName	The name of the input table for training.
positiveLabel	Optional. The value of the positive sample. If this parameter is not specified, the system randomly selects a value.

4.4.6.1.3. Logistic regression for binary classification

Binary classification is a classic logistic regression method. Logistic regression on the algorithm platform supports multiclass classification. The logistic regression component supports two data types: sparse and dense.

Parameter settings

Parameters

Parameter	Description
Regularization Type	Optional. The type of regularization. Valid values: *L1*, *L2*, and *None*. Default value: *L1*.
Maximum Iterations	Optional. The maximum number of L-BFGS iterations. Default value: 100.
Regularization Coefficient	Optional. The regularization coefficient. Default value: 1.0. If regularizedType is set to *None*, this parameter is ignored.
Minimum Convergence Deviance	Optional. The condition to terminate L-BFGS. This is the log-likelihood deviation between two iterations. Default value: *1.0e-06*.

The logistic regression component outputs a model, which is available in the model list.

Model name format: `Experiment Name + "-" + Component Name + "model"` .

PAI command (F/L setup settings are not used)

```
PAI –name LogisticRegression
–project algo_public
-DmodelName="xlab_m_logistic_regression_6096"
-DregularizedLevel="1"
-DmaxIter="100"
-DregularizedType="l1"
-Depsilon="0.000001"
-DlabelColName="y"
-DfeatureColNames="pdays,emp_var_rate"
-DgoodValue="1"
-DinputTableName="bank_data";
```

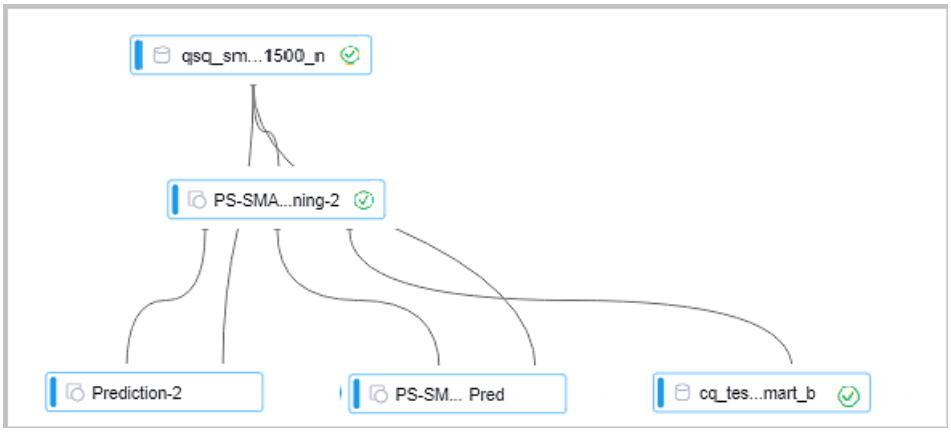
Parameters

Parameter	Description
name	The name of the component.
project	The name of the project. This parameter is used to specify the workspace of the algorithm. The default value is algo_public. If you change the name, the system reports an error.
modelName	The name of the output model.
regularizedLevel	Optional. The regularization coefficient. Default value: 1.0. If regularizedType is set to *None*, this parameter is ignored.
maxIter	Optional. The maximum number of L-BFGS iterations. Default value: 100.
regularizedType	Optional. The type of regularization. Valid values: *L1*, *L2*, and *None*. Default value: *L1*.
epsilon	Optional. The convergence deviation. It is the condition to terminate L-BFGS. This is the log-likelihood deviation between two iterations. Default value: *1.0e-06*.
labelColName	The name of the label column selected from the input table.
featureColNames	The names of feature columns selected from the input table for training.
goodValue	Optional. The base value. For binary classification, specify the label value of the training coefficient. If this parameter is not specified, the system randomly selects a value.
inputTableName	The name of the input table for training.

4.4.6.1.4. PS-SMART binary classification

A parameter server (PS) is used to train a large number of models online and offline. Scalable Multiple Additive Regression Tree (SMART) is an implementation of Gradient Boosting Decision Tree (GBDT) on PS. PS-SMART can run training tasks containing up to tens of billions of samples and hundreds of thousands of features on thousands of nodes. It also supports failover for high stability. PS-SMART supports various data formats, training targets, evaluation targets, output feature importance, and histogram approximation for training acceleration.

Quick start



As shown in the figure, a PS-SMART binary classification model is learned based on training data. The model has three output ports:

- Output model: offline model, which is connected to the unified prediction component. This model does not support the output of leaf node numbers.
- Output model table: a binary table that is not readable and is used to ensure compatibility with the PS-SMART prediction component. The table supports the output of leaf node numbers, which ensures higher efficiency, less resource consumption, and higher stability.
- Output feature importance table: lists the importance of each feature. Three importance types are supported. For more information, see Parameters.

PAI command

- Training

```
PAI -name ps_smart
  -project algo_public
  -DinputTableName="smart_binary_input"
  -DmodelName="xlab_m_pai_ps_smart_bi_545859_v0"
  -DoutputTableName="pai_temp_24515_545859_2"
  -DoutputImportanceTableName="pai_temp_24515_545859_3"
  -DlabelColName="label"
  -DfeatureColNames="f0,f1,f2,f3,f4,f5"
  -DenableSparse="false"
  -Dobjective="binary:logistic"
  -Dmetric="error"
  -DfeatureImportanceType="gain"
  -DtreeCount="5";
  -DmaxDepth="5"
  -Dshrinkage="0.3"
  -Dl2="1.0"
  -Dl1="0"
  -Dlifecycle="3"
  -DsketchEps="0.03"
  -DsampleRatio="1.0"
  -DfeatureRatio="1.0"
  -DbaseScore="0.5"
  -DminSplitLoss="0"
```

- Prediction

```
PAI -name prediction
  -project algo_public
  -DinputTableName="smart_binary_input";
  -DmodelName="xlab_m_pai_ps_smart_bi_545859_v0"
  -DoutputTableName="pai_temp_24515_545860_1"
  -DfeatureColNames="f0,f1,f2,f3,f4,f5"
  -DappendColNames="label,qid,f0,f1,f2,f3,f4,f5"
  -DenableSparse="false"
  -Dlifecycle="28"
```

Parameters

- Data parameters

Command option	Parameter	Description	Valid values	Remarks

Command option	Parameter	Description	Valid values	Remarks
featureColNames	Feature Columns	The names of feature columns selected from the input table for training.	If the column name is in dense format, it must be of the bigint or double type. If the column name is in sparse KV format, it must be a string, and its keys and values must be numeric.	Required
labelColName	Label Column	The name of the label column selected from the input table.	The column name can be of either string or numeric type, but only numeric data can be stored in the columns. For example, in binary classification, the column value can be 0 or 1.	Required
weightCol	Weight Column	This column specifies the weight of each sample.	The column name can be of the numeric type.	Optional. Default value: null.
enableSparse	Use Sparse Format	This parameter specifies whether the data in the input table is in sparse format, in which key-value pairs are separated by spaces whereas keys and values are separated by colons (:), for example, 1:0.3 3:0.9.	[true, false]	Optional. Default value: false.
inputTableName	Input Table Name	N/A	N/A	Required
modelName	Output Model Name	N/A	N/A	Required
outputImportanceTableName	Output Feature Importance Table Name	N/A	N/A	Optional. Default value: null.

Command option	Parameter	Description	Valid values	Remarks
inputTablePartitions	Input Table Partitions	N/A	N/A	Optional. The parameter value must be in ds=1/pt=1 format.
outputTableName	Output Model Table Name	The output table is a MaxCompute table that uses the binary format and is not readable. The prediction component that comes with SMART can be used to generate leaf node numbers.	String	Optional
lifecycle	Output Table Lifecycle	N/A	Positive integer	Optional. Default value: 3.

- Algorithm parameters

Command option	Parameter	Description	Valid values	Remarks
objective	Objective Function Type	The objective function type affects learning and must be selected properly. Select **binary:logistic** for binary classification.	N/A	Required
metric	Evaluation Indicator Type	Evaluation indicators in the training set, which are exported to stdout of the coordinator in a logview.	logloss, error and auc	Optional. Default value: null.
treeCount	Trees	The number of trees. The training time is proportional to this number.	Positive integer	Optional. Default value: 1.

Command option	Parameter	Description	Valid values	Remarks
maxDepth	Maximum Tree Depth	The maximum depth of a tree. We recommend that you set this value to 5, which means the tree can contain up to 32 leaf nodes.	A positive integer in the range of [1, 20]	Optional. Default value: 5.
sampleRatio	Data Sampling Fraction	The data sampling rate when trees are built. The sample data is used to build a weak learner to accelerate training.	(0, 1]	Optional. The default value is 1.0, which means data sampling is disabled.
featureRatio	Feature Sampling Fraction	The feature sampling rate when trees are built. The sample features are used to build a weak learner to accelerate training.	(0, 1]	Optional. The default value is 1.0, which means feature sampling is disabled.
l1	L1 Penalty Coefficient	This parameter determines the number of leaf nodes. The greater the value, the less the leaf nodes. You can set this parameter to a greater value if overfitting occurs.	Non-negative real number	Optional. Default value: 0.
l2	L2 Penalty Coefficient	This parameter determines the size of a leaf node. The greater the value, the more evenly the leaf nodes are distributed. You can set this parameter to a greater value if overfitting occurs.	Non-negative real number	Optional. Default value: 1.0.

Command option	Parameter	Description	Valid values	Remarks
shrinkage	Learning Rate	N/A	(0, 1]	Optional. Default value: 0.3.
sketchEps	Sketch-based Approximate Precision	The threshold for selecting quantiles when you build a sketch. The number of buckets is O(1.0/sketchEps). The smaller the parameter value, the more buckets are generated. Typically, you do not need to modify this value.	(0, 1)	Optional. Default value: 0.03.
minSplitLoss	Minimum Split Loss Change	The minimum split loss changes required for splitting a node. The greater the value, the more conservatively the node splits.	Non-negative real number	Optional. Default value: 0.
featureNum	Features	The number of features or the maximum feature ID. Specify this parameter for resource usage estimation.	Positive integer	Optional
baseScore	Global Offset	Original predicted values of all samples.	Real number	Optional. Default value: 0.5.

Command option	Parameter	Description	Valid values	Remarks
featureImportanceType	Feature Importance Type	The type of feature importance. **weight** indicates the number of times that a feature splits. **gain** indicates information gain brought by the feature. **cover** indicates the number of samples that the feature covers on the splitting nodes.	**weight**, **gain**, and **cover**	Optional. Default value: **gain**.

- Note
  - Specify different values for the objective parameter in different learning models. On the binary classification Web GUI, the objective function is automatically specified and invisible to users. On the command line, set the objective parameter to `binary:logistic`.
  - Mappings between metrics and objective functions are: **logloss** for **negative loglikelihood for logistic regression**, **error** for **binary classification error**, and **auc** for **Area under curve for classification**.

Execution optimization

Command option	Parameter	Description	Valid values	Remarks
coreNum	Cores	The number of cores. The greater the value, the faster the computing algorithm runs.	Positive integer	Optional. Automatically calculated.
memSizePerCore	Memory Size per Core (MB)	The memory size of each core, where 1024 represents 1 GB of memory.	Positive integer	Optional. Automatically calculated.

Example

- Data generation

  The following example uses data in dense format.

```
drop table if exists lm_test_input;
create table smart_binary_input lifecycle 3 as
select
*
from
(
select 0.72 as f0, 0.42 as f1, 0.55 as f2, -0.09 as f3, 1.79 as f4, -1.2 as f5, 0 as label from dual
union all
select 1.23 as f0, -0.33 as f1, -1.55 as f2, 0.92 as f3, -0.04 as f4, -0.1 as f5, 1 as label from dual
union all
select -0.2 as f0, -0.55 as f1, -1.28 as f2, 0.48 as f3, -1.7 as f4, 1.13 as f5, 1 as label from dual
union all
select 1.24 as f0, -0.68 as f1, 1.82 as f2, 1.57 as f3, 1.18 as f4, 0.2 as f5, 0 as label from dual
union all
select -0.85 as f0, 0.19 as f1, -0.06 as f2, -0.55 as f3, 0.31 as f4, 0.08 as f5, 1 as label from dual
union all
select 0.58 as f0, -1.39 as f1, 0.05 as f2, 2.18 as f3, -0.02 as f4, 1.71 as f5, 0 as label from dual
union all
select -0.48 as f0, 0.79 as f1, 2.52 as f2, -1.19 as f3, 0.9 as f4, -1.04 as f5, 1 as label from dual
union all
select 1.02 as f0, -0.88 as f1, 0.82 as f2, 1.82 as f3, 1.55 as f4, 0.53 as f5, 0 as label from dual
union all
select 1.19 as f0, -1.18 as f1, -1.1 as f2, 2.26 as f3, 1.22 as f4, 0.92 as f5, 0 as label from dual
union all
select -2.78 as f0, 2.33 as f1, 1.18 as f2, -4.5 as f3, -1.31 as f4, -1.8 as f5, 1 as label from dual
) tmp;
```

- Training

  Configure the training data and training components, as shown in Quick start. Select the label column as the target column and columns f0, f1, f2, f3, f4, f5 as feature columns.

  - You do not need to set the number of features because this number is calculated automatically by the algorithm. If you have a large number of features and want the algorithm to accurately estimate the amount of required resources, specify the actual number of features.
  - To accelerate the training, set the number of cores on the execution optimization page. The greater the number, the faster the algorithm runs. Typically, you do not need to enter the memory size per core because the algorithm can accurately calculate the memory size. The PS algorithm starts to run only when all hosts have obtained the required resources. Therefore, you may need to wait for a longer period of time when the cluster is busy and resources are requested in large volumes.
  - You can view the output values of the metrics in the stdout of the coordinator in a logview (HTTP link starting with http://logview.odps.aliyun-inc.com:8080/logview). A single PS-SMART training job can contain multiple tasks, and therefore multiple logviews are created. Select the logview whose name starts with PS to view the output of the PS job.

- Prediction
  - Use the unified prediction component

    The model generated after training is saved in binary format and can be used for prediction. Configure the input model and test data for the prediction component, as shown in Quick start.

    If the dense format is used, you only need to select feature columns. (All columns are selected by default, and extra columns do not affect the prediction.) If the KV format is used, set the data format to sparse format and select the correct delimiter. In the SMART model, key-value pairs are separated by space characters. Therefore, the delimiter must be set to space or \u0020 (escape expression of spaces).

    In the "prediction_detail" column, value 1 indicates a positive sample, and value 0 indicates a negative sample. The values following 0 and 1 indicate the probabilities of the corresponding classes.

  - Use the PS-SMART prediction component

    The output model table obtained after training is saved in binary format and can be used by the PS-SMART prediction component for prediction. Configure the input model and test data for the prediction component, as shown in Quick start. Set the required parameters, including the data format, feature columns, target column, and number of classes. The ID column can only be a string type column other than a feature column or a target column. The loss function must be set to binary:logistic.

    The **prediction_score** column lists probabilities of predicted positive samples. A sample is predicted as a positive sample if its score is greater than 0.5. Otherwise, it is predicted as a negative sample. The **leaf_index** column lists the predicted leaf node numbers. Each sample has N numbers, where N is the number of decision trees. Each tree is mapped to a number, which indicates the leaf node number of the sample on this tree.

    > Note
    > - The output model table is a binary table that is not readable and is used to support the PS-SMART prediction component. The table provides outputs such as leaf node numbers and evaluation indicators. However, the output table has strict requirements on data formats, which negatively affects user experience. This component is being continually improved, and may be replaced by another component in the future.
    > - A string type column must be selected as the label column. You can enter strings in the column but cannot be blank or NULL. A feature column can be converted to the string type by using the data type conversion component.
    > - The loss function must be explicitly set to **binary:logistic**. By default, the function does not work.

- View feature importance

  To view feature importance, you can export the third output port to an output table, or right-click **PS-SMART training component** and choose **View Data > Output Feature Importance Table** from the shortcut menu.

order	id	value
1	0	0.5690338015556335
2	1	0.21714292466640472
3	4	0.21382322907447815

In the table, the ID column lists the numbers of input features. In this example, the data is in dense format. The input features are **f0,f1,f2,f3,f4,f5**. Therefore, ID 0 represents f0 and ID 4 represents f4. If the KV format is used, the IDs represent keys in key-value pairs. Each value indicates a feature importance type. The default value is **gain**, indicating the sum of information gains brought by a feature in the model. The preceding figure shows only three features because only these three features are used during the tree split process. In this case, the importance of unused features is 0.

FAQ

- Q: Does PS_SMART support non-numerical features and tags?
- A: No.
- Q: What is the scale of features supported by PS-SMART? Can we use large-scale 0-1 features?
- A: Although PS-SMART supports tasks that contain hundreds of thousands of features, such tasks consume large amounts of resources and run slowly. Therefore, we recommend that you do not use such a large number of features. The GBDT algorithm is suitable for training with continuous features. The categorical features require one-hot coding to filter out infrequent features before they can be used for training. The continuous numerical features can be used for training with the GBDT algorithm directly. Discretization is not recommended for numerical features.
- Q: Why is the result different every time although the SMART algorithm has the same data and the same parameter settings?
- A: The PS-SMART algorithm applies randomness in many scenarios. For example, the data_sample_ratio and fea_sample_ratio items introduce data and feature sampling respectively. In addition, the PS-SMART algorithm uses histograms to show similarity. When multiple workers run in a cluster in distributed mode, local sketches are merged to global sketches in a random order. Although different merging orders result in different tree structures, this does not introduce too much variation to the output model. Therefore, it is normal situation to obtain different results after the algorithm runs multiple times with the same data and same parameter settings.

> **Note**
>
> - The target column in a PS-SMART binary classification model supports only numerical values (0 for negative samples and 1 for positive samples). Even if values in the MaxCompute table are strings, they are saved as numerical values. If the classification target is a type string similar to **Good** or **Bad**, convert it to 1 or 0.
> - In the key-value format, feature IDs must be positive integers, and feature values must be real numbers. If feature IDs are strings, use the serialization component to serialize them. If the feature values are classification type strings, perform feature engineering, such as discretization.

4.4.6.2. Multiclass classification

4.4.6.2.1. KNN

The KNN algorithm is used to resolve classification issues. For a row in the prediction table, this component selects K entries nearest to the row from the training table. It then assigns the row to the class that is most common among the K entries.

PAI command

```
PAI -name knn
  -DtrainTableName=pai_knn_test_input
  -DtrainFeatureColNames=f0,f1
  -DtrainLabelColName=class
  -DpredictTableName=pai_knn_test_input
  -DpredictFeatureColNames=f0,f1
  -DoutputTableName=pai_knn_test_output
  -Dk=2;
```

Parameters

Parameter	Description	Valid value	Default value
trainTableName	Required. The name of the training table.	Table name	N/A
trainFeatureColNames	Required. The names of feature columns selected from the training table.	Column name	N/A
trainLabelColName	Required. The name of the label column selected from the training table.	Column name	N/A
trainTablePartitions	Optional. The partitions selected from the training table.	Partition name	All partitions are selected by default.
predictTableName	Required. The name of the prediction table.	Table name	N/A
outputTableName	Required. The name of the output table.	Table name	N/A
predictFeatureColNames	Optional. The names of feature columns selected from the prediction table.	Column name	N/A
predictTablePartitions	Optional. The partitions selected from the prediction table.	Partition name	All partitions are selected by default.
appendColNames	Optional. The names of columns appended to the output table from the prediction table.	Column name	N/A

Parameter	Description	Valid value	Default value
outputTablePartition	Optional. The partitions in the output table.	Partition name	The output table is non-partitioned by default.
k	Optional. The number of the nearest neighbors.	A positive integer in the range of [1, 1000]	100
enableSparse	Optional. This parameter specifies whether the data in the input table is in sparse format.	true and false	false
itemDelimiter	Optional. The delimiter used to separate key-value pairs when the data in the input table is in sparse format.	Symbol	The default delimiter is a space.
kvDelimiter	Optional. The delimiter used to separate keys and values when the data in the input table is in sparse format.	Symbol	The default delimiter is a colon (:).
coreNum	Optional. The number of cores.	This parameter is used with memSizePerCore. The value must be a positive integer in the range of [1, 20000].	Automatically calculated.
memSizePerCore	Optional. The memory size of each core. Unit: MB.	A positive integer in the range of [1024, 65536]	Automatically calculated.
lifecycle	Optional. The lifecycle of the output table.	A positive integer	No lifecycle is set by default.

Examples

- **Test data**

```
create table pai_knn_test_input as
select * from
(
 select 1 as f0,2 as f1, 'good' as class from dual
 union all
 select 1 as f0,3 as f1, 'good' as class from dual
 union all
 select 1 as f0,4 as f1, 'bad' as class from dual
 union all
 select 0 as f0,3 as f1, 'good' as class from dual
 union all
 select 0 as f0,4 as f1, 'bad' as class from dual
)tmp;
```

- PAI command

```
PAI -name knn
  -DtrainTableName=pai_knn_test_input
  -DtrainFeatureColNames=f0,f1
  -DtrainLabelColName=class
  -DpredictTableName=pai_knn_test_input
  -DpredictFeatureColNames=f0,f1
  -DoutputTableName=pai_knn_test_output
  -Dk=2;
```

- Output description

f0	f1	prediction_result	prediction_score	prediction_detail
1	4	bad	1.0	{"bad": 1}
0	4	bad	1.0	{"bad": 1}
0	3	bad	0.5	{ "bad": 0.5, "good": 0.5}
1	3	good	1.0	{"good": 1}
1	2	good	1.0	{"good": 1}

  - f0 and f1: the appended columns in the output table.
  - prediction_result: the classification result.
  - prediction_score: the probabilities for the classification result.
  - prediction_detail: the latest K conclusions and their probabilities.

4.4.6.2.2. Logistic regression for multiclass classification

Logistic regression of Apsara Stack Machine Learning Platform for AI supports multiclass classification. The logistic regression component supports two data formats: sparse and dense.

Parameter settings

Parameters

Parameter	Description
Regularization Type	Optional. The type of regularization. Valid values: *L1*, *L2*, and *None*. Default value: *L1*.
Max Iterations	Optional. The maximum number of L-BFGS iterations. Default value: 100.
Regularization Coefficient	Optional. The regularization coefficient. Default value: 1.0. If regularizedType is set to *None,* this parameter is ignored.
Minimum Convergence Deviance	Optional. The condition to terminate L-BFGS. This is the log-likelihood deviance between two iterations. Default value: *1.0e-06*.

The logistic regression component outputs a model, which is available in the model list.

Model naming format: `Experiment Name + "-" + Component Name + "model"` .

PAI command (F/L setup settings are not used)

```
PAI –name LogisticRegression
–project algo_public
-DmodelName="xlab_m_logistic_regression_6096"
-DregularizedLevel="1"
-DmaxIter="100"
-DregularizedType="l1"
-Depsilon="0.000001"
-DlabelColName="y"
-DfeatureColNames="pdays,emp_var_rate"
-DgoodValue="1"
-DinputTableName="bank_data";
```

Parameters

Parameter	Description
name	The name of the component.
project	The name of the project. This parameter is used to specify the workspace of the algorithm. The default value is algo_public. If you change the name, the system reports an error.
modelName	The name of the output model.

Parameter	Description
regularizedLevel	Optional. The regularization coefficient. Default value: 1.0. If regularizedType is set to *None* , this parameter is ignored.
maxIter	Optional. The maximum number of L-BFGS iterations. Default value: 100.
regularizedType	Optional. The type of regularization. Valid values: *L1*, *L2*, and *None*. Default value: *L1*.
epsilon	Optional. The convergence deviation. It is the condition to terminate L-BFGS. This is the loglikelihood deviation between two iterations. Default value: *1.0e-06*.
labelColName	The name of the label column selected from the input table.
featureColNames	The names of feature columns selected from the input table for training.
goodValue	Optional. The base value. For multiclass classification, specify the label value of the training coefficient. If this parameter is not specified, the system randomly selects a value.
inputTableName	The name of the input table for training.

4.4.6.2.3. Random forest

A random forest is a classifier that contains multiple decision trees. Its output class is decided by the mode of individual tree output classes.

Procedure

1. Drag and drop the Random Forest component onto the canvas and select columns.

Parameters

Parameter	Description
Feature Columns	Optional. All columns except the label and weight columns are selected by default.
Excluded Columns	Optional. This parameter is used to exclude specified columns from training. This parameter is mutually exclusive with featureColNames.
Columns Forced to Convert	Optional. The default feature parsing rules are as follows: ◦ Parse columns of string, boolean, and datetime types to discrete columns. ◦ Parse columns of double and bigint types to contiguous columns. ◦ Set the *forceCategorical* parameter to parse bigint type columns to categorical columns.
Weight Columns	Optional. You can select all columns except the input and label columns. The double and bigint types are supported.

Parameter	Description
Label Column	You can select all columns except the input column. The bigint, double, and string types are supported.

2. Set the parameters of the Random Forest component.

Parameters

Parameter	Description
Trees	The number of trees in the forest. Valid values: (0, 1000).
Single-tree Algorithm Type	Optional. The algorithm type of each tree in the forest. Valid values: id3, c4.5, and cart. If the forest has n trees and the condition is **algorithmTypes = a,b** , then **[0,a)** indicates **id3** , **[a,b)** indicates **cart** , and **[b,n)** indicates **c4.5** . If this parameter is set to [2, 4] for a forest with five trees, [0, 1) indicates the ID3 algorithm, [2, 3) indicates the CART algorithm, and 4 indicates the C4.5 algorithm. If the value is None, the algorithms are evenly allocated across the forest.
Random Features per Tree	The number of features selected randomly. Valid values: 1 to N. N indicates the number of features.
Minimum Samples per Leaf Node	Optional. The minimum number of samples per leaf node. The value must be a positive integer no less than 2.
Minimum Fraction of Samples on Leaf Node to Samples on Parent Node	The minimum fraction of samples on a leaf node to samples on a parent node. A value of -1 indicates that no limit is set. Default value: -1. Valid values: [0, 1].
Maximum Tree Depth	The maximum depth of a tree. -1 indicates a completely grown tree. Valid values: [1, ∞).
Random Samples Input per Tree	The number of random samples input per tree. Valid values: (1000, 1000000].

Note

- With improvement of the bagging method, the Random Forest component builds a forest without correlated trees in the big cube. Random forests are similar to the boosting method in many aspects, particularly their training processes.
- For the growth of a single tree, this method provides the id3, cart, and c4.5 options. The treeNum parameter is used to specify the number of trees in the forest, in the range of [1, 1000]. The structure of a single tree can be controlled based on the edited template. You can use other parameters to specify the minimum number of samples per leaf node, the minimum fraction of samples on a leaf node to samples on a parent node, and the maximum depth of a tree.
- Each row in the weight column corresponds to a sample and indicates the proportion of this sample in training. If the age column is selected as the weight column, the sample in the row with a higher weight value in the age column has a higher proportion during the training.
- The "input table is empty!" error may occur in the following situations: The sampling fraction is too small, which means that the value of maxRecordSize is too small, or the input table is empty.

PAI command (F/L setup settings are not used)

```
PAI –name RandomForests
–project algo_public
-DmodelName="xlab_m_random_forests_6036"
-DrandomColNum="1.0"
-DlabelColName="campaign"
-DmaxTreeDeep="10"
-DmaxRecordSize="100000"
-DfeatureColNames="age,pdays,previous,emp_var_rate,cons_price_idx,cons_conf_idx,euribor3m,nr_employed"
-DisFeatureContinuous="1,1,1,1,1,1,1,1"
-DminNumPer="-1"
-DminNumObj="2"
-DinputTableName="bank_data"
-DweightColName="y"
-DtreeNum="10";
```

Parameters

Parameter	Description
name	The name of the component.

Parameter	Description
project	The name of the project. This parameter is used to specify the workspace of the algorithm. The default value is algo_public. If you change the name, the system reports an error.
modelName	The name of the output model.
randomColNum	Optional. The random attribute type. This parameter specifies the number of features randomly selected each time a single tree is generated. *-1* indicates `log2N`. Valid values: 1 to N. N indicates the number of features.
labelColName	The name of the label column selected from the input table.
maxTreeDeep	Optional. The maximum depth of a tree. *-1* indicates a completely grown tree. Valid values: [1, ∞].
maxRecordSize	Optional. The maximum number of samples per tree. Valid values: (1000, 1000000). *-1* indicates 100000.
featureColNames	The names of feature columns selected from the input table for training.
isFeatureContinuous	Specifies whether the feature for subsequent columns is continuous or discrete. *1* indicates that the feature column data is continuous, while *0* indicates that the feature column data is discrete. *1,0,0* indicates that values are continuous in the first feature column and discrete in the second and third feature columns. The number of values corresponds to the feature length.
minNumPer	Optional. The minimum fraction of samples on a leaf node to samples on a parent node. A value of *-1* indicates that no limit is set. Valid values: [0.0, 1.0].
minNumObj	Optional. The minimum number of samples per leaf node.
inputTableName	The name of the input table for training.
weightColName	Optional. The name of the weight column selected from the input table. If there is no weight column, set this parameter to *None*. If there is any weight column, the value of weightColName is greater than 0.
treeNum	The number of trees. Valid values: (0, 1000).

4.4.6.2.4. Naive Bayes

Naive Bayes classifier is a simple probabilistic classifier based on applying Bayes theorem with strong independence assumptions between the features. A probabilistic model that can more accurately describe this potential is called an independent feature model.

Component description

Component parameter settings (For more information, see the description of the Random Forest component.)

PAI command

```
PAI –name NaiveBayes
–project algo_public
-DmodelName="xlab_m_NaiveBayes_23772"
-DinputTablePartitions="pt=20150501"
-DlabelColName="poutcome"
-DfeatureColNames="age,previous,cons_conf_idx,euribor3m"
-DisFeatureContinuous="1,1,1,1"
-DinputTableName="bank_data_partition";
```

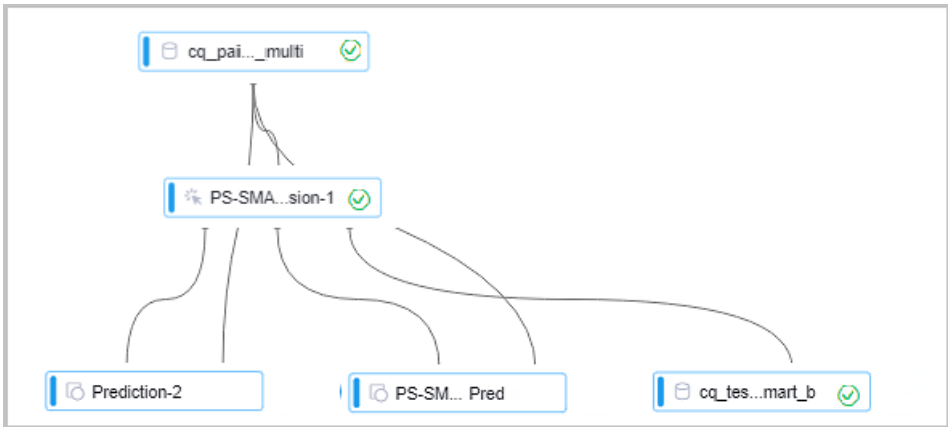
Parameters

Parameter	Description
name	The name of the component.
project	The name of the project. This parameter is used to specify the workspace of the algorithm. The default value is algo_public. If you change the name, the system reports an error.
modelName	The name of the model generated by training.
inputTablePartitions	Optional. The partitions selected from the input prediction table. If no partitions are specified, the entire table is selected.
labelColName	The name of the label column selected from the input table.
featureColNames	The names of feature columns selected from the input table for training.
isFeatureContinuous	Specifies whether the feature for subsequent columns is continuous or discrete. *1* indicates that the feature column data is continuous, while *0* indicates that the feature column data is discrete. *1,0,0* indicates that values are continuous in the first feature column and discrete in the second and third feature columns. The number of values corresponds to the feature length.
inputTableName	The name of the input table.

4.4.6.2.5. PS-SMART multiclass classification

A parameter server (PS) is used to train a large number of models online and offline. Scalable Multiple Additive Regression Tree (SMART) is an implementation of Gradient Boosting Decision Tree (GBDT) on PS. PS-SMART can run training tasks containing up to tens of billions of samples and hundreds of thousands of features on thousands of nodes. It also supports failover for high stability. PS-SMART supports various data formats, training targets, evaluation targets, output feature importance, and histogram approximation for training acceleration.

Quick start



As shown in the figure, a PS-SMART multiclass classification model is learned based on training data. The model has three output ports:

- Output model: offline model, which is connected to the unified prediction component. This model does not support the output of leaf node numbers.
- Output model table: a binary table that is not readable and is used to support the PS-SMART prediction component. The table provides outputs such as leaf node numbers and assessment metrics. However, the output table has strict requirements on data formats, which negatively affects user experience. This component is being continually improved, and may be replaced by another component in the future.
- Output feature importance table: lists the importance of each feature. Three importance types are supported. For more information, see Parameters.

PAI command

- Training

```
PAI -name ps_smart
  -project algo_public
  -DinputTableName="smart_multiclass_input"
  -DmodelName="xlab_m_pai_ps_smart_bi_545859_v0"
  -DoutputTableName="pai_temp_24515_545859_2"
  -DoutputImportanceTableName="pai_temp_24515_545859_3"
  -DlabelColName="label"
  -DfeatureColNames="features"
  -DenableSparse="true"
  -Dobjective="multi:softprob"
  -Dmetric="mlogloss"
  -DfeatureImportanceType="gain"
  -DtreeCount="5";
  -DmaxDepth="5"
  -Dshrinkage="0.3"
  -Dl2="1.0"
  -Dl1="0"
  -Dlifecycle="3"
  -DsketchEps="0.03"
  -DsampleRatio="1.0"
  -DfeatureRatio="1.0"
  -DbaseScore="0.5"
  -DminSplitLoss="0"
```

- Prediction

```
PAI -name prediction
  -project algo_public
  -DinputTableName="smart_multiclass_input";
  -DmodelName="xlab_m_pai_ps_smart_bi_545859_v0"
  -DoutputTableName="pai_temp_24515_545860_1"
  -DfeatureColNames="features"
  -DappendColNames="label,features"
  -DenableSparse="true"
  -DkvDelimiter=":"
  -Dlifecycle="28"
```

Parameters

- Data parameters

Command option	Parameter	Description	Valid values	Remarks
featureColNames	Feature Column	The names of feature columns selected from the input table for training.	If the column name is in dense format, it must be of the bigint or double type. If the column name is in sparse KV format, it must be a string, and its keys and values must be numeric.	Required
labelColName	Label Column	The name of the label column selected from the input table.	The column name can be of either string or numeric type, but only numeric data can be stored in the columns. For multiclass classification, column values can be 0, 1, 2, ..., n-1, where n is the number of classes.	Required
weightCol	Weight Column	This column specifies the weight of each sample.	The column name can be of the numeric type.	Optional. Default value: null.
enableSparse	Use Sparse Format	This parameter specifies whether the data in the input table is in sparse format, in which key-value pairs are separated by spaces whereas keys and values are separated by colons (:), for example, **1:0.3 3:0.9**.	true, false	Optional. Default value: false.
inputTableName	Input Table Name	N/A	N/A	Required
modelName	Output Model Name	N/A	N/A	Required

Command option	Parameter	Description	Valid values	Remarks
outputImportanceTableName	Output Feature Importance Table Name	N/A	N/A	Optional. Default value: null.
inputTablePartitions	Input Table Partitions	N/A	N/A	Optional. The parameter value must be in ds=1/pt=1 format.
outputTableName	Output Model Table	The output table is a MaxCompute table that uses the binary format and is not readable. The prediction component that comes with SMART can be used to generate leaf node numbers.	String	Optional
lifecycle	Output Table Lifecycle	N/A	Positive integer	Optional. Default value: 3.

- Algorithm parameters

Command option	Parameter	Description	Valid values	Remarks
classNum	Classes	The number of classes in multiclass classification. If the number of classes is n, the label column name can be 0, 1, 2, ..., or n-1.	A non-negative integer, greater than or equal to 3.	Required
objective	Objective Function Type	The objective function type affects learning and must be selected properly. Set it to **multi:softprob** for multiclass classification.	N/A	Required

Command option	Parameter	Description	Valid values	Remarks
metric	Evaluation Indicator Type	Evaluation indicators in the training set, which are exported to stdout of the coordinator in a logview.	**mloglossmerror**	Optional. Default value: null.
treeCount	Trees	The number of trees. The training time is proportional to this number.	Positive integer	Optional. Default value: 1.
maxDepth	Maximum Decision Tree Depth	The maximum depth of a tree. We recommend that you set this value to 5, which means the tree can contain up to 32 leaf nodes.	A positive integer in the range of [1, 20].	Optional. Default value: 5.
sampleRatio	Data Sampling Fraction	The data sampling rate when trees are built. The sample data is used to build a weak learner to accelerate training.	(0, 1]	Optional. The default value is 1.0, which means data sampling is disabled.
featureRatio	Feature Sampling Fraction	The feature sampling rate when trees are built. The sample features are used to build a weak learner to accelerate training.	(0, 1]	Optional. The default value is 1.0, which means feature sampling is disabled.

Command option	Parameter	Description	Valid values	Remarks
l1	L1 Penalty Coefficient	This parameter determines the number of leaf nodes. The greater the value, the fewer the leaf nodes. You can set this parameter to a greater value if overfitting occurs.	Non-negative real number	Optional. Default value: 0.
l2	L2 Penalty Coefficient	This parameter determines the size of a leaf node. The greater the value, the more evenly the leaf nodes are distributed. You can set this parameter to a greater value if overfitting occurs.	Non-negative real number	Optional. Default value: 1.0.
shrinkage	Learning Rate	N/A	(0, 1]	Optional. Default value: 0.3.
sketchEps	Sketch-based Approximate Precision	The threshold for selecting quantiles when you build a sketch. The number of buckets is O(1.0/sketchEps). The smaller the parameter value, the more buckets are generated. Typically, you do not need to modify this value.	(0, 1)	Optional. Default value: 0.03.
minSplitLoss	Minimum Split Loss	The minimum split loss changes required for splitting a node. The greater the value, the more conservatively the node splits.	Non-negative real number	Optional. Default value: 0.

Command option	Parameter	Description	Valid values	Remarks
featureNum	Features	The number of features or the maximum feature ID. Specify this parameter for resource usage estimation.	Positive integer	Optional
baseScore	Global Offset	Original predicted values of all samples.	Real number	Optional. Default value: 0.5.
featureImportanceType	Feature Importance Type	The type of feature importance. **weight** indicates the number of times that a feature splits. **gain** indicates information gain brought by the feature. **cover** indicates the number of samples that the feature covers on the splitting nodes.	**weight**, **gain**, and **cover**	Optional. Default value: **gain**.

- Note
  - Specify different values for the objective parameter in different learning models. On the multiclass classification Web GUI, the objective function is automatically specified and invisible to users. On the command line, set the objective parameter to `multi:softprob`.
  - Mappings between metrics and objective functions are: **mlogloss** for **multiclass negative log likelihood**, and **merror** for **multiclass classification error**.
- Execution optimization

Command option	Parameter	Description	Valid values	Remarks
coreNum	Cores	The number of cores. The greater the value, the faster the computing algorithm runs.	Positive integer	Optional. Automatically calculated.

Command option	Parameter	Description	Valid values	Remarks
memSizePerCore	Memory Size per Core (MB)	The memory size of each core, where 1024 represents 1 GB of memory.	Positive integer	Optional. Automatically calculated.

Example

- Data generation

  The following example uses data in sparse KV format.

```
drop table if exists smart_multiclass_input;
create table smart_multiclass_input lifecycle 3 as
select
*
from
(
select 2 as label, '1:0.55 2:-0.15 3:0.82 4:-0.99 5:0.17' as features from dual
  union all
select 1 as label, '1:-1.26 2:1.36 3:-0.13 4:-2.82 5:-0.41' as features from dual
  union all
select 1 as label, '1:-0.77 2:0.91 3:-0.23 4:-4.46 5:0.91' as features from dual
  union all
select 2 as label, '1:0.86 2:-0.22 3:-0.46 4:0.08 5:-0.60' as features from dual
  union all
select 1 as label, '1:-0.76 2:0.89 3:1.02 4:-0.78 5:-0.86' as features from dual
  union all
select 1 as label, '1:2.22 2:-0.46 3:0.49 4:0.31 5:-1.84' as features from dual
  union all
select 0 as label, '1:-1.21 2:0.09 3:0.23 4:2.04 5:0.30' as features from dual
  union all
select 1 as label, '1:2.17 2:-0.45 3:-1.22 4:-0.48 5:-1.41' as features from dual
  union all
select 0 as label, '1:-0.40 2:0.63 3:0.56 4:0.74 5:-1.44' as features from dual
  union all
select 1 as label, '1:0.17 2:0.49 3:-1.50 4:-2.20 5:-0.35' as features from dual
) tmp;
```

  The data has five dimensions of features.

- Training

Configure the training data and training components, as shown in Quick start. Select the label column as the target column and the features column as the feature column.

- You do not need to set the number of features because this number is calculated automatically by the algorithm. If you have a large number of features and want the algorithm to accurately estimate required resources, specify the actual number of features.
- To accelerate the training, set the number of cores on the execution optimization page. The greater the number, the faster the algorithm runs. Typically, you do not need to enter the memory size per core because the algorithm can accurately calculate the memory size. The PS algorithm starts to run only when all hosts have obtained the required resources. Therefore, you may need to wait for a longer time when the cluster is busy and resources are requested in large volumes.
- You can view the output values of the metrics in the stdout of the coordinator in a logview (HTTP link starting with http://logview.odps.aliyun-inc.com:8080/logview). A single PS-SMART training job can contain multiple tasks, which creates multiple logviews. Select the logview whose name starts with PS to view the output of the PS job.

Then, perform operations in the logview.

- Prediction
  - Use the unified prediction component

    The model generated after training is saved in binary format and can be used for prediction. Configure the input model and test data for the prediction component, as shown in Quick start.

    If the dense format is used, you only need to select feature columns. (All columns are selected by default, and extra columns do not affect the prediction.) If the KV format is used, set the data format to sparse format and select the correct delimiter. In the SMART model, key-value pairs are separated with spaces. Therefore, the delimiter must be set to space or **\u0020** (escape expression of spaces).

    In the **prediction_detail**column, values 0, 1, and 2 indicate classes, and the values following them indicate probabilities of the corresponding classes. The **predict_result** column lists the selected classes with the highest probability, and the **predict_score** column lists the probability of each selected class.

- Use the PS-SMART prediction component

  The output model table obtained after training is saved in binary format and can be used by the PS-SMART prediction component for prediction. Configure the input model and test data for the prediction component, as shown in Quick start. Set the required parameters, including the data format, feature columns, target column, and number of classes. The ID column can only be a string type column other than a feature column or a target column. The loss function must be explicitly set to **multi:softprob**.

  The **score_class_k** columns list probabilities of class k. The class with the highest probability is the predicted class. The **leaf_index** column lists the predicted leaf node numbers. Each sample has N × M numbers, where N is the number of decision trees, and M is the number of classes. In this example, each sample has 15 numbers (5 × 3 = 15). Each tree is mapped to a number, which indicates the leaf node number of the sample on this tree.

  > **Note**
  >
  > - The output model table is a binary table that is not readable and is used to support the PS-SMART prediction component. The table provides outputs such as leaf node numbers and evaluation indicators. However, the output table has strict requirements on data formats, which negatively affects user experience. This component is being continually improved, and may be replaced by another component in the future.
  > - A string type column must be selected as the label column. You can enter strings in the column but cannot be blank or NULL. A feature column can be converted to the string type by using the data type conversion component.
  > - The loss function must be explicitly set to **multi:softprob**. By default, the loss function does not work.

- View feature importance

  To view feature importance, you can export the third output port to an output table, or right-click **PS-SMART training component** and choose **View Data > Output Feature Importance Table** from the shortcut menu.The following figure shows the output feature importance table.

order	id	value
1	1	0.276059627532959
2	3	0.20854459702968597
3	4	0.31002077460289
4	5	0.20537501573562622

  In the table, the ID column lists the numbers of input features. In this example, the data is in KV format, and the IDs represent keys in key-value pairs. If the dense format is used and input features are **f0,f1,f2,f3,f4,f5**, ID 0 represents f0 and ID 4 represents f4. Each value indicates a feature importance type. The default value is **gain**, indicating the sum of information gains brought by a feature in the model. The preceding figure shows only four features because only these four features are used during the tree split process. In this case, the importance of unused features is 0.

FAQ

- Q: Does PS_SMART support non-numerical features and tags?
- A: No.
- Q: What is the scale of features supported by PS-SMART? Can we use large-scale 0-1 features?

- A: Although PS-SMART supports tasks that contain hundreds of thousands of features, such tasks consume large amounts of resources and run slowly. Therefore, we recommend that you do not use a large number of features. The GBDT algorithm is suitable for training with continuous features. The categorical features require one-hot coding (to filter out infrequent features) before they can be used for training. The continuous numerical features can be used for training with the GBDT algorithm directly. Discretization is not recommended for numerical features.
- Q: Why is the result different every time although the SMART algorithm has the same data and the same parameter settings?
- A: The PS-SMART algorithm applies randomness in many scenarios. For example, the data_sample_ratio and fea_sample_ratio items introduce data and feature sampling respectively. In addition, the PS-SMART algorithm uses histograms to show similarity. When multiple workers run in a cluster in distributed mode, local sketches are merged to global sketches in a random order. Although different merging orders result in different tree structures, this does not introduce too much variation to the output model. Therefore, it is normal situation to obtain different results after the algorithm runs multiple times with the same data and same parameter settings.

> Note
>
> - The target column in a PS-SMART multiclass classification model supports only positive integer IDs (class numbers are 0, 1, 2, ..., n-1, where n is the number of classes). Even if the values in the MaxCompute table are strings, they are saved as numerical values. If the classification target is a type string similar to **Good**, **Medium**, or **Bad**, convert it into a numeric value (0, 1, 2, ..., n-1).
> - In the key-value format, feature IDs must be positive integers, and feature values must be real numbers. If feature IDs are strings, use the serialization component to serialize them. If the feature values are classification type strings, perform feature engineering, such as discretization.

4.4.6.3. K-means clustering

K-means clustering is a widely used algorithm that is used to divide n objects into k clusters while maintaining high similarity within each cluster. Similarity is calculated based on the average value of objects in a cluster. This algorithm is similar to the expectation maximization algorithm for calculating mixed normality distribution, as both algorithms try to find the natural clustering center in data. K-means clustering randomly selects k objects. Each object represents the average value or center of a cluster. Based on its distance from each cluster center, each remaining object is then assigned to the nearest cluster and the average value of each cluster is re-calculated. This process is repeated until the criterion function converges. This algorithm assumes that object properties are from the spatial vector. Its objective is to minimize the sum of the mean square deviance inside each group.

Parameter settings

Parameters

Parameter	Description
Clusters	The number of clusters. Default value: 10.

Parameter	Description
Distance Measurement Method	Valid values: *euclidean*, *cityblock* (the sum of absolute deviations), and *cosine*. Default value: euclidean.
Initial Centroid Location	Valid values: *sample* (randomly selected), *topk* (first K rows), *uniform* (evenly distributed and randomly generated), *matrix* (an initial centroid table must be specified), and *kmpp* (k-means++ initialization). Default value: sample.
Maximum Iterations	The maximum number of iterations. Default value: 100.
Minimum Iteration Precision	The minimum iteration precision. Default value: 0.0.

Procedure

1. After running the K-means Clustering component, you can view the cluster center table.

   Cluster center table: The number of columns in this table is equal to the total number of columns selected from the input table. The number of rows is equal to the number of clusters, with each row representing a cluster center location.

2. Right-click the target table and choose **View Data** to view the cluster index table (idxTablename).
   - Cluster index table: The number of rows is equal to the total number of rows in the input table. The value in each row represents the cluster index of the point in the corresponding row of the input table.
   - The names of all columns are displayed. A classification marking column is appended to the table.
   - 0, 1, 2, 3 are classification IDs.
   - You can also use the table name generated by PAI command to view the cluster center table, cluster index table, and cluster count table in IDE.

Note If *matrix* is selected as the initial centroid location, you must define the initial centroid table, with the same columns as the original table. The number of rows is the same as the number of clusters. When you prepare the table, configure k centers and use SQL or MapReduce for sampling, or select another method based on your requirements.

PAI command

```
PAI –name KMeans
–project algo_public
-DcenterCount="10"
-DidxTableName="bank_data_index"
-DdistanceType="euclidean"
-DappendColsIndex="0,1,2,3,4,5,6,7,8,9,10"
-DcenterTableName="pai_temp_3300_27298_3"
-Dloop="100"
-DclusterCountTableName="pai_temp_3300_27298_2"
-DinitCentersMethod="sample"
-Daccuracy="0.0"
-DinputTableName="bank_data"
-DselectedColNames="cons_conf_idx,emp_var_rate,euribor3m,pdays,previous";
```

Parameters

Parameter	Description
name	The name of the component.
project	The name of the project. This parameter is used to specify the workspace of the algorithm. The default value is algo_public. If you change the name, the system reports an error.
centerCount	The number of clusters. The value must be an integer. Default value: 10.
idxTableName	The name of the output cluster index table. The number of rows is equal to the total number of rows in the input table. The value in each row represents the cluster index of the point in the corresponding row of the input table.
distanceType	Optional. The method used to measure the distance. Valid values: euclidean, cityblock, and cosine. Default value: euclidean.
appendColsIndex	Optional. The name of the ID column appended to the output table. No ID column is appended to the output table by default.
centerTableName	The name of the output cluster center table. The number of columns in this table is equal to the total number of columns selected from the input table. The number of rows is equal to the number of clusters, with each row representing a cluster center location.
loop	Optional. The maximum number of iterations. The value must be an integer. Default value: 100.
clusterCountTableName	The name of the cluster point count table. The number of rows is equal to the number of clusters, which indicates the total number of cluster points in the class in each clustering centroid row.

Parameter	Description
initCentersMethod	Optional. The method used to determine the initial centroid location. The options include sample (randomly selected), topk (first K rows), uniform (evenly distributed and randomly generated), matrix (an initial centroid table must be specified), and kmpp (k-means++ initialization). Default value: sample.
accuracy	The minimum iteration precision. Default value: 0.0.
inputTableName	The name of the input table.
selectedColNames	The names of columns selected from the input table, which are separated with commas (,). Only double type is supported.
initCenterTableName	Optional. The name of the table that stores the initial center values. This table is not required unless initCentersMethod is set to *matrix*.

4.4.6.4. Regression

4.4.6.4.1. GBDT regression

Gradient boosting decision tree (GBDT) is an iterative decision tree algorithm based on multiple decision trees. The final output is the sum of conclusions of all trees. GBDT can be applied to almost all regression models (linear or nonlinear) and has a wider scope of application than logistic regression that is only applicable to linear regression.

For more information, see A Regression Framework for Learning Ranking Functions Using Relative Relevance Judgments. For more information, see GBDT binary classification.

PAI command

```
PAI -name gbdt
-project algo_public
-DfeatureSplitValueMaxSize="500"
-DlossType="0"
-DrandSeed="0"
-DnewtonStep="0"
-Dshrinkage="0.05"
-DmaxLeafCount="32"
-DlabelColName="campaign"
-DinputTableName="bank_data_partition"
-DminLeafSampleCount="500"
-DsampleRatio="0.6"
-DgroupIDColName="age"
-DmaxDepth="11"
-DmodelName="xlab_m_GBDT_83602"
-DmetricType="2"
-DfeatureRatio="0.6"
-DinputTablePartitions="pt=20150501"
-Dtau="0.6"
-Dp="1"
-DtestRatio="0.0"
-DfeatureColNames="previous,cons_conf_idx,euribor3m"
-DtreeCount="500"
```

Parameters

Parameter	Description	Valid values	Default value
inputTableName	Required. The name of the input table.	Table name	-
featureColNames	Optional. The names of feature columns selected from the input table for training.	Column name	All columns are selected by default.
labelColName	Optional. The name of the label column selected from the input table.	Column name	-

Parameter	Description	Valid values	Default value
inputTablePartitions	Optional. The partitions selected from the input table for training, in the format of `partition_name=value`. To specify multiple partitions, use the following format: `name1=value1/name2=value2`. Separate multiple partitions with commas (,).	-	All partitions are selected by default.
modelName	Required. The name of the output model.	-	-
outputImportanceTableName	Optional. The name of the output feature importance table.	-	-
groupIDColName	Optional. The name of the stratification column.	Column name	The whole table is selected by default.
lossType	Optional. The loss function type. The function types include *0: GBRANK*, *1:LAMBDAMART_DCG*, *2: LAMBDAMART_NDCG*, *3: LEAST_SQUARE*, and *4: LOG_LIKELIHOOD*.	0, 1, 2, 3, and 4	0
metricType	Optional. The type of metrics. *0(NDCG)* indicates the normalized discounted cumulative gain, *1 (DCG)* indicates the discounted cumulative gain, and *2 (AUC)* is applicable only to 0/1 label.	0, 1, and 2	2
treeCount	Optional. The number of trees.	[1, 10000]	500
shrinkage	Optional. The learning rate.	(0, 1]	0.05

Parameter	Description	Valid values	Default value
maxLeafCount	Optional. The maximum number of leaves. This value must be an integer.	[2, 1000]	32
maxDepth	Optional. The maximum depth of a tree. This value must be an integer.	[1, 11]	11
minLeafSampleCount	Optional. The minimum number of samples on a leaf node. This value must be an integer.	[100, 1000]	500
sampleRatio	Optional. The fraction of training samples.	(0, 1]	0.6
featureRatio	Optional. The fraction of training features.	(0, 1]	0.6
tau	Optional. The Tau parameter in gbrank loss.	[0, 1]	0.6
p	Optional. The p parameter in gbrank loss.	[1, 10]	1
randSeed	Optional. The random seed.	[0, 10]	0
newtonStep	Optional. This parameter specifies whether to use the Newton method.	0 and 1	1
featureSplitValueMaxSize	Optional. The maximum number of splits per feature.	[1, 1000]	500
lifecycle	Optional. The lifecycle of the output table.	-	No lifecycle is set by default.

Examples

SQL statement to generate data:

```
drop table if exists gbdt_ls_test_input;
create table gbdt_ls_test_input as select    * from (
select      cast(1 as double) as f0,
cast(0 as double) as f1,
cast(0 as double) as f2,
cast(0 as double) as f3,
cast(0 as bigint) as label    from dual    union all
select        cast(0 as double) as f0,
cast(1 as double) as f1,
cast(0 as double) as f2,
cast(0 as double) as f3,
cast(0 as bigint) as label    from dual    union all
select        cast(0 as double) as f0,
cast(0 as double) as f1,
cast(1 as double) as f2,
cast(0 as double) as f3,
cast(1 as bigint) as label    from dual    union all
select        cast(0 as double) as f0,
cast(0 as double) as f1,
cast(0 as double) as f2,
cast(1 as double) as f3,
cast(1 as bigint) as label    from dual    union all
select        cast(1 as double) as f0,
cast(0 as double) as f1,
cast(0 as double) as f2,
cast(0 as double) as f3,
cast(0 as bigint) as label    from dual    union all
select        cast(0 as double) as f0,
cast(1 as double) as f1,
cast(0 as double) as f2,
cast(0 as double) as f3,
cast(0 as bigint) as label    from dual ) a;
```

PAI command

- Training:

```
drop offlinemodel if exists gbdt_ls_test_model;
PAI -name gbdt
-project algo_public
-DfeatureSplitValueMaxSize="500"
-DlossType="3"
-DrandSeed="0"
-DnewtonStep="1"
-Dshrinkage="0.5"
-DmaxLeafCount="32"
-DlabelColName="label"
-DinputTableName="gbdt_ls_test_input"
-DminLeafSampleCount="1"
-DsampleRatio="1"
-DmaxDepth="10"
-DmetricType="0"
-DmodelName="gbdt_ls_test_model"
-DfeatureRatio="1"
-Dp="1"
-Dtau="0.6"
-DtestRatio="0"
-DfeatureColNames="f0,f1,f2,f3"
-DtreeCount="10"
```

- Prediction:

```
drop table if exists gbdt_ls_test_prediction_result;
PAI -name prediction
-project algo_public
-DdetailColName="prediction_detail"
-DmodelName="gbdt_ls_test_model"
-DitemDelimiter=","
-DresultColName="prediction_result"
-Dlifecycle="28"
-DoutputTableName="gbdt_ls_test_prediction_result"
-DscoreColName="prediction_score"
-DkvDelimiter=":"
-DinputTableName="gbdt_ls_test_input"
-DenableSparse="false"
-DappendColNames="label"
```

Input description

gbdt_ls_test_input

f0	f1	f2	f3	label
1.0	0.0	0.0	0.0	0
0.0	0.0	1.0	0.0	1
0.0	0.0	0.0	1.0	1
0.0	1.0	0.0	0.0	0
1.0	0.0	0.0	0.0	0
0.0	1.0	0.0	0.0	0

Output description

gbdt_ls_test_prediction_result

label	prediction_result	prediction_score	prediction_detail
0	NULL	0.0	{"label": 0}
0	NULL	0.0	{"label": 0}
1	NULL	0.9990234375	{"label": 0.9990234375}
1	NULL	0.9990234375	{"label": 0.9990234375}
0	NULL	0.0	{"label": 0}
0	NULL	0.0	{"label": 0}

4.4.6.4.2. Linear regression

This component is used to resolve regression issues and analyze the linear relationship between a dependent variable and multiple independent variables. Certain columns from an input table are selected as feature columns and one column is selected as the label column for linear regression training and linear regression model generation.

PAI command

```
PAI -name linearregression
  -project algo_public
  -DinputTableName=lm_test_input
  -DfeatureColNames=x
  -DlabelColName=y
  -DmodelName=lm_test_input_model_out;
```

Parameters

Parameter	Description	Valid values	Default value
inputTableName	Required. The name of the input table.	-	-
modelName	Required. The name of the output model.	-	-
outputTableName	Optional. The name of the output model evaluation table.	This parameter must be specified when enableFitGoodness is set to *true*.	-
labelColName	Required. The name of the label column.	The name must be a double or bigint type value. Only one column can be specified.	-
featureColNames	Required. The name of the feature column.	The name must be a double or bigint type value in dense format, or a string type value in sparse format. Multiple columns can be specified.	-
inputTablePartitions	Optional. The partitions selected from the input table for training.	-	No partitions are selected by default.
maxIter	Optional. The maximum number of iterations.	-	100
epsilon	Optional. The minimum likelihood deviance.	-	0.000001
enableSparse	Optional. This parameter specifies whether the data is in sparse format.	true and false	false

Parameter	Description	Valid values	Default value
enableFitGoodness	Optional. This parameter specifies whether to perform model evaluation. Model evaluation can be performed using a variety of metrics, including R-squared, adjusted R-Squared, Akaike information criterion, degrees of freedom, residual standard deviation, and deviation.	true and false	false
enableCoefficientEstimate	Optional. This parameter specifies whether to estimate the regression coefficient. The metrics of this parameter are value t, value p, and confidence interval [2.5%, 97.5%]. This parameter takes effect only when enableFitGoodness is set to *true*. This parameter is ignored when enableFitGoodness is set to *false*.	true and false	false
itemDelimiter	Optional. The delimiter used to separate key-value pairs. This parameter takes effect only when enableSparse is set to *true*.	-	Use spaces on command lines and use commas (,) on webpages.
kvDelimiter	Optional. The delimiter used to separate keys and values. This parameter takes effect only when enableSparse is set to *true*.	-	The default delimiter is a colon (:).
lifecycle	Optional. The lifecycle of the output table.	An integer greater than or equal to -1	Default value: -1. This value indicates that no lifecycle is set.

Parameter	Description	Valid values	Default value
coreNum	Optional. The number of cores.	An integer larger than 0	Default value: -1. This value indicates that the number of instances is determined by the amount of input data.
memSizePerCore	Optional. The memory size of each core.	(100, 65536)	Default value: -1. This value indicates that the memory size is determined by the amount of input data.

Examples

- SQL statement to generate data:

```
drop table if exists lm_test_input;
    create table lm_test_input as
    select
     *
    from
    (
     select 10 as y, 1.84 as x1, 1 as x2, '0:1.84 1:1' as sparsecol1 from dual
      union all
     select 20 as y, 2.13 as x1, 0 as x2, '0:2.13' as sparsecol1 from dual
      union all
     select 30 as y, 3.89 as x1, 0 as x2, '0:3.89' as sparsecol1 from dual
      union all
     select 40 as y, 4.19 as x1, 0 as x2, '0:4.19' as sparsecol1 from dual
      union all
     select 50 as y, 5.76 as x1, 0 as x2, '0:5.76' as sparsecol1 from dual
      union all
     select 60 as y, 6.68 as x1, 2 as x2, '0:6.68 1:2' as sparsecol1 from dual
      union all
     select 70 as y, 7.58 as x1, 0 as x2, '0:7.58' as sparsecol1 from dual
      union all
     select 80 as y, 8.01 as x1, 0 as x2, '0:8.01' as sparsecol1 from dual
      union all
     select 90 as y, 9.02 as x1, 3 as x2, '0:9.02 1:3' as sparsecol1 from dual
      union all
     select 100 as y, 10.56 as x1, 0 as x2, '0:10.56' as sparsecol1 from dual
    ) tmp;
```

- PAI command

```
PAI -name linearregression
  -project algo_public
  -DinputTableName=lm_test_input
  -DlabelColName=y
  -DfeatureColNames=x1,x2
  -DmodelName=lm_test_input_model_out
  -DoutputTableName=lm_test_input_conf_out
  -DenableCoefficientEstimate=true
  -DenableFitGoodness=true
  -Dlifecycle=1;
pai -name prediction
  -project algo_public
  -DmodelName=lm_test_input_model_out
  -DinputTableName=lm_test_input
  -DoutputTableName=lm_test_input_predict_out
  -DappendColNames=y;
```

- Output description:
  - When enableFitGoodness is set to *true*, partitions specified by `p='goodness'` are created in the model evaluation table. The output metrics are *R-squared*, *adjusted R-Squared*, *Akaike information criterion*, *degrees of freedom*, *residual standard deviation*, and *deviation*.
  - When enableCoefficientEstimate is set to *true*, partitions specified by `p='coefficient'` are created in the model evaluation table. The table contains the intercepts and the *name*, *coefficient*, *t-score*, *p-value*, and *confidence interval [2.5%, 97.5%]* of the features.

- Output model evaluation table: lm_test_input_conf_out.

colname	value	tscore	pvalue	confidenceinterval	p
Intercept	-6.423784966877 63	-2.272575595139 0028	0.06	{"2.5%": -11.964027, "97.5%": -0.883543}	coefficient
x1	10.260063429838898	23.270944360826963	0.0	{"2.5%": 9.395908, "97.5%": 11.124219}	coefficient
x2	0.353744983238 46265	0.294924732099 7519	0.81	{"2.5%": -1.997160, "97.5%": 2.704650}	coefficient
rsquared	0.987967566738 4592	NULL	NULL	NULL	goodness
adjusted_rsquared	0.984529728663 7332	NULL	NULL	NULL	goodness
aic	59.331109494251805	NULL	NULL	NULL	goodness
degree_of_freedom	7.0	NULL	NULL	NULL	goodness
standardErr_residual	3.765777749448906	NULL	NULL	NULL	goodness
deviance	99.267574407711128	NULL	NULL	NULL	goodness

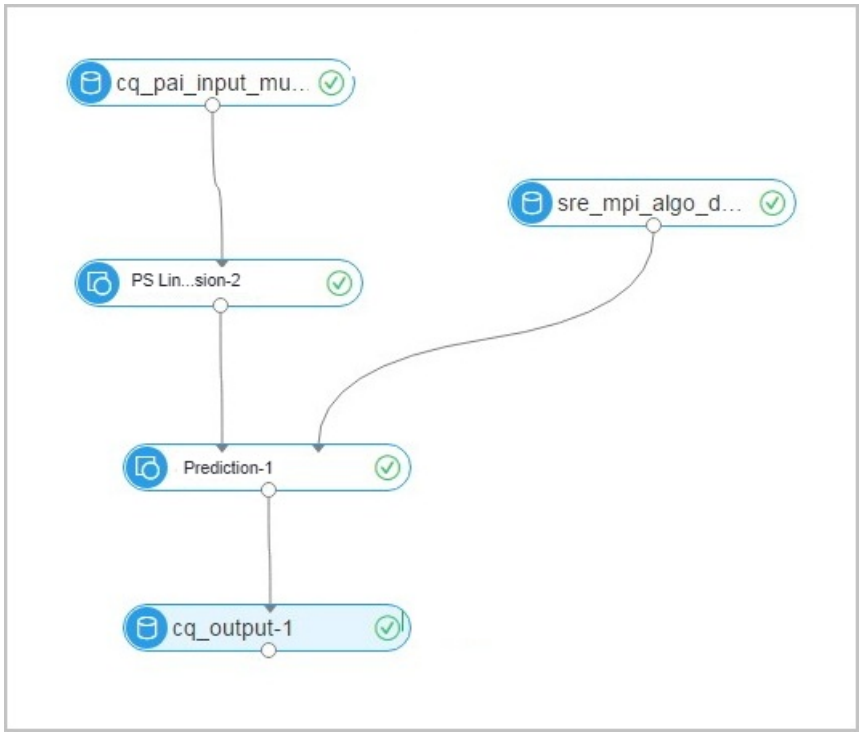
- Output prediction table: lm_test_input_predict_out.

y	prediction_result	prediction_score	prediction_detail
10	NULL	12.808476727264404	{"y": 12.8084767272644}
20	NULL	15.43015013867922	{"y": 15.43015013867922}
30	NULL	33.48786177519568	{"y": 33.48786177519568}
40	NULL	36.565880804147355	{"y": 36.56588080414735}
50	NULL	52.674180388994415	{"y": 52.67418038899442}
60	NULL	62.82092871092313	{"y": 62.82092871092313}
70	NULL	71.34749583130122	{"y": 71.34749583130122}
80	NULL	75.75932310613193	{"y": 75.75932310613193}
90	NULL	87.1832221199846	{"y": 87.18322211998461}
100	NULL	101.92248485222113	{"y": 101.9224848522211}

4.4.6.4.3. PS linear regression

Linear regression is a classic regression algorithm used to analyze the linear relationship between a dependent variable and multiple independent variables. Parameter servers (PSs) are used to run large amounts of training tasks online and offline. Parameter servers can use hundreds of billions of samples to efficiently train billions of feature models. The PS linear regression model can run training tasks with hundreds of billions of samples and billions of features, and supports L1 and L2 regular expressions.

Quick start



PAI command

- Training

```
PAI -name ps_linearregression
  -project algo_public
  -DinputTableName="lm_test_input"
  -DmodelName="linear_regression_model"
  -DlabelColName="label"
  -DfeatureColNames="features"
  -Dl1Weight=1.0
  -Dl2Weight=0.0
  -DmaxIter=100
  -Depsilon=1e-6
  -DenableSparse=true
```

- Prediction

```
drop table if exists logistic_regression_predict;
PAI -name prediction
  -DmodelName="linear_regression_model"
  -DoutputTableName="linear_regression_predict"
  -DinputTableName="lm_test_input"
  -DappendColNames="label,features"
  -DfeatureColNames="features"
  -DenableSparse=true
```

Parameters

- Data parameters

Command option	Parameter	Description	Valid values	Default value
featureColNames	Feature Columns	Required. The names of feature columns selected from the input table for training.	If a column name is in dense format, it must be of the bigint or double type. If the column name is in sparse KV format, it must be a string.	-
labelColName	Label Column	Required. The name of the label column selected from the input table.	The column name must be of the bigint or double type.	-
enableSparse	Use Sparse Format	Optional. If you choose to use the sparse KV format, do not use feature ID 0. We recommend that the feature IDs start from 1.	true and false	false
itemDelimiter	KV Pair Delimiter	Optional. The delimiter used to separate key-value pairs when data in the input table is in sparse format.	Symbol	The default delimiter is a space.

Command option	Parameter	Description	Valid values	Default value
kvDelimiter	KV Delimiter	Optional. The delimiter used to separate keys and values when data in the input table is in sparse format.	Symbol	The default delimiter is a colon (:).
inputTableName	Input Table Name	Required.	Table name	-
modelName	Output Model Name	Required.	Model name	-
inputTablePartitions	Input Table Partitions	Optional.	Partition name	The parameter value must be in the ds=1/pt=1 format.
enableModelIo	Output to Offline Model	Optional. When this parameter is set to false, the data is output to a MaxCompute table where you can view model weights.	true and false	true

- **Algorithm parameters**

Command option	Parameter	Description	Valid values	Default value
l1Weight	L1 Weight	Optional. The L1 regularization coefficient. The larger this value is, the fewer non-zero elements a model has. To overfit the model, set this parameter to a larger value.	A non-negative real number	1.0

Command option	Parameter	Description	Valid values	Default value
l2Weight	L2 Weight	Optional. The L2 regularization coefficient. The larger this value is, the smaller the absolute values of the model parameters are. To overfit the model, set this parameter to a larger value.	A non-negative real number	0
maxIter	Maximum Iterations	Optional. The maximum number of LBFGS/OWL-QN iterations. Value 0 indicates that no limit is set.	A non-negative integer	100
epsilon	Minimum Convergence Deviance	Optional. The mean of the relative loss change rates in ten iterations, which is used as a condition to determine whether to terminate the optimization algorithm. The smaller this value is, the stricter the condition is, and the longer the algorithm runs.	A real number between 0 and 1	1.0e-06

Command option	Parameter	Description	Valid values	Default value
modelSize	Largest Feature ID	Optional. The largest feature ID among all feature IDs (feature dimension). It can be larger than the actual largest feature ID. The larger this value is, the higher the memory usage is. If you leave this parameter empty, the system starts an SQL task to calculate the largest feature ID automatically.	A non-negative integer	0

> **Note** Both the maximum iterations and minimum convergence deviance determine when the algorithm stops. If both parameters are set, the algorithm stops when one of the conditions is met.

- **Execution optimization**

Command option	Parameter	Description	Valid values	Default value
coreNum	Cores	Optional. The number of cores. The larger this value is, the faster the computing algorithm runs.	A positive integer	Automatically allocated.
memSizePerCore	Memory Size per Core (MB)	Optional. The memory size of each core, where 1024 represents 1 GB of memory.	A positive integer	Automatically allocated. Typically, you do not need to set this parameter because the algorithm can accurately estimate the memory size required.

Examples

- **Data generation**

  The following example uses data in sparse KV format:

```
drop table if exists lm_test_input;
create table lm_test_input as
select
*
from
(
select 2 as label, '1:0.55 2:-0.15 3:0.82 4:-0.99 5:0.17' as features from dual
  union all
select 1 as label, '1:-1.26 2:1.36 3:-0.13 4:-2.82 5:-0.41' as features from dual
  union all
select 1 as label, '1:-0.77 2:0.91 3:-0.23 4:-4.46 5:0.91' as features from dual
  union all
select 2 as label, '1:0.86 2:-0.22 3:-0.46 4:0.08 5:-0.60' as features from dual
  union all
select 1 as label, '1:-0.76 2:0.89 3:1.02 4:-0.78 5:-0.86' as features from dual
  union all
select 1 as label, '1:2.22 2:-0.46 3:0.49 4:0.31 5:-1.84' as features from dual
  union all
select 0 as label, '1:-1.21 2:0.09 3:0.23 4:2.04 5:0.30' as features from dual
  union all
select 1 as label, '1:2.17 2:-0.45 3:-1.22 4:-0.48 5:-1.41' as features from dual
  union all
select 0 as label, '1:-0.40 2:0.63 3:0.56 4:0.74 5:-1.44' as features from dual
  union all
select 1 as label, '1:0.17 2:0.49 3:-1.50 4:-2.20 5:-0.35' as features from dual
) tmp;
```

The feature IDs start from 1, and the maximum feature ID is 5.

- **Training**

  Configure the training data and training components based on Quick start. Select the label column as the target column and features column as the feature column. Then, select the sparse data format.

  - You can retain the default value 0 for the largest feature ID. The algorithm can start an SQL task to calculate the largest feature ID automatically. If you do not want to start the SQL task, enter a value greater than 5. This value indicates the number of feature columns in dense format and indicates the largest feature ID in KV format.
  - To accelerate the training, you can set the number of cores on the tuning page. The larger the number is, the faster the algorithm runs. Typically, you do not need to enter the memory size per core because the algorithm can accurately calculate the memory size. The PS algorithm starts to run only when all hosts have obtained the resources. Therefore, you may need to wait a longer period of time when the cluster is busy and resources are requested in large volume.

- **Prediction**

The model generated after training is saved in binary format and can be used for prediction. Configure the input settings (model and testing data) for the prediction component and set parameters based on Quick start.

Select the KV format for training and set a correct delimiter. When the KV format is used, key-value pairs are separated by spaces. Therefore, the delimiter must be set to space or `\u0020` (the escape expression of space).

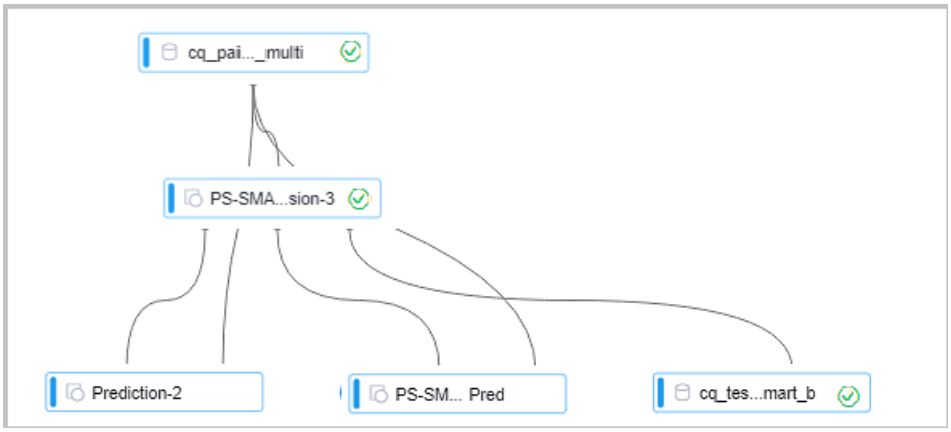
Restrictions and guidelines

In the key-value format, feature IDs must be positive integers, and feature values must be real numbers. If feature IDs are strings, use the serialization component to serialize them. If the feature values are classification type strings, perform feature engineering, such as discretization.

4.4.6.4.4. PS-SMART regression

A parameter server (PS) is used to train a large number of models online and offline. Scalable Multiple Additive Regression Tree (SMART) is an implementation of Gradient boosting decesion tree （GBDT） on PS. PS-SMART can run training tasks containing up to tens of billions of samples and hundreds of thousands of features on thousands of nodes. It also supports failover for high stability. PS-SMART supports various data formats, training targets, evaluation targets, output feature importance, and histogram approximation for training acceleration.

Quick start



As shown in the figure, a PS-SMART regression model is learned based on training data. The model has three output ports:

- Output model: offline model, which is connected to the unified prediction component. This model does not support the output of leaf node numbers.
- Output model table: a binary table that is not readable and is used to ensure compatibility with the PS-SMART prediction component. The table provides outputs such as leaf node numbers and evaluation metrics. However, the output table has strict requirements on data formats, which negatively affects user experience. This component is being continually improved, and may be replaced by another component in the future.
- Output feature importance table: lists the importance of each feature. Three importance types are supported. For more information, see Parameters.

PAI command

- Training

```
PAI -name ps_smart
  -project algo_public
  -DinputTableName="smart_regression_input"
  -DmodelName="xlab_m_pai_ps_smart_bi_545859_v0"
  -DoutputTableName="pai_temp_24515_545859_2"
  -DoutputImportanceTableName="pai_temp_24515_545859_3"
  -DlabelColName="label"
  -DfeatureColNames="features"
  -DenableSparse="true"
  -Dobjective="reg:linear"
  -Dmetric="rmse"
  -DfeatureImportanceType="gain"
  -DtreeCount="5";
  -DmaxDepth="5"
  -Dshrinkage="0.3"
  -Dl2="1.0"
  -Dl1="0"
  -Dlifecycle="3"
  -DsketchEps="0.03"
  -DsampleRatio="1.0"
  -DfeatureRatio="1.0"
  -DbaseScore="0.5"
  -DminSplitLoss="0"
```

- Prediction

```
PAI -name prediction
  -project algo_public
  -DinputTableName="smart_regression_input";
  -DmodelName="xlab_m_pai_ps_smart_bi_545859_v0"
  -DoutputTableName="pai_temp_24515_545860_1"
  -DfeatureColNames="features"
  -DappendColNames="label,features"
  -DenableSparse="true"
  -Dlifecycle="28"
```

Parameters

- Data parameters

Command option	Parameter	Description	Valid values	Remarks

Command option	Parameter	Description	Valid values	Remarks
featureColNames	Feature Column	The names of feature columns selected from the input table for training.	If the column name is in dense format, it must be of the bigint or double type. If the column name is in sparse KV format, it must be a string, and its keys and values must be numeric.	Required
labelColName	Label Column	The name of the label column selected from the input table.	The column name can be of either string or numeric type, but only numeric data can be stored in the columns. For example, the column value can be 0 or 1 for regression.	Required
weightCol	Weight Column	This column specifies the weight of each sample.	The column name can be of the numeric type.	Optional. Default value: null.
enableSparse	Use Sparse Format	This parameter specifies whether the data in the input table is in sparse format, in which key-value pairs are separated by spaces whereas keys and values are separated by colons (:), for example, **1:0.3 3:0.9**.	true, false	Optional. Default value: false.
inputTableName	Input Table Name	N/A	N/A	Required
modelName	Output Model Name	N/A	N/A	Required
outputImportanceTableName	Output Feature Importance Table Name	N/A	N/A	Optional. Default value: null.

Command option	Parameter	Description	Valid values	Remarks
inputTablePartitions	Input Table Partitions	N/A	N/A	Optional. The parameter value must be in ds=1/pt=1 format.
outputTableName	Output Model Table Name	The output table is a MaxCompute table that uses the binary format and is not readable. The prediction component that comes with SMART can be used to generate leaf node numbers.	String	Optional
lifecycle	Output Table Lifecycle	N/A	Positive integer	Optional. Default value: 3.

- Algorithm parameters

Command option	Parameter	Description	Valid values	Remarks
objective	Objective Function Type	The objective function type affects learning and must be selected properly. Multiple loss functions are available for regression. For more information, see the notes.		Required. The default type is Linear regression.
metric	Evaluation Indicator Type	Evaluation indicators in the training set, which must correspond to the objective function type and are exported to stdout of the coordinator in a logview. For more information, see the following notes and samples.		Optional. Default value: null.

Command option	Parameter	Description	Valid values	Remarks
treeCount	Trees	The number of trees. The training time is proportional to this number.	Positive integer	Optional. Default value: 1.
maxDepth	Maximum Decision Tree Depth	The maximum depth of a tree. We recommend that you set this value to 5, which means the tree can contain up to 32 leaf nodes.	A positive integer in the range of [1, 20]	Optional. Default value: 5.
sampleRatio	Data Sampling Fraction	The data sampling rate when trees are built. The sample data is used to build a weak learner to accelerate training.	(0, 1]	Optional. The default value is 1.0, which means data sampling is disabled.
featureRatio	Feature Sampling Fraction	The feature sampling rate when trees are built. The sample features are used to build a weak learner to accelerate training.	(0, 1]	Optional. The default value is 1.0, which means feature sampling is disabled.
l1	L1 Penalty Coefficient	This parameter determines the number of leaf nodes. The greater the value, the fewer the leaf nodes. You can set this parameter to a greater value if overfitting occurs.	Non-negative real number	Optional. Default value: 0.

Command option	Parameter	Description	Valid values	Remarks
l2	L2 Penalty Coefficient	This parameter determines the size of a leaf node. The greater the value, the more evenly the leaf nodes are distributed. You can set this parameter to a greater value if overfitting occurs.	Non-negative real number	Optional. Default value: 1.0.
shrinkage	Learning Rate	N/A	(0, 1]	Optional. Default value: 0.3.
sketchEps	Sketch-based Approximate Precision	The threshold for selecting quantiles when you build a sketch. The number of buckets is O(1.0/sketchEps). The smaller the parameter value, the more buckets are generated. Typically, you do not need to change this value.	(0, 1)	Optional. Default value: 0.03.
minSplitLoss	Minimum Split Loss	The minimum split loss changes required for splitting a node. The greater the value, the more conservatively the node splits.	Non-negative real number	Optional. Default value: 0.
featureNum	Features	The number of features or the maximum feature ID. Specify this parameter for resource usage estimation.	Positive integer	Optional
baseScore	Global Offset	Original predicted values of all samples.	Real number	Optional. Default value: 0.5.

Command option	Parameter	Description	Valid values	Remarks
featureImportanceType	Feature Importance Type	The type of feature importance. **weight** indicates the number of times that a feature splits. **gain** indicates information gain brought by the feature. **cover** indicates the number of samples that the feature covers on the splitting nodes.	**weight**, **gain**, and **cover**	Optional. Default value: **gain**.
tweedieVarPower	Tweedie Distribution Index	Tweedie distribution index indicates the relationship between the variance and mean. For example, $Var(y) ~ E(y)^tweedie_variance_power$.	(1, 2)	Optional. Default value: 1.5.

- Note
  - Specify different values for the objective parameter in different learning models. The regression Web GUI provides multiple objective functions.

    reg:linear (Linear regression) // The range of label numbers is (-∞, +∞).
    reg:logistic (Logistic regression) // The range of label numbers is [0, 1].
    count:poisson (Poisson regression for count data, output mean of poisson distribution) // Label numbers must be greater than 0.
    reg:gamma (Gamma regression for modeling insurance claims severity, or for any outcome that might be [gamma-distributed](https://en.wikipedia.org/wiki/Gamma_distribution#Applications)) // Label numbers must be greater than 0.
    reg:tweedie (Tweedie regression for modeling total loss in insurance, or for any outcome that might be [Tweedie-distributed](https://en.wikipedia.org/wiki/Tweedie_distribution#Applications).) // Label numbers must be greater than or equal to 0.

- Metrics for these objective functions are:

  rmse (rooted mean square error, corresponding to objective reg:linear)
  mae (mean absolute error, corresponding to objective reg:linear)
  poisson-nloglik (negative loglikelihood for poisson regression, corresponding to objective count:poisson)
  gamma-deviance (Residual deviance for gamma regression, corresponding to objective reg:gamma)
  gamma-nloglik (Negative log-likelihood for gamma regression, corresponding to objective reg:gamma)
  tweedie-nloglik (tweedie-nloglik@1.5, negative log-likelihood for Tweedie regression, at a specified value of the tweedie_variance_power parameter)

- Execution optimization

Command option	Parameter	Description	Valid values	Remarks
coreNum	Cores	The number of cores. The greater the value, the faster the computing algorithm runs.	Positive integer	Optional. Automatically allocated.
memSizePerCore	Memory Size per Core (MB)	The memory size of each core, where 1024 represents 1 GB of memory.	Positive integer	Optional. Automatically allocated.

Example

- Data generation

  The following example uses data in sparse KV format.

```
drop table if exists smart_regression_input;
create table smart_regression_input as
select
*
from
(
select 2.0 as label, '1:0.55 2:-0.15 3:0.82 4:-0.99 5:0.17' as features from dual
  union all
select 1.0 as label, '1:-1.26 2:1.36 3:-0.13 4:-2.82 5:-0.41' as features from dual
  union all
select 1.0 as label, '1:-0.77 2:0.91 3:-0.23 4:-4.46 5:0.91' as features from dual
  union all
select 2.0 as label, '1:0.86 2:-0.22 3:-0.46 4:0.08 5:-0.60' as features from dual
  union all
select 1.0 as label, '1:-0.76 2:0.89 3:1.02 4:-0.78 5:-0.86' as features from dual
  union all
select 1.0 as label, '1:2.22 2:-0.46 3:0.49 4:0.31 5:-1.84' as features from dual
  union all
select 0.0 as label, '1:-1.21 2:0.09 3:0.23 4:2.04 5:0.30' as features from dual
  union all
select 1.0 as label, '1:2.17 2:-0.45 3:-1.22 4:-0.48 5:-1.41' as features from dual
  union all
select 0.0 as label, '1:-0.40 2:0.63 3:0.56 4:0.74 5:-1.44' as features from dual
  union all
select 1.0 as label, '1:0.17 2:0.49 3:-1.50 4:-2.20 5:-0.35' as features from dual
) tmp;
```

Feature IDs are numbered starting from 1, and the maximum feature ID is 5.

- Training

  Select the label column as the target column and the features column as the feature column.

  - You do not need to set the number of features because this number is calculated automatically by the algorithm. If you have a large number of features and want the algorithm to accurately estimate the amount of required resources, specify the actual number of features.
  - To accelerate the training, set the number of cores on the execution optimization page. The greater the number, the faster the algorithm runs. Typically, you do not need to enter the memory size per core because the algorithm can accurately calculate the memory size. The PS algorithm starts to run only when all hosts have obtained the required resources. Therefore, you may need to wait for a longer time when the cluster is busy and resources are requested in large volumes.
  - You can view the output values of the metrics in the stdout of the coordinator in a logview (HTTP link starting with http://logview.odps.aliyun-inc.com:8080/logview). A single PS-SMART training job can contain multiple tasks, and therefore multiple logviews are created. Select the logview whose name starts with PS to view the output of the PS job.

- Prediction
  - Use the unified prediction component

    The model generated after training is saved in binary format and can be used for prediction. Configure the input model and test data for the prediction component, as shown in Quick start.

    If the dense format is used, you only need to select feature columns. (All columns are selected by default, and extra columns do not affect the prediction.) If the KV format is used, set the data format to sparse format and select the correct delimiter. In the SMART model, key-value pairs are separated with spaces. Therefore, the delimiter must be set to space or **\u0020** (escape expression of spaces).
  - Use the PS-SMART prediction component

    The output model table obtained after training is saved in binary format and can be used by the PS-SMART prediction component for prediction. Configure the input model and test data for the prediction component, as shown in Quick start. Set the required parameters, including the data format, feature columns, target column, and number of classes. The ID column can only be a string type column other than a feature column or a target column. The loss function must be explicitly set to the objective function used for training.

    The **prediction_score** column lists the predicted values. The **leaf_index** column lists the predicted leaf node numbers. Each sample has N numbers, where N is the number of decision trees. Each tree is mapped to a number, which indicates the leaf node number of the sample on this tree.

    > **Note**
    > - The output model table is a binary table that is not readable and is used to support the PS-SMART prediction component. The table provides outputs such as leaf node numbers and evaluation indicators. However, the output table has strict requirements on data formats, which negatively affects user experience. This component is being continually improved, and may be replaced by another component in the future.
    > - A string type column must be selected as the label column. You can enter strings in the column but cannot be blank or NULL. A feature column can be converted to the string type by using the data type conversion component.
    > - The loss function must be explicitly set to the objective function used for training. By default, the loss function does not work.

- View feature importance

  To view feature importance, you can export the third output port to an output table, or right-click **PS-SMART training component** and choose **View Data > Output Feature Importance Table** from the shortcut menu.

order	id	value
1	1	0.14059734344482422
2	4	0.8594027161598206

  In the table, the ID column lists the numbers of input features. In this example, the data is in KV format and the IDs represent keys in key-value pairs. If the dense format is used and input features are **f0,f1,f2,f3,f4,f5**, ID 0 represents f0, and ID 4 represents f4. Each value indicates a feature importance type. The default value is **gain**, indicating the sum of information gains brought by a feature in the model. The preceding figure shows only two features because only these two features are used during the tree split process. In this case, the importance of unused features is 0.

FAQ

- Q: Does PS_SMART support non-numerical features and tags?
- A: No.
- Q: What is the scale of features supported by PS-SMART? Can we use large-scale 0-1 features?
- A: Although PS-SMART supports tasks that contain hundreds of thousands of features, such tasks consume large amounts of resources and run slowly. Therefore, we recommend that you do not use a large number of features. The GBDT algorithm is suitable for training with continuous features. The categorical features require one-hot coding (to filter out infrequent features) before they can be used for training. The continuous numerical features can be used for training with the GBDT algorithm directly. Discretization is not recommended for numerical features.
- Q: Why is the result different every time although the SMART algorithm has the same data and the same parameter settings?
- A: The PS-SMART algorithm applies randomness in many scenarios. For example, the data_sample_ratio and fea_sample_ratio items introduce data and feature sampling respectively. In addition, the PS-SMART algorithm uses histograms to show similarity. When multiple workers run in a cluster in distributed mode, local sketches are merged to global sketches in a random order. Although different merging orders result in different tree structures, this does not introduce too much variation to the output model. Therefore, it is normal situation to obtain different results after the algorithm runs multiple times with the same data and same parameter settings.

> Note
>
> - The target column in a PS-SMART regression model supports only numerical values. Even if values in the MaxCompute table are strings, they are saved as numerical values.
> - In the key-value format, feature IDs must be positive integers, and feature values must be real numbers. If feature IDs are strings, use the serialization component to serialize them. If feature values are classification type strings, perform feature engineering, such as discretization.

4.4.6.5. Collaborative filtering (etrec)

etrec is an item-based collaborative filtering algorithm that takes two input columns and provides the top N items that have the highest similarity.

Set the user and item columns.

- You can configure three similarity types.
- topN indicates the first N items with the highest similarity.
- Calculation method: the method used to calculate items that appear multiple times.

PAI command

```
PAI -name pai_etrec
-project algo_public
-DsimilarityType="wbcosine"
-Dweight="1"
-DminUserBehavior="2"
-Dlifecycle="28"
-DtopN="2000"
-Dalpha="0.5"
-DoutputTableName="etrec_test_result"
-DmaxUserBehavior="500"
-DinputTableName="etrec_test_input"
-Doperator="add"
-DuserColName="user"
-DitemColName="item"
```

Parameters

Parameters

Parameter	Description	Valid value	Default value
inputTableName	Required. The name of the input table.	N/A	N/A
userColName	Required. The name of the input table column selected as the user column.	N/A	N/A
itemColName	The name of the input table column selected as the item column.	N/A	N/A
payloadColName	Optional. The name of the input table column selected as the payload column.	N/A	No payload column is set by default.
inputTablePartitions	Optional. The partitions selected from the input table for training.	N/A	The whole table is selected by default.
outputTableName	Required. The name of the output table.	N/A	N/A
outputTablePartition	Optional. The partitions in the output table.	N/A	The output table is non-partitioned by default.

Parameter	Description	Valid value	Default value
similarityType	Optional. The type of similarity.	wbcosine, asymcosine, and jaccard	wbcosine
topN	Optional. N items with the highest similarity.	[1, 10000]	2000
minUserBehavior	Optional. The minimum user behavior.	[2,)	2
maxUserBehavior	Optional. The maximum user behavior.	[2, 100000]	500
itemDelimiter	Optional. The delimiter used to separate items in the output table.	N/A	The default delimiter is a space.
kvDelimiter	Optional. The delimiter used to separate keys and values in the output table.	N/A	The default delimiter is a colon (:).
alpha	Optional. The value of the smoothing factor for asymcosine.	N/A	0.5
weight	Optional. The weight used for asymcosine.	N/A	1.0
operator	Optional. The action to be performed when the same items exist for one user.	add, mul, min, and max	add
lifecycle	Optional. The lifecycle of the output table.	N/A	1

Examples

- SQL statement to generate data:

```
drop table if exists etrec_test_input;
create table etrec_test_input as select * from
(
select cast(0 as string) as user,
cast(0 as string) as item from dual
union all
select cast(0 as string) as user,
cast(1 as string) as item from dual
union all
select cast(1 as string) as user,
cast(0 as string) as item from dual
union all
select cast(1 as string) as user,
cast(1 as string) as item from dual ) a;
```

- PAI command

```
drop table if exists etrec_test_result;
PAI -name pai_etrec
-project algo_public
-DsimilarityType="wbcosine"
-Dweight="1"
-DminUserBehavior="2"
-Dlifecycle="28"
-DtopN="2000"
-Dalpha="0.5"
-DoutputTableName="etrec_test_result"
-DmaxUserBehavior="500"
-DinputTableName="etrec_test_input"
-Doperator="add"
-DuserColName="user"
-DitemColName="item"
```

- Input description

etrec_test_input

User	Item
0	0
0	1
1	0

User	Item
1	1

- Output description

  ### etrec_test_result

Item ID	Similarity
0	1:1
1	0:1

4.4.6.6. Evaluation

4.4.6.6.1. Regression model evaluation

You can evaluate a regression model based on the predicted and actual results. Indicators include SST, SSE, SSR, R2, R, MSE, RMSE, MAE, MAD, MAPE, count, yMean, and predictMean.

PAI command

```
Pai –name regression_evaluation
–project algo_public
-DinputTableName=input_table
-DyColName=y_col
-DpredictionColName=prediction_col
-DoutputTableName=output_table;
```

Parameters

Parameter	Description	Default value
inputTableName	Required. The name of the input table.	-
inputTablePartitions	Optional. The partitions selected from the input table for training.	All partitions of the input table are selected by default.
yColName	Required. The name of the original dependent variable column in the input table. It must be a numerical value.	-
predictionColName	Required. The name of the predicted dependent variable column. It must be a numerical value.	-
outputTableName	Required. The name of the output table.	-

Parameter	Description	Default value
inputTablePartitions	Optional. The partitions selected from the input table.	-
lifecycle	Optional. The lifecycle of the output table.	No lifecycle is set by default.

Output

The following table describes the JSON columns.

Column description

Column	Description
SST	The sum of squares total.
SSE	The sum of squares error.
SSR	The sum of squares regression.
R2	The coefficient of determination.
R	The coefficient of multiple correlations.
MSE	The mean squared error.
RMSE	The root-mean-square error.
MAE	The mean absolute error.
MAD	The mean absolute difference.
MAPE	The mean absolute percentage error.
count	The number of rows.
yMean	The mean of original dependent variables.
predictionMean	The mean of prediction results.

4.4.6.6.2. Clustering model evaluation

You can evaluate clustering models, including metrics and icons, based on raw data and clustering models.

PAI command

```
PAI -name cluster_evaluation
-project algo_public
-DinputTableName=pai_cluster_evaluation_test_input
-DselectedColNames=f0,f3
-DmodelName=pai_kmeans_test_model
-DoutputTableName=pai_ft_cluster_evaluation_out;
```

Parameters

Parameters

Parameter	Description	Valid value	Default value
inputTableName	Required. The name of the input table.	Table name	N/A
selectedColNames	Optional. The names of columns selected from the input table for evaluation. The column names must be separated with commas (,). The column names must be the same as the feature names saved in the model.	Column name	All columns are selected by default.
inputTablePartitions	Optional. The partitions selected from the input table for evaluation, in the `name1=value1/name2=value2` format. Separate multiple partitions with commas (,).	N/A	All partitions are selected by default.
enableSparse	Optional. This parameter specifies whether data in the input table is in sparse format.	true and false	false
itemDelimiter	Optional. The delimiter used to separate key-value pairs when data in the input table is in sparse format.	N/A	The default delimiter is a space.

Parameter	Description	Valid value	Default value
kvDelimiter	Optional. The delimiter used to separate keys and values when data in the input table is in sparse format.	N/A	The default delimiter is a colon (:).
modelName	Required. The name of the input clustering model.	Model name	N/A
outputTableName	Required. The name of the output table.	Table name	N/A
lifecycle	Optional. The lifecycle of the output table.	A positive integer	No lifecycle is set by default.

Evaluation formula

The Calinski-Harabasz metric is also known as the variance ratio criterion (VRC), which is defined as follows:

$$VRC_k = \frac{SS_B}{SS_W} \times \frac{(N-k)}{(k-1)},$$

- SS_B represents the inter-clustering variance. The definition is as follows:

  $$SS_B = \sum_{i=1}^{k} n_i \|m_i - m\|^2,$$

  - `k` represents the number of cluster centers.
  - m_i represents the center of cluster i.
  - `m` represents the mean of the input data.
- SS_W represents the intra-clustering variance. The definition is as follows:

  $$SS_W = \sum_{i=1}^{k} \sum_{x \in c_i} \|x - m_i\|^2,$$

  - `k` represents the number of cluster centers.
  - `x` represents a data point.
  - c_i represents the number i cluster.
  - m_i represents the center of cluster i.
- `N` represents the total number of records. `k` represents the number of cluster centers.

Examples

- Test data

```
create table if not exists pai_cluster_evaluation_test_input
as select * from ( select 1 as id,
1 as f0,2 as f3 from dual union all
select 2 as id, 1 as f0,3 as f3 from dual union all
select 3 as id, 1 as f0,4 as f3 from dual union all
select 4 as id, 0 as f0,3 as f3 from dual union all
select 5 as id, 0 as f0,4 as f3 from dual )tmp;
```

- Clustering model building

```
pai -name kmeans
-project algo_public
-DinputTableName=pai_cluster_evaluation_test_input
-DselectedColNames=f0,f3
-DcenterCount=3
-Dloop=10
-Daccuracy=0.00001
-DdistanceType=euclidean
-DinitCenterMethod=random
-Dseed=1
-DmodelName=pai_kmeans_test_model
-DidxTableName=pai_kmeans_test_idx
```

- PAI command

```
PAI -name cluster_evaluation
-project algo_public
-DinputTableName=pai_cluster_evaluation_test_input
-DselectedColNames=f0,f3
-DmodelName=pai_kmeans_test_model
-DoutputTableName=pai_ft_cluster_evaluation_out;
```

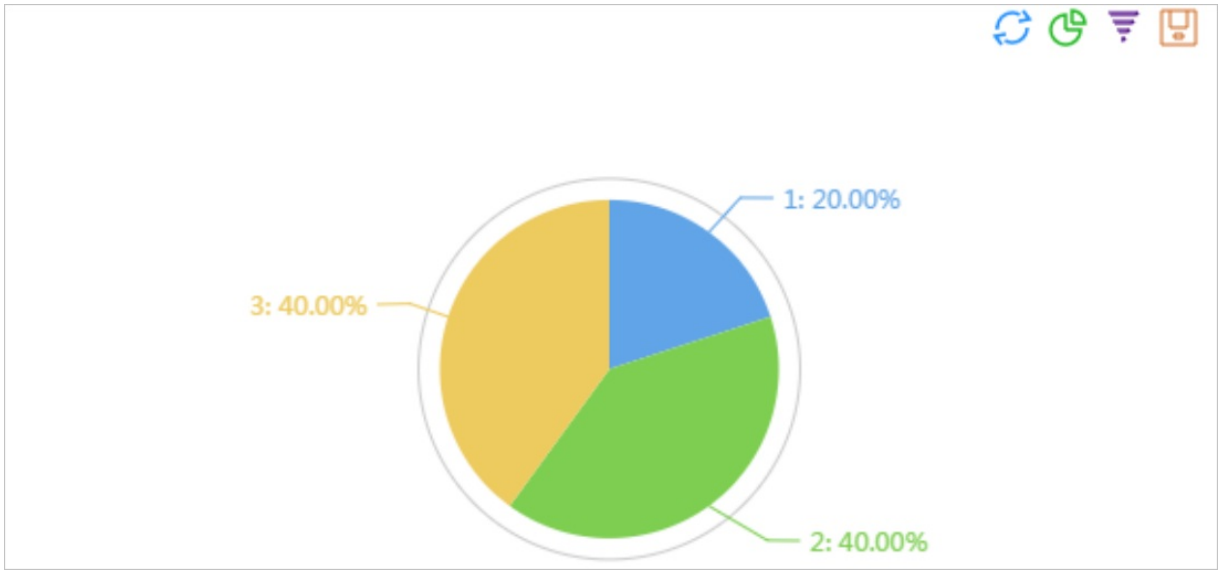
- Output description

Output table (outputTableName)

Column	Description
count	The total number of records.
centerCount	The number of cluster centers.
calinhara	The Calinski Harabasz metric.
clusterCounts	The number of points included in each cluster.

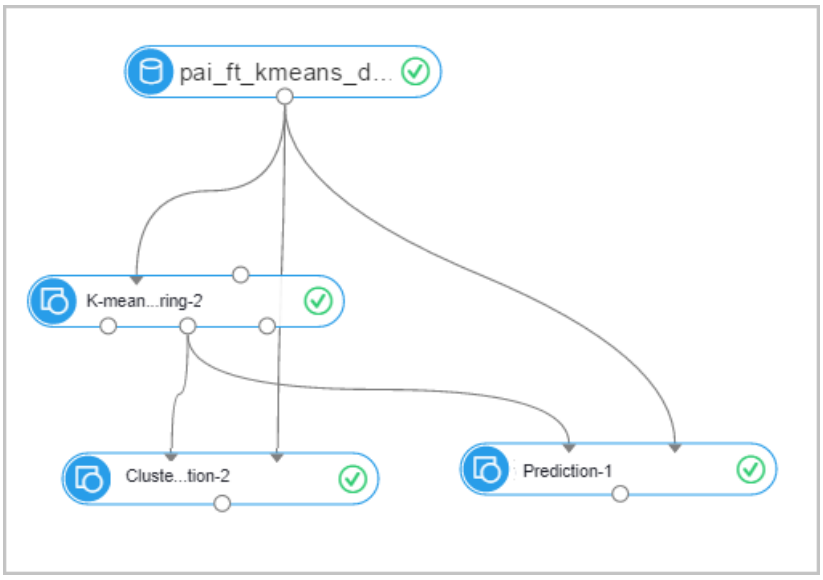
PaiWeb demonstration

Clustering model evaluation



PaiWeb-Pipeline

PaiWeb-Pipeline



4.4.6.6.3. Binary classification evaluation

You can evaluate a regression algorithm model based on its predicted and actual results. The metrics include MSE, MAE, and MAPE.

PAI command

```
pai -name evaluation
-DinputTableName=input_table
-DlabelColName=label_name
-DpredictionColName=prediction_score
-DoutputTableName=output_table;
```

Algorithm parameters

Parameters

Parameter	Description	Valid value	Default value
inputTableName	Required. The name of the input table.	N/A	N/A
inputTablePartitions	Optional. The partitions selected from the input table for calculation.	N/A	All partitions of the input table are selected by default.
labelColName	Required. The name of the original label column in the input table. It must be a numerical value.	N/A	N/A
predictionColName	Required. The name of the label column in the prediction result table. It must be a numerical value.	N/A	N/A
outputTableName	Required. The name of the output table.	N/A	N/A
lifecycle	Optional. The lifecycle of the output table.	A positive integer	No lifecycle is set by default.

Output table

Output column description

Column	Description
MSE	The mean square error, which is used to measure the mean error and evaluate data changes. The smaller the MSE, the more accurately a prediction model describes the test data.
MAE	The mean absolute error, which is used to measure the mean difference between the predicted value and the actual value.
MAPE	The mean absolute percentage error, which is used to measure prediction accuracy. The value is expressed in percentage. If MAPE is set to 15, the mean absolute percentage error is 15%.

4.4.6.6.4. Confusion matrix

The Confusion Matrix component is a visualization tool typically used in supervised learning. This tool is used to calculate the classification accuracy of a confusion matrix model by comparing its results with measured values.

Procedure

1. Configure the confusion matrix parameters.

   The default settings are typically used. You can also select a target column and a prediction probability column. A prediction probability column is the target column generated by the Prediction component.

2. Connect the Confusion Matrix component and the Prediction component.

   > **Note** The parent node of the Confusion Matrix component must be a Prediction component. You can perform confusion matrix analysis only when a classification model is used.

3. Right-click the Confusion Matrix component and choose **View Evaluation Report**.

PAI command

```
PAI –name confusionmatrix
–project algo_public
-DoutputTableName="pai_temp_2954_24178_1"
-DlabelColName="age"
-DpredictionColName="prediction_result"
-DinputTableName="pai_temp_2954_24176_1";
```

Parameters

Parameter	Description
name	The name of the component.
project	The name of the project. This parameter is used to specify the workspace of the algorithm. The default value is algo_public. If you change the name, the system reports an error.
outputTableName	The name of the output table.
labelColName	The name of the label column selected from the input table.
predictionColName	The name of the prediction result column.
inputTableName	The name of the input table for predicting results.

4.4.6.6.5. Multiclass classification evaluation

You can evaluate a multiclass classification model based on its predicted and actual results. The indicators include accuracy, kappa, and F1-Score.

Component description

The Multiclass Classification Evaluation component must be connected to a Prediction component and does not support regression models.

PAI command

```
PAI -name MultiClassEvaluation -project algo_public
  –DinputTableName="test_input"
  -DoutputTableName="test_output"
  -DlabelColName="label"
  -DpredictionColName="prediction_result"
  -Dlifecycle=30;
```

Algorithm parameters

Parameters

Parameter	Description	Valid values	Default value
inputTableName	Required. The name of the input table.	-	-
inputTablePartitions	Optional. The partitions selected from the input table for training.	-	All partitions of the input table are selected by default.
labelColName	Required. The name of the original label column in the input table. It must be a numerical value.	-	-
predictionColName	Required. The name of the label column in the prediction result table. It must be a numerical value.	-	-
outputTableName	Required. The name of the output table.	-	-
predictionColName	Optional. The name of the probability column that lists prediction results. It must be in the {"A":0.2,"B":0.3} format.	-	-
lifecycle	Optional. The lifecycle of the output table.	A positive integer	No lifecycle is set by default.

4.4.6.7. Prediction

The Prediction component is used to make model-based predictions. The component has two inputs (training model and prediction data) and one output (prediction result). Conventional data mining algorithms often use this component for prediction.

Procedure

1. Connect all components.
2. Configure column settings.

Parameters

Parameter	Description
Feature Columns	The feature columns used for prediction. All feature columns are selected by default.
Reserved Columns	The columns reserved and exported to the prediction result.
Output Result Column	The default value is used.
Output Score Column	The default value is used.
Output Detail Column	The default value is used.

> **Note** Feature columns must be selected if data is in sparse format such as `k1:v1,k2:v2`.

3. After you configure the preceding parameters, right-click the Prediction component and choose **View Data** from the shortcut menu.

   The following three columns are appended to the prediction data:

   - predict_result: the prediction result column.
   - predict_score: the probability score in prediction results. This column is only appended onto the outputs of binary classification models.
   - predict_detail: the prediction result of each category. This column is only appended onto the outputs of binary classification models.

PAI command

```
PAI -name Prediction
–project algo_public
-DdetailColName="prediction_detail"
-DsplitCharacteristic="2"
-DappendColNames="age,campaign,pdays,previous,poutcome,emp_var_rate,cons_price_idx,cons_conf_id
x,euribor3m,nr_employed,y"
-DmodelName="xlab_m_random_forests_6036"
-DresultColName="prediction_result"
-DoutputTableName="pai_temp_675_6048_1"
-DscoreColName="prediction_score"
-DinputTableName="bank_data";
```

Parameters

Parameter	Description
name	The name of the component.
project	The name of the project. This parameter is used to specify the workspace of the algorithm. The default value is algo_public. If you change the name, the system reports an error.
detailColName	Optional. The name of the detail column in the output table. The default value is prediction_detail.
splitCharacteristic	Optional. The type of classification. The value *1* indicates binary classification. The value *2* indicates multiclass classification.
appendColNames	Optional. The names of columns in the input prediction table to be appended to the output table.
modelName	The name of the random forest model.
resultColName	Optional. The name of the result column in the output table. The default value is *prediction_result*.
outputTableName	The name of the output prediction table.
scoreColName	Optional. The name of the score column in the output table. The default value is *prediction_score*.
inputTableName	The name of the input prediction table.

4.4.7. Deep learning (must be activated separately)

4.4.7.1. Activate deep learning

The deep learning service is not a basic function of Apsara Stack Machine Learning Platform for AI. You must purchase it separately.

If you have already deployed the deep learning service, activate it by using the following procedure:

1. Log on to the Apsara Stack Machine Learning Platform for AI console.
2. Click **Settings** in the left-side navigation pane.
3. Click **General**. Under **Deep Learning**, select **Enable GPU Compute**.

4.4.7.2. Read OSS buckets

When using the **Read OSS Bucket** component on Machine Learning Platform for AI, you must assign the default system role **AliyunODPSPAIDefaultRole** to your DTplus service account. OSS buckets can be correctly read and written by algorithms of the machine learning platform only when the role is correctly assigned.

> **Note** The machine learning platform shares service accounts with MaxCompute, because it runs on the MaxCompute framework. During authorization, you must assign the default role to your MaxCompute service account.

You can use RAM authorization to grant OSS access permissions to Machine Learning Platform for AI. Click **Settings** to grant permission to read and write OSS data. For more information, see RAM authorization.

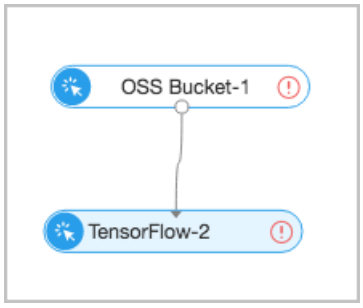
RAM authorization

1. Log on to the Machine Learning Platform For AI console, click **Settings** in the left-side navigation pane, and select **General**.
2. Under **OSS Authorization**, select **Authorize Machine Learning Platform for AI to access my OSS resources**.
3. The following page is displayed. Click **Click here to authorize access in RAM**. The RAM page is displayed.
4. Click **I Agree**.

> **Note** To view details about the AliyunODPSPAIDefaultRole policy, log on to the RAM console. The default role AliyunODPSPAIDefaultRole contains the following permission information.

Permission (Action)	Description
oss:PutObject	Upload a file or folder object.
oss:GetObject	Obtain a file or folder object.
oss:ListObjects	Query file information.
oss:DeleteObjects	Delete an object.

5. Go back to the machine learning page and click **Refresh**. RAM information is automatically recorded to the components.
6. Use the deep learning framework. Connect the **Read OSS Bucket** component to the corresponding deep learning component to obtain permissions to read and write OSS data.



4.4.7.3. TensorFlow 1.4

TensorFlow (TF) is an open-source machine learning framework. It is easy to use for algorithm developers. The TF framework is integrated into Apsara Stack Machine Learning Platform for AI. You can write code and adjust computing resources flexibly by using the TF compute engine. The TF computing engine is a Graphics Processing Unit (GPU) cluster.

Parameters

- Parameter settings

Parameter settings

Parameter	Description
Python Code Files	The program execution files. Multiple files can be packaged and uploaded in the tar.gz format.
Primary Python File	Optional. The primary file in a compressed code file package.
Data Source Directory	The path of data sources. You can select Object Storage Service (OSS) data sources.
Configuration File Hyperparameters and Custom Parameters	Machine Learning Platform for AI Tensorflow allows you to use commands to pass in hyperparameter settings and try different learning rates and batch sizes during model testing.
Output Directory	The path of the output model.

- Tuning

  You can specify the number of GPUs based on the complexity of jobs.

PAI command

> **Note** You do not need to set all parameters. For the definitions of these parameters, see Parameters. We recommend that you do not directly copy the following command.

```
PAI -name tensorflow_ext140
-Dbuckets="oss://imagenet.oss-cn-shanghai-internal.aliyuncs.com/smoke_tensorflow/mnist/"
-DgpuRequired="100"
-Darn="acs:ram::166408185518****:role/aliyunodpspaidefaultrole"
-Dscript="oss://imagenet.oss-cn-shanghai-internal.aliyuncs.com/smoke_tensorflow/mnist_ext.py";
```

The following table lists the descriptions of the parameters.

Parameters

Parameter	Description	Valid values	Default value
script	Required. The TF algorithm file. This file can be a single file or compressed as a tar.gz format package.	oss://imagenet.oss-cn-shanghai-internal.aliyuncs.com/smoke_tensorflow/mnist_ext.py	N/A
entryFile	Optional. The name of the primary Python file. If the script is a compressed package in the tar.gz format, this parameter is required.	train.py	Null
buckets	Required. The input OSS buckets. You can specify multiple buckets separated with commas (,). Each bucket must end with a forward slash (/).	oss://imagenet.oss-cn-shanghai-internal.aliyuncs.com/smoke_tensorflow/mnist/	Null
arn	Required. The Alibaba Cloud Resource Name (ARN) of an OSS object.	N/A	Null
gpuRequired	Required. This parameter indicates the number of GPUs to be used.	200	100
checkpointDir	Optional. The TF checkpoint directory.	oss://imagenet.oss-cn-shanghai-internal.aliyuncs.com/smoke_tensorflow/mnist/	Null

Parameter	Description	Valid values	Default value
cluster	Optional.	A JSON format value. Quotation marks must be escaped.	Null
hyperParameters	Optional. The path of the command line hyperparameters.	oss://imagenet.oss-cn-shanghai-internal.aliyuncs.com/smoke_tensorflow/mnist/hyper_parameters.txt	Null

- script and entryFile are used to specify the TF algorithm script to be executed. If the algorithm is complex and divided into multiple files, you can package the files into a tar.gz file and use entryFile to specify the primary Python file.
- checkpointDir is used to specify the OSS path to be written by algorithms. You must specify the OSS path when you save TensorFlow models.
- buckets is used to specify the OSS path to be read by algorithms. To use OSS, you must specify arn.
- Distributed Machine Learning Platform for AI TensorFlow supports cluster. You can use cluster to specify the number of parameter servers and workers. cluster is in JSON format, and the quotation marks must be escaped. The JSON code must contain two keys: ps and worker. Both the ps and worker parameters contain count, gpu, cpu, and memory.

Keyword	Description	Default value	Remarks
count	Required. The number of parameter servers or workers.	-	None
gpu	Optional. The number of GPUs allocated to each parameter server or worker. 100 represents a single GPU card.	For parameter servers, the default value is 0. For workers, the default value is 100.	If the number of GPUs allocated to each worker is set to 0, Machine Learning Platform for AI will reset the value to 100 to ensure the task is scheduled properly.
cpu	Optional. The number of CPUs allocated to each parameter server or worker. 100 represents a single CPU card.	600	None
memory	The memory size allocated to each parameter server or worker. 100 represents 100 MB.	30000	None

Examples

The MNIST digit classification set is a set of handwritten digits 1 through 9 that contains training and test sets for machine learning models.

1. Upload the Python execution files and training datasets to OSS. In this case, create a bucket on OSS in China (Shanghai) and name the bucket as tfmnist001. Upload the Python script and training data.
2. Drag and drop the **Read OSS Bucket** and **TensorFlow** components onto the canvas to create the following experiment. Set the region for the OSS bucket and configure RAM authorization.
3. Set the TensorFlow parameters. Set the paths for **Python Code Files**, **Primary Python File**, and **Data Source Directory**.
4. Click **Run** and wait for the experiment to complete running.
5. Right-click the **TensorFlow** component and view the running log.

4.4.8. Time series

4.4.8.1. x13_arima

Autoregressive Integrated Moving Average Model (ARIMA) is a well-known time series prediction method defined by Box and Jenkins in the early 1970s. This model is also called the Box-Jenkins model or the Box-Jenkins method. x13-arima is an ARIMA algorithm for seasonal adjustment based on the open-source X-13ARIMA-SEATS algorithm.

PAI command

```
pai -name x13_arima
  -project algo_public
  -DinputTableName=pai_ft_x13_arima_input
  -DseqColName=id
  -DvalueColName=number
  -Dorder=3,1,1
  -Dstart=1949.1
  -Dfrequency=12
  -Dseasonal=0,1,1
  -Dperiod=12
  -DpredictStep=12
  -DoutputPredictTableName=pai_ft_x13_arima_out_predict
  -DoutputDetailTableName=pai_ft_x13_arima_out_detail
```

Algorithm parameters

Parameters

Parameter	Description	Valid value	Default value

Parameter	Description	Valid value	Default value
inputTableName	Required. The name of the input table.	Table name	N/A
inputTablePartitions	Optional. The partitions selected from the input table for training, in the `partition_name=value` format. To specify multiple partitions, use the following format: `name1=value1/name2=value2`. Separate multiple partitions with commas (,).	Partition name	All partitions are selected by default.
seqColName	Required. The name of the time series column.	Column name	This parameter is only used to sort the column specified by valueColName. The value does not affect the calculated results.
valueColName	Required. The name of the value column.	Column name	N/A
groupColNames	Optional. The name of the stratification column. Separate multiple columns with commas (,), such as `col0,col1;`. A time series is created for each stratum.	Column name	N/A
order	Required. *p*, *d*, and *q* indicate the autoregressive coefficient, difference, and moving regression coefficient, respectively.	*p*, *d*, and *q* must be non-negative integers in the range of [0, 36].	N/A
start	Optional. The start date of a time series.	A string in the `year.seasonal` format, such as 1986.1 For more information, see the time series format section.	1.1

Parameter	Description	Valid value	Default value
frequency	Optional. The frequency of a time series. Unit: months/year	A positive integer in the range of (0, 12) For more information, see the time series format section.	12
seasonal	Optional. *sp*, *sd*, and *sq* indicate the seasonal autoregressive coefficient, seasonal difference, and seasonal moving regression coefficient, respectively.	*sp*, *sd*, and *sq* must be non-negative integers in the range of [0, 36].	*seasonal* is not set by default.
period	Optional. The seasonal period.	A number in the range of (0, 100]	frequency
maxiter	Optional. The maximum number of iterations.	A positive integer	1500
tol	Optional. The degree of tolerance.	A double type value	1e-5
predictStep	Optional. The number of prediction items.	A number in the range of (0, 365]	12
confidenceLevel	Optional. The prediction confidence level.	A number in the range of (0, 1)	0.95
outputPredictTableName	Required. The name of the output prediction table.	Table name	N/A
outputDetailTableName	Required. The name of the output detail table.	Table name	N/A
outputTablePartition	Optional. The partition in the output table.	Partition name	The output table is non-partitioned by default.
coreNum	Optional. The number of cores.	A positive integer used with memSizePerCore	Automatically calculated.
memSizePerCore	Optional. The memory size of each core. Unit: MB.	A positive integer in the range of [1024, 65536]	Automatically calculated.
lifecycle	Optional. The lifecycle of the output table.	A positive integer	No lifecycle is set by default.

Time series format

- The start and frequency parameters specify the two time dimensions of data (valueColName): TS1 and TS2.
- The frequency parameter indicates the data frequency within a period, which equals the frequency of TS2 in each TS1.
- The start parameter must be in the `n1.n2` format. This indicates that the start date is the N2 TS2 in the N1 TS1.

Unit time	TS1	TS2	Frequency	Start date
12 months/year	Year	Month	12	1949.2 indicates the second month of year 1949.
Four quarters/year	Year	Quarter	4	1949.2 indicates the second quarter of year 1949.
Seven days/week	Day	Week	7	1949.2 indicates the second day of the1949th week.
1	Any time unit	1	1	1949.1 indicates the 1949th (year, day, or hour).

Example: value=[1,2,3,5,6,7,8,9,10,11,12,13,14,15]

- `start=1949.3` and `frequency=12` indicate that the data frequency is monthly, and the prediction start date is 1950.06.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1949			1	2	3	4	5	6	7	8	9	10
1950	11	12	13	14	15							

- `start=1949.3` and `frequency=4` indicate that the data frequency is quarterly, and the prediction start date is 1953.02.

Year	Qtr1	Qtr2	Qtr3	Qtr4
1949			1	2
1950	3	4	5	6
1951	7	8	9	10
1952	11	12	13	14

Year	Qtr1	Qtr2	Qtr3	Qtr4
1953	14			

- `start=1949.3` and `frequency=7` indicate that the data frequency is daily, and the prediction start date is 1951.04.

Week	Sun	Mon	Tue	Wed	Thu	Fri	Sat
1949			1	2	3	4	5
1950	6	7	8	9	10	11	12
1951	13	14	15				

- `start=1949.1` and `frequency=1` indicate that the prediction start date is 1963.00 regardless of the time unit used.

Cycle	p1
1949	1
1950	2
1951	3
1951	4
1952	5
1953	6
1954	7
1955	8
1956	9
1957	10
1958	11
1959	12
1960	13
1961	14
1962	15

Examples

- Data used for testing: AirPassengers. The data set contains the number of passengers for international airlines each month from 1949 to 1960. It can be downloaded from https://stat.ethz.ch/R-manual/R-devel/library/datasets/html/AirPassengers.html .

```
create table pai_ft_x13_arima_input(id bigint,number bigint);
tunnel upload data/airpassengers.csv pai_ft_x13_arima_input -h true;
```

- PAI command

```
pai -name x13_arima
 -project algo_public
 -DinputTableName=pai_ft_x13_arima_input
 -DseqColName=id
 -DvalueColName=number
 -Dorder=3,1,1
 -Dseasonal=0,1,1
 -Dstart=1949.1
 -Dfrequency=12
 -Dperiod=12
 -DpredictStep=12
 -DoutputPredictTableName=pai_ft_x13_arima_out_predict
 -DoutputDetailTableName=pai_ft_x13_arima_out_detail
```

- Output description

- The columns of the output table specified by outputPredictTableName are as follows.

Column	Description
pdate	The prediction date.
forecast	The prediction result.
lower	The lower threshold of the prediction result when the confidence level is specified (default value: 0.95).
upper	The upper threshold of the prediction result when the confidence level is specified (default value: 0.95).

Output data

1	196101	444.445401291661	422.354385657496	466.536416925825
2	196102	420.971087699795	394.745551231805	447.196624167785
3	196103	453.432019696644	423.435661316528	483.428378076759
4	196104	490.922534668881	458.870488854835	522.974580482926
5	196105	503.877174753018	470.308964411549	537.445385094488
6	196106	566.536076521906	531.945171132091	601.126981911721
7	196107	652.606993945368	617.2596149799	687.954372910837
8	196108	639.841497141155	603.933582941945	675.749411340364
9	196109	542.341866147189	506.000630530659	578.683101763719
10	196110	494.745102803541	458.0614903363	531.428715270782
11	196111	426.635134341211	389.672783323704	463.597485358717
12	196112	468.722280768837	431.527372120416	505.917189417259

- The columns of the output table specified by outputDetailTableName are as follows.

Column	Description
key	"model" indicates the model. "evaluation" indicates the evaluation result. "parameters" indicates the training parameters. "log" indicates the training log.
summary	The storage details.

Output data

1	model	{ "comment": { "ma": "arima estimate", "mr": "regress...
2	evaluation	{ "comment": { "aic": "AIC", "aicc": "AICC (F-correcte...
3	paramters	{ "arima": { "d": 1, "isSeasonal": true, "p": 3, "period":...
4	log	1 Log for X-13ARIMA-SEATS program (Version 1.1...

- Model data (key=model)

operator	factor	period	lag	estimate	standard error
AR	Nonseasonal	1	1	0.6135	0.0928
AR	Nonseasonal	1	2	0.2403	0.1035
AR	Nonseasonal	1	3	-0.0732	0.0906
MA	Nonseasonal	1	1	0.9737	0.0376
MA	Seasonal	12	12	0.1051	0.1031

- Evaluation metrics (key=evaluation)

Name	Indicator
AIC	1019.6973
BIC	1036.9485
Hannan Quinn	1026.7072
Log likelihood	-503.8487
Effective number of observations	131
Number of observations	144
variance	127.0384

4.4.8.2. x13_auto_arima

ARIMA is described in x13_arima. The x13_auto_arima algorithm includes a process of automatic model selection.

The x13_auto_arima selection process is as follows:

- **Default model estimation**

  In the case of `frequency = 1`, the default model is `(0,1,1)`.

  In the case of `frequency > 1`, the default model is `(0,1,1)(0,1,1)`.

- **Identification of differencing orders**

Skip this step if you have configured diff and SeasonalDiff.

Use `Unit root test (wiki )` to determine the difference d and the seasonal difference D.

- **Identification of ARMA model orders**

  Select the optimal model based on BIC (wiki). The maxOrder and maxSeasonalOrder parameters are used in this step.

- **Comparison of identified model with default model**

  Use Ljung-Box Q statistic(wiki) to compare the models. If both models are unacceptable, use the `(3,d,1)(0,D,1)` model.

- **Final model checks**

PAI command

```
pai -name x13_auto_arima
  -project algo_public
  -DinputTableName=pai_ft_x13_arima_input
  -DseqColName=id
  -DvalueColName=number
  -Dstart=1949.1
  -Dfrequency=12
  -DpredictStep=12
  -DoutputPredictTableName=pai_ft_x13_arima_out_predict2
  -DoutputDetailTableName=pai_ft_x13_arima_out_detail2
```

Algorithm parameters

Parameters

Parameter	Description	Valid values	Default value
inputTableName	Required. The name of the input table.	Table name	-

Parameter	Description	Valid values	Default value
inputTablePartitions	Optional. The partitions selected from the input table for training, in the format of `partition_name=value`. To specify multiple partitions, use the following format: `name1=value1/name2=value2`. Separate multiple partitions with commas (,).	Partition name	All partitions are selected by default.
seqColName	Required. The name of the time series column.	Column name	This parameter is only used to sort valueColNames. It is not relevant to the calculated output.
valueColName	Required. The name of the value column.	Column name	-
groupColNames	Optional. The name of the stratification column. Separate multiple columns with commas (,), such as `col0,col1;`. A time series is created for each group.	Column name	-
start	Optional. The start date of a time series.	A string in the format of `year.seasonal`, such as 1986.1 For more information, see the time series format section.	1.1
frequency	Optional. The frequency of a time series.	A positive integer in the range of (0, 12) For more information, see the time series format section.	The frequency is 12 months/year by default.
maxOrder	Optional. The maximum values of p and q.	A positive integer in the range of [0, 4]	2

Parameter	Description	Valid values	Default value
maxSeasonalOrder	Optional. The seasonal maximum values of p and q.	A positive integer in the range of [0, 2]	1
maxDiff	Optional. The maximum value of differential d.	A positive integer in the range of [0, 2]	2
maxSeasonalDiff	Optional. The maximum value of seasonal differential d.	A positive integer in the range of [0, 1]	1
diff	Optional. The differential d.	A positive integer in the range of [0, 2] If both diff and maxDiff are set, maxDiff is ignored. If diff is set, then seasonalDiff must also be set.	Default value: -1. This value indicates that diff is not specified by default.
seasonalDiff	Optional. The seasonal differential d.	A positive integer in the range of [0, 1] If both seasonalDiff and maxSeasonalDiff are set, maxSeasonalDiff is ignored.	Default value: -1. This value indicates that seasonalDiff is not specified by default.
maxiter	Optional. The maximum number of iterations.	A positive integer	1500
tol	Optional. The degree of tolerance.	A double type value	1e-5
predictStep	Optional. The number of prediction items.	A number in the range of (0, 365]	12
confidenceLevel	Optional. The prediction confidence level.	A number in the range of (0, 1)	0.95
outputPredictTableName	Required. The name of the output prediction table.	Table name	-
outputDetailTableName	Required. The name of the output detail table.	Table name	-
outputTablePartition	Optional. The partitions in the output table.	Partition name	No partition is specified by default.

Parameter	Description	Valid values	Default value
coreNum	Optional. The number of cores.	A positive integer used with memSizePerCore	Automatically calculated.
memSizePerCore	Optional. The memory size of each core. Unit: MB.	A positive integer in the range of [1024, 65536]	Automatically calculated.
lifecycle	Optional. The lifecycle of the output table.	A positive integer	No lifecycle is set by default.

Time format

- The start and frequency parameters specify the two time dimensions of data (valueColName): TS1 and TS2.
- The frequency parameter indicates the data frequency within a period, which equals the frequency of TS2 in each TS1.
- The start parameter is in the format of `n1.n2`. This indicates that the start date is the N2 TS2 in the N1 TS1.

Unit time	ts1	ts2	Frequency	Start date
12	Year	Month	12	1949.2 indicates the second month of year 1949.
4	Year	Quarter	4	1949.2 indicates the second quarter of year 1949.
7	Day	Week	7	1949.2 indicates the second day of a week in year 1949.
1	Any time unit	1	1	1949.1 indicates the 1949th (year, day, or hour).

For example, value=[1,2,3,5,6,7,8,9,10,11,12,13,14,15].

- `start=1949.3` and `frequency=12` indicate that the data frequency is monthly, and the prediction start date is 1950.06.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1949			1	2	3	4	5	6	7	8	9	10
1950	11	12	13	14	15							

- `start=1949.3` and `frequency=4` indicate that the data frequency is quarterly, and the prediction start date is 1953.02.

Year	Qtr1	Qtr2	Qtr3	Qtr4
1949			1	2
1950	3	4	5	6
1951	7	8	9	10
1952	11	12	13	14
1953	14			

- `start=1949.3` and `frequency=7` indicate that the data frequency is daily, and the prediction start date is 1951.04.

Week	Sun	Mon	Tue	Wed	Thu	Fri	Sat
1949			1	2	3	4	5
1950	6	7	8	9	10	11	12
1951	13	14	15				

- `start=1949.1` and `frequency=1` indicate that the end date is 1963.00.

Period	p1
1949	1
1950	2
1951	3
1951	4
1952	5
1953	6
1954	7
1955	8
1956	9
1957	10
1958	11
1959	12

Period	p1
1960	13
1961	14
1962	15

Examples

- Data used for testing: AirPassengers. This data set contains the number of passengers for international airlines each month from 1949 to 1960. It can be downloaded from https://stat.ethz.ch/R-manual/R-devel/library/datasets/html/AirPassengers.html.

```
create table pai_ft_x13_arima_input(id bigint,number bigint);
tunnel upload data/airpassengers.csv pai_ft_x13_arima_input -h true;
```

- PAI command

```
pai -name x13_auto_arima
 -project algo_public
 -DinputTableName=pai_ft_x13_arima_input
 -DseqColName=id
 -DvalueColName=number
 -Dstart=1949.1
 -Dfrequency=12
 -DmaxOrder=4
 -DmaxSeasonalOrder=2
 -DmaxDiff=2
 -DmaxSeasonalDiff=1
 -DpredictStep=12
 -DoutputPredictTableName=pai_ft_x13_arima_auto_out_predict
 -DoutputDetailTableName=pai_ft_x13_arima_auto_out_detail
```

- Output description:

- Output table: outputPredictTableName. The columns are as follows.

Column name	Description
pdate	The prediction date.
forecast	The prediction result.
lower	The lower threshold of the prediction result when the confidence level is confidenceLevel (default value: 0.95).
upper	The upper threshold of the prediction result when the confidence level is confidenceLevel (default value: 0.95).

Data:

	key	summary
1	model	{ "comment": { "ma": "arima estimate", "mr": "regress...
2	evaluation	{ "comment": { "aic": "AIC", "aicc": "AICC (F-correcte...
3	paramters	{ "arima": { "d": 1, "isSeasonal": true, "p": 3, "period":...
4	log	1 Log for X-13ARIMA-SEATS program (Version 1.1...

- Output table: outputDetailTableName. The columns are as follows.

Column name	Description
key	"model" indicates the model. "evaluation" indicates the evaluation result. "parameters" indicates the training parameters. "log" indicates the training log.
summary	Storage details.

4.4.9. Text analysis

4.4.9.1. Word splitting

Based on Alibaba Word Segmenter (AliWS), this component performs word splitting on documents specified by columns. Segmented words are separated with spaces. If you have set the part-of-speech (POS) tagging or semantic tagging parameters, the component outputs the word splitting results, POS tagging results, and semantic tagging results. Forward slashes `(/)` are used as delimiters for POS tagging. Vertical bars `(|)` are used as delimiters for semantic tagging. Only Chinese Taobao word segmentation and Internet word segmentation are supported.

Parameter settings

Word segmentation algorithms: CRF and UNIGRAM.

Parameters

Parameter	Description
Recognition Options	Specifies whether to recognize nouns with special meanings during word splitting.
Merge Options	Considers the terms used in certain industries as a whole without splitting.
Tokenizer	Allows you to select the Taobao word segmentation or Internet word segmentation. Taobao word segmentation is recommended.
Pos Tagger	Specifies whether to mark the part of speech for each word. If this parameter is specified, the part of speech for each word is marked in the output.

Examples

The following input table consists of the id column (document IDs) and the text column (document content).

PAI command

```
pai -name split_word
-project algo_public
-DinputTableName=doc_test
-DselectedColNames=content1,content2
-DoutputTableName=doc_test_split_word
-DinputTablePartitions="region=cctv_news"
-DoutputTablePartition="region=news"
-Dtokenizer=TAOBAO_CHN
-DenableDfa=true
-DenablePersonNameTagger=false
-DenableOrgnizationTagger=false
-DenablePosTagger=false
-DenableTelephoneRetrievalUnit=true
-DenableTimeRetrievalUnit=true
-DenableDateRetrievalUnit=true
-DenableNumberLetterRetrievalUnit=true
-DenableChnNumMerge=false
-DenableNumMerge=true
-DenableChnTimeMerge=false
-DenableChnDateMerge=false
-DenableSemanticTagger=true
```

Algorithm parameters

Parameters

Parameter	Description	Valid values	Default value
inputTableName	The name of the input table.	-	-
selectedColNames	The names of the columns selected from the input table for word segmentation.	Separate multiple columns with commas (,).	-
outputTableName	The name of the output table.	-	-
inputTablePartitions	Optional. The partitions selected from the input table for training, in the format of `partition_name=value`. To specify multiple partitions, use the following format: `name1=value1/name2=value2`. Separate multiple partitions with commas (,).	-	All partitions in the input table are selected by default.
outputTablePartition	The partition in the output table.	-	The output table is non-partitioned by default.
tokenizer	The type of the classifier.	TAOBAO_CHN and INTERNET_CHN	Default value: TAOBAO_CHN. *TAOBAO_CHN* represents Taobao word segmentation. *INTERNET_CHN* represents Internet word segmentation.
enableDfa	Specifies whether to enable simple entity recognition.	true and false	true
enablePersonNameTagger	Specifies whether to enable personal name recognition.	true and false	false

Parameter	Description	Valid values	Default value
enableOrgnizationTagger	Specifies whether to enable organization name recognition.	true and false	false
enablePosTagger	Specifies whether to enable part-of-speech tagging.	true and false	false
enableTelephoneRetrievalUnit	Specifies whether to enable retrieval unit configuration for telephone number recognition.	true and false	true
enableTimeRetrievalUnit	Specifies whether to enable retrieval unit configuration for time ID recognition.	true and false	true
enableDateRetrievalUnit	Specifies whether to enable retrieval unit configuration for date ID recognition.	true and false	true
enableNumberLetterRetrievalUnit	Specifies whether to enable retrieval unit configuration for number and letter recognition.	true and false	true
enableChnNumMerge	Specifies whether to merge Chinese numbers into a retrieval unit.	true and false	false
enableNumMerge	Specifies whether to merge regular numbers into a retrieval unit.	true and false	true
enableChnTimeMerge	Specifies whether to merge Chinese time into a semantic unit.	true and false	false
enableChnDateMerge	Specifies whether to merge Chinese dates into a semantic unit.	true and false	false
enableSemanticTagger	Specifies whether to enable semantic tagging.	true and false	false

4.4.9.2. Deprecated word filtering

Deprecated word filtering is a preprocessing method in text analysis. This method is used to filter out the noise in word splitting results, such as of, yes, and ah.

Parameter settings

The left and right input ports are as follows:

- Input table, which is a word splitting result table for filtering. Parameter: inputTableName
- Deprecated word table, which is a one-column table with each row containing a deprecated word. Parameter: noiseTableName

PAI command

```
PAI -name FilterNoise
-project algo_public
-DinputTableName="test_input"
-DnoiseTableName="noise_input"
-DoutputTableName="test_output"
-DselectedColNames="words_seg1,words_seg2"
-Dlifecycle=30
```

Parameters

Parameter	Description	Valid values	Default value
inputTableName	Required. The name of the input table.	-	-
inputTablePartitions	Optional. The partitions selected from the input table for calculation.	-	All partitions in the input table are selected by default.
noiseTableName	Required. The name of the deprecated word table.	A one-column table with each row containing a deprecated word	-
noiseTablePartitions	Optional. The partitions selected from the deprecated word table.	-	All partitions in the table are selected by default.
outputTableName	Required. The name of the output table.	-	-
selectedColNames	Required. The name of the column to be filtered. Separate multiple columns with commas (,).	-	-

Parameter	Description	Valid values	Default value
lifecycle	Optional. The lifecycle of the output table.	A positive integer	No lifecycle is set by default.
coreNum	Optional. The number of cores.	A positive integer	Automatically calculated.
memSizePerCore	Optional. The memory size of each core. Unit: MB.	A positive integer in the range of (0, 65536)	Automatically calculated.

4.4.9.3. String similarity

String similarity calculation is a basic operation in machine learning that is used in information retrieval, natural language processing, and bioinformatics. This algorithm supports five methods to calculate similarity: Levenshtein distance, longest common substring, string subsequence kernel, cosine, and simhash_hamming. It also supports two input methods: string-to-string calculation and top N calculation.

PAI command

```
PAI -name string_similarity
-project algo_public
-DinputTableName="pai_test_string_similarity"
-DoutputTableName="pai_test_string_similarity_output"
-DinputSelectedColName1="col0"
-DinputSelectedColName2="col1";
```

Parameters

Parameter	Description	Valid values	Default value
inputTableName	Required. The name of the input table.	-	-
outputTableName	Required. The name of the output table.	-	-
inputSelectedColName1	Optional. The name of the first column for similarity calculation.	-	By default, the first string type column in the table is selected.
inputSelectedColName2	Optional. The name of the second column for similarity calculation.	-	The second string type column in the table is selected by default.

Parameter	Description	Valid values	Default value
inputAppendColNames	Optional. The names of columns appended to the output table.	-	No column is appended by default.
inputTablePartitions	Optional. The partitions selected from the input table for calculation.	-	The whole table is selected by default.
outputColName	Optional. The name of the similarity column in the output table. The column name can be up to 128 characters in length and can contain letters, digits, and underscores (_). It must start with a letter.	-	output
method	Optional. The similarity calculation method.	levenshtein, levenshtein_sim, lcs, lcs_sim, ssk, cosine, simhash_hamming, simhash_hamming_sim, minhash_sim, and hash_jaccard_sim	levenshtein_sim
lambda	Optional. The weight of the matching string. This parameter takes effect when similarityType is set to ssk.	(0, 1)	0.5
k	Optional. The length of the substring. This parameter takes effect when similarityType is set to ssk or cosine.	(0, 100)	2
kVec	Optional. The number of MinHash instances.	A positive integer	2
b	Optional. The number of buckets.	A positive integer	1
seed	Optional. The random seed used in a MinHash instance.	A positive integer	0
lifecycle	Optional. The lifecycle of the output table.	A positive integer	No lifecycle is set by default.

Parameter	Description	Valid values	Default value
coreNum	Optional. The number of cores.	A positive integer	Automatically calculated.
memSizePerCore	Optional. The memory size of each core. Unit: MB.	A positive integer in the range of (0, 65536)	Automatically calculated.

Examples

- SQL statement to generate data:

```
create table pai_ft_string_similarity_input
as select * from
(select 0 as id, "Beijing" as col0,
"Beijing" as col1 from dual union all
select 1 as id,
"Beijing" as col0,
"Beijing Shanghai" as col1 from dual union all
select 2 as id,
"Beijing" as col0,
"Beijing Shanghai Hongkong" as col1 from dual )tmp;
```

- PAI command

```
PAI -name string_similarity
-project sre_mpi_algo_dev
-DinputTableName=pai_ft_string_similarity_input
-DoutputTableName=pai_ft_string_similarity_output
-DinputSelectedColName1=col0
-DinputSelectedColName2=col1
-Dmethod=simhash_hamming
-DinputAppendColNames=col0,col1;
```

- Output description
  - Output obtained by using the simhash_hamming method:

col0	col1	output
beijing	beijing	0
beijing	beijing shanghai	6
beijing	beijing shanghai xianggang	13

- Output obtained by using the simhash_hamming_sim method:

col0	col1	output
beijing	beijing	1
beijing	beijing shanghai	0.90625
beijing	beijing shanghai xianggang	0.796875

4.4.9.4. Convert row, column, and value to KV pair

This component converts rows, columns, and values into KV pairs. A row, column, and value set is defined as XXD or XXL, where X can represent any type, D represents Double, and L represents Bigint. The row, column, and value set is converted into KV format (row,[col_id:value]). The row and value types are consistent with the original input data. The col_id type is Bigint, and the column is mapped to col_id based on the index table.

PAI command

```
PAI -name triple_to_kv
-project algo_public
-DinputTableName=test_data
-DoutputTableName=test_kv_out
-DindexOutputTableName=test_index_out
-DidColName=id
-DkeyColName=word
-DvalueColName=count
-DinputTablePartitions=ds=test1
-DindexInputTableName=test_index_input
-DindexInputKeyColName=word
-DindexInputKeyIdColName=word_id
-DkvDelimiter=:
-DpairDelimiter=;
-Dlifecycle=3
```

Parameters

Parameters

Parameter	Description	Default value
inputTableName	Required. The name of the input table.	The input table cannot be empty.
idColName	Required. The name of the column to be retained after the table is converted into a KV table.	-

Parameter	Description	Default value
keyColName	Required. The name of the key column in the KV table.	-
valueColName	Required. The name of the value column in the KV table.	-
outputTableName	Required. The name of the output KV table.	-
indexOutputTableName	Required. The name of the index table for the output keys.	-
indexInputTableName	Optional. The name of the input index table.	No index table is set by default. The table cannot be empty and it does not need to contain indexes for all of the output keys.
indexInputKeyColName	Optional. The name of the key column in the input index table.	No key column is specified by default. This parameter is required if indexInputTableName is set.
indexInputKeyIdColName	Optional. The name of the index column in the input index table.	No index column is specified by default. This parameter is required if indexInputTableName is set.
inputTablePartitions	Optional. The partitions in the input table.	No partition is specified by default. Only one partition can be input.
kvDelimiter	Optional. The delimiter used to separate the key and value.	The default delimiter is a colon (:).
pairDelimiter	Optional. The delimiter used to separate KV pairs.	The default delimiter is a semicolon (;).
lifecycle	Optional. The lifecycle of the output table.	No lifecycle is set by default.
coreNum	Optional. The number of cores.	-1
memSizePerCore	Optional. The memory size of each core. Valid values: 100 to 65536.	-1

Examples

- SQL statement to generate data:

```
drop table if exists triple2kv_test_input;
create table triple2kv_test_input as
select * from
( select '01' as id, 'a' as word,
10 as count from dual union all
select '01' as id, 'b' as word,
20 as count from dual union all
select '01' as id, 'c' as word,
30 as count from dual union all
select '02' as id,
'a' as word,
100 as count from dual union all
select '02' as id, 'd' as word,
200 as count from dual union all
select '02' as id, 'e' as word,
300 as count from dual ) tmp;
```

- PAI command

```
PAI -name triple_to_kv
-project algo_public
-DinputTableName=triple2kv_test_input
-DoutputTableName=triple2kv_test_input_out
-DindexOutputTableName=triple2kv_test_input_index_out
-DidColName=id
-DkeyColName=word
-DvalueColName=count
-Dlifecycle=1;
```

Input description

Input table

Input description

id	word	count
01	a	10
01	b	20
01	c	30

Output description

- The output KV table is as follows, where custom KV delimiters can be used.

Output description

id	key_value
01	1:10;2:20;3:30

- The output index table that contains indexes for the words is as follows.

Output index table

key	key_id
a	1
b	2
c	3

4.4.9.5. String similarity - Top N

String similarity calculation is a basic operation in machine learning that is used in information retrieval, natural language processing, and bioinformatics. This algorithm supports five methods to calculate similarity: Levenshtein distance, longest common substring, string subsequence kernel, cosine, and simhash_hamming. It also supports two input methods: string-to-string calculation and top N calculation.

PAI command

```
PAI -name string_similarity_topn
-project algo_public
-DinputTableName="pai_test_string_similarity_topn"
-DoutputTableName="pai_test_string_similarity_topn_output"
-DmapTableName="pai_test_string_similarity_map_topn"
-DinputSelectedColName="col0"
-DmapSelectedColName="col1";
```

Parameters

Parameter	Description	Valid values	Default value
inputTableName	Required. The name of the input table.	-	-
mapTableName	Required. The name of the mapping table.	-	-
outputTableName	Required. The name of the output table.	-	-

Parameter	Description	Valid values	Default value
inputSelectedColName	Optional. The name of the column selected from the left table for similarity calculation.	-	The first string type column in the table is selected by default.
mapSelectedColName	Optional. The name of the column selected from the mapping table for similarity calculation. The similarities between each row in the left table and all strings in the mapping table are calculated, and the top N entries are output.	-	The first string type column in the table is selected by default.
inputAppendColNames	Optional. The names of columns appended to the output table from the input table.	-	No column is appended by default.
inputAppendRenameColNames	Optional. The aliases of columns appended to the output table from the input table. This parameter takes effect when inputAppendColNames is specified.	-	No alias is specified by default.
mapAppendColNames	Optional. The names of columns appended to the output table from the mapping table.	-	No column is appended by default.
mapAppendRenameColNames	Optional. The aliases of columns appended to the output table from the mapping table.	-	No alias is specified by default.
inputTablePartitions	Optional. The partitions selected from the input table.	-	The whole table is selected by default.
mapTablePartitions	Optional. The partitions in the mapping table.	-	The whole table is selected by default.

Parameter	Description	Valid values	Default value
outputColName	Optional. The name of the similarity column in the output table. The column name can be up to 128 characters in length and can contain letters, digits, and underscores (_). It must start with a letter.	-	output
method	Optional. The similarity calculation method.	levenshtein_sim, lcs_sim, ssk, cosine, simhash_hamming_sim, minhash_sim, and hash_jaccard_sim	levenshtein_sim
lambda	Optional. The weight of the matching string. This parameter takes effect when similarityType is set to ssk.	(0, 1)	0.5
k	Optional. The length of the substring. This parameter takes effect when similarityType is set to ssk or cosine.	(0, 100)	2
kVec	Optional. The number of MinHash instances.	A positive integer	2
b	Optional. The number of buckets.	A positive integer	1
seed	Optional. The random seed used in a MinHash instance.	A positive integer	0
topN	Optional. The number of similarity maximums to be output.	(0, +∞)	10
lifecycle	Optional. The lifecycle of the output table.	A positive integer	No lifecycle is set by default.
coreNum	Optional. The number of cores.	A positive integer	Automatically calculated.
memSizePerCore	Optional. The memory size of each core. Unit: MB.	A positive integer in the range of (0, 65536)	Automatically calculated.

Examples

- SQL statement to generate data:

```
create table pai_ft_string_similarity_topn_input
as select * from
(select 0 as id,
"Beijing" as col0 from dual union all
select 1 as id,
"Beijing Shanghai" as col0 from dual union all
select 2 as id,
"Beijing Shanghai Hongkong" as col0 from dual )tmp;
```

- PAI command

```
PAI -name string_similarity_topn
-project sre_mpi_algo_dev
-DinputTableName=pai_ft_string_similarity_topn_input
-DmapTableName=pai_ft_string_similarity_topn_input
-DoutputTableName=pai_ft_string_similarity_topn_output
-DinputSelectedColName=col0
-DmapSelectedColName=col0
-DinputAppendColNames=col0
-DinputAppendRenameColNames=input_col0
-DmapAppendColNames=col0
-DmapAppendRenameColNames=map_col0
-Dmethod=simhash_hamming_sim;
```

- Output.

input_col0	map_col0	output
beijing	beijing	1
beiji beijing	beijing shanghai	0.90625
beijing	beijing shanghai xianggang	0.796875
beijing shanghai	beijing shanghai	1
beijing shanghai	beijing	0.90625
beijing shanghai	beijing shanghai xianggang	0.828125
beijing shanghai xianggang	beijing shanghai xianggang	1
beijing shanghai xianggang	beijing shanghai	0.828125
beijing shanghai xianggang	beijing	0.796875

4.4.9.6. N-gram counting

N-gram counting is a step in language model training. N-grams are generated based on words.The number of the corresponding N-grams in all corpora is counted. The N-gram counting model counts the number of N-grams in all documents rather than in a single document. For more information, see ngram-count.

PAI command

```
PAI -name ngram_count
  -project algo_public
  -DinputTableName=pai_ngram_input
  -DoutputTableName=pai_ngram_output
  -DinputSelectedColNames=col0
  -DweightColName=weight
  -DcoreNum=2
  -DmemSizePerCore=1000;
```

Parameters

Parameter	Description	Valid values	Default value
inputTableName	Required. The name of the input table.	Table name	N/A
outputTableName	Required. The name of the output table.	Table name	N/A
inputSelectedColNames	Optional. The names of columns selected from the input table.	Column name	The first character type column is selected by default.
weightColName	Optional. The name of the weight column.	Column name	1
inputTablePartitions	Optional. The partitions selected from the input table.	Partition name	The whole table is selected by default.
countTableName	Optional. The name of the former N-gram counting output table. This table is merged into the output result.	Table name	N/A
countWordColName	Optional. The name of the word column in the counting table.	Column name	The second column is selected by default.
countCountColName	Optional. The name of the counting column in the counting table.	Column name	The third column is selected by default.

Parameter	Description	Valid values	Default value
countTablePartitions	Optional. The partitions in the counting table.	Partition name	N/A
vocabTableName	Optional. The name of the bag-of-words table. The words that are not contained in the bag-of-words table are marked with \<unk\>.	Table name	N/A
vocabSelectedColName	Optional. The name of the bag-of-words column.	Column name	The first character type column is selected by default.
vocabTablePartitions	Optional. The partitions in the bag-of-words table.	Partition name	N/A
order	Optional. The maximum length of N-grams.	N/A	3
lifecycle	Optional. The lifecycle of the output table.	A positive integer	N/A
coreNum	Optional. The number of cores.	A positive integer	N/A
memSizePerCore	Optional. The memory size of each core.	A positive integer	N/A

4.4.9.7. Text summarization

Automatic summarization uses computers to automatically extract summaries from a source document. A summary is a simple, concise, and short document that completely and accurately describes the content of a certain document. This TextRank-based algorithm generates summaries by extracting existing sentences in the document.

PAI command

```
PAI -name TextSummarization
-project algo_public
–DinputTableName="test_input"
-DoutputTableName="test_output"
-DdocIdCol="doc_id"
-DsentenceCol="sentence"
-DtopN=2
-Dlifecycle=30;
```

Algorithm parameters

Parameters

Parameter	Description	Valid values	Default value
inputTableName	Required. The name of the input table.	-	-
inputTablePartitions	Optional. The partitions selected from the input table for calculation.	-	All partitions in the input table are selected by default.
outputTableName	Required. The name of the output table.	-	-
docIdCol	Required. The name of the document ID column.	-	-
sentenceCol	Required. The sentence column.	Only one column can be specified.	-
topN	Optional. The top N key sentences to be output.	-	3
similarityType	Optional. The method used to calculate sentence similarity.	lcs_sim, levenshtein_sim, cosine, and ssk	lcs_sim
lambda	Optional. The weight of the matching string. This parameter takes effect when similarityType is set to ssk.	(0, 1)	0.5
k	Optional. The length of the substring. This parameter takes effect when similarityType is set to ssk or cosine.	(0, 100)	2
dampingFactor	Optional. The damping factor.	(0, 1)	0.85
maxIter	Optional. The maximum number of iterations.	[1, +]	100
epsilon	Optional. The convergence coefficient.	(0, ∞)	0.000001
lifecycle	Optional. The lifecycle of the output table.	A positive integer	No lifecycle is set by default.

Parameter	Description	Valid values	Default value
coreNum	Optional. The number of cores.	A positive integer	Automatically calculated.
memSizePerCore	Optional. The memory size of each core.	A positive integer	Automatically calculated.

The sentence similarity options are as follows:

- lcs_sim: The formula is `1.0 - (Length of the longest common subsequence)/max(len(A), len(B))` .
- levenshtein_sim: The formula is `1.0 - (Levenshtein distance)/max(len(A), len(B))` .
- cosine: See `Lodhi, Huma; Saunders, Craig; Shawe-Taylor, John; Cristianini, Nello; Watkins, Chris (2002). "Text classification using string kernels". Journal of Machine Learning Research: 419-444` .
- ssk: See `Leslie, C.; Eskin, E.; Noble, W.S. (2002), The spectrum kernel: A string kernel for SVM protein classification 7, pp. 566-575` .

> **Note** `A` and `B` indicate two strings, and `len(A)` indicates the length of string A.

Output format description

The output table contains the doc_id and abstract columns, as shown in Output table example.

Output table example

doc_id	abstract
1000894	In 2008, the Shanghai Stock Exchange published disclosure guidelines for the corporate social responsibility of listed companies. Three types of companies were urged to disclose their CSR reports, and other qualified listed companies were encouraged to voluntarily disclose their CSR reports. In 2012, a total of 379 listed companies making up a 40% of all listed companies disclosed CSR reports. Of those companies, 305 were mandated to disclose CSR reports and and 75 voluntarily disclosed CSR reports. According to Hu Ruyin, Shanghai Stock Exchange will explore how to expand the scope of CSR report disclosure, revise and refine the guidelines on disclosure of the CSR reports, and encourage more organizations to promote CSR product innovation.

4.4.9.8. Keyword extraction

Keyword extraction is one of the important technologies in natural language processing. It is used to extract keywords from a document. This algorithm is based on TextRank, a variation of the PageRank algorithm used to describe the relationship between webpages. This algorithm uses the relationship between certain words to construct a network, calculate the importance of each word, and determine words with larger weights as keywords.

PAI command

```
PAI -name KeywordsExtraction
-DinputTableName=maple_test_keywords_basic_input
-DdocIdCol=docid -DdocContent=word
-DoututTableName=maple_test_keywords_basic_output
-DtopN=19;
```

Algorithm parameters

Parameters

Parameter	Description	Valid values	Default value
inputTableName	Required. The name of the input table.	Table name	-
inputTablePartitions	Optional. The partitions selected from the input table for training, in the format of `partition_name=value`. To specify multiple partitions, use the following format: `name1=value1/name2=value2`. Separate multiple partitions with commas (,).	-	All partitions are selected by default.
outputTableName	Required. The name of the output table.	-	-
docIdCol	Required. The name of the document ID column.	Only one column can be specified.	-
docContent	Required. The word column.	Only one column can be specified.	-

Parameter	Description	Valid values	Default value
topN	Optional. The number of top N keywords to be output. If this number is smaller than the number of keywords, all keywords are output.	-	5
windowSize	Optional. The window size of the TextRank algorithm.	-	2
dumpingFactor	Optional. The damping factor of the TextRank algorithm.	-	0.85
maxIter	Optional. The maximum number of iterations of the TextRank algorithm.	-	100
epsilon	Optional. The convergence residual threshold of the TextRank algorithm.	-	0.000001
lifecycle	Optional. The lifecycle of the output table.	A positive integer	No lifecycle is set by default.
coreNum	Optional. The number of cores.	This parameter is used with memSizePerCore. The value must be a positive integer in the range of [1, 9999].	Automatically calculated.
memSizePerCore	Optional. The memory size of each core. Unit: MB.	A positive integer in the range of [1024, 65536]	Automatically calculated.

Examples

The words in the input table are separated with spaces, and deprecated words and all punctuations are filtered out.

Examples

docid: string	word: string

docid: string	word: string
doc0	The blended-wing-body aircraft is a new direction for the future development in the aviation field Many research institutions inside and outside China have carried out research on the blended-wing-body aircraft while its fully automated shape optimization algorithm has become a new hot topic Based on the existing research achievements inside and outside China common modeling and flow solver tools have been analyzed and compared The geometric modeling grid flow field solver and shape optimization modules have been designed The pros and cons between different algorithms have been compared to achieve the optimized shape of the blended-wing-body aircraft in the conceptual design stage Geometric modeling and grid generation module are achieved based on the transfinite interpolation algorithm and spline based grid generation method The flow solver module includes the finite difference solver the finite element solver and the panel method solver The finite difference solver includes mathematical modeling of the potential flow the derivation of the Cartesian grid based variable step length difference scheme Cartesian grid generation and indexing algorithm the Cartesian grid based Neumann boundary conditions expression form derivation are achieved based on finite element difference solver The aerodynamic parameters of a two-dimensional airfoil are calculated based on the finite difference solver The finite element solver includes potential flow modeling based on the variational principle of the finite element theory the derivation of the two-dimensional finite element Kutta conditional least squares based speed solving algorithm Gmsh based two-dimensional field grid generator of airfoil with wakes design The aerodynamic parameters of a two-dimensional airfoil are calculated based on the finite element solver The panel method solver includes modeling and automatic wake generation the design of the three-dimensional flow solver of the blended-wing-body drag estimation based on the Blasius solution solver implemented in the Fortran language a mixed compilation of Python and Fortran OpenMP and CUDA based acceleration algorithm The aerodynamic parameters of a three-dimensional wing body are calculated based on the panel method solver The shape optimization module includes free form deformation algorithm genetic algorithms differential evolution algorithm Aircraft surface area calculation algorithm is based on the moments integration algorithm The volume of an aircraft calculation algorithm is based on VKT data visualization format tool

PAI command

```
PAI -name KeywordsExtraction
-DinputTableName=maple_test_keywords_basic_input
-DdocIdCol=docid -DdocContent=word
-DoututTableName=maple_test_keywords_basic_output
-DtopN=19;
```

Input/output description

Output table description

docid	keywords	weight
doc0	Based on	0.041306752223538405
doc0	Algorithm	0.03089845626854151
doc0	Modeling	0.021782865850562882
doc0	Grid	0.020669749212693957
doc0	Solver	0.020245609506360847
doc0	Aircraft	0.019850761705313365
doc0	Research	0.014193732541852615
doc0	Finite element	0.013831122054200538
doc0	Solving	0.012924593244133104
doc0	Module	0.01280216562287212
doc0	Derivation	0.011907588923852495
doc0	Shape	0.011505456605632607
doc0	Difference	0.011477831662367547
doc0	Flow	0.010969269350293957
doc0	Design	0.010830986516637251
doc0	Implementation	0.010747536556701583
doc0	Two-dimensional	0.010695570768457084
doc0	Development	0.010527342662670088
doc0	New	0.010096978306668461

4.4.9.9. Sentence splitting

You can split sentences in a document by punctuation. This component is used to preprocess text summarizations. It splits text such that each row contains only a single sentence.

PAI command

```
PAI -name SplitSentences
-project algo_public
-DinputTableName="test_input"
-DoutputTableName="test_output"
-DdocIdCol="doc_id"
-DdocContent="content"
-Dlifecycle=30
```

Parameters

Parameters

Parameter	Description	Valid values	Default value
inputTableName	Required. The name of the input table.	-	-
inputTablePartitions	Optional. The partitions selected from the input table for calculation.	-	All partitions in the input table are selected by default.
outputTableName	Required. The name of the output table.	-	-
docIdCol	Required. The name of the document ID column.	-	-
docContent	Required. The name of the document content column.	Only one column can be specified.	-
delimiter	Optional. A set of characters used to determine the end of a sentence.	-	The default delimiter set contains the period (.), question mark (!), and exclamation mark (?).
lifecycle	Optional. The lifecycle of the output table.	A positive integer	No lifecycle is set by default.
coreNum	Optional. The number of cores.	A positive integer	Automatically calculated.

Parameter	Description	Valid values	Default value
memSizePerCore	Optional. The memory size of each core.	A positive integer	Automatically calculated.

Output format description

The output table contains the doc_id and sentence columns, as shown in Output table example.

Output table example

doc_id	sentence
1000894	In 2008, the Shanghai Stock Exchange published disclosure guidelines for the corporate social responsibility of listed companies. Three types of companies were urged to disclose their CSR reports, and other qualified listed companies were encouraged to voluntarily disclose their CSR reports.
1000894	In 2012, a total of 379 listed companies making up a 40% of all listed companies disclosed CSR reports. Of those companies, 305 were mandated to disclose CSR reports and and 75 voluntarily disclosed CSR reports.

4.4.9.10. Semantic vector distance

You can calculate the extension words or sentences of the specified words or sentences based on the calculated semantic vectors, such as word vectors calculated by the Word2Vec component. The extension words or sentences are a set of vectors closest to a certain vector. The following example shows how to generate a list of words that are most similar to the word that you entered based on the word vectors calculated by the Word2Vec component.

PAI command

```
PAI -name SemanticVectorDistance
-project algo_public
-DinputTableName="test_input"
-DoutputTableName="test_output"
-DidColName="word"
-DvectorColNames="f0,f1,f2,f3,f4,f5"
-Dlifecycle=30
```

Parameters

Parameter	Description	Valid values	Default value

Parameter	Description	Valid values	Default value
inputTableName	Required. The name of the input table.	-	-
inputTablePartitions	Optional. The partitions selected from the input table for calculation.	-	All partitions in the input table are selected by default.
outputTableName	Required. The name of the output table.	-	-
idTableName	Optional. The name of the vector ID table for vector calculation. The table contains only one column and each row stores a vector ID.	-	No vector ID table is specified by default. This means that all vectors in the input table are calculated.
idTablePartitions	Optional. The partitions selected from the ID table for calculation.	-	All partitions are selected by default.
idColName	Required. The name of the ID column.	-	3
vectorColNames	Optional. A list of vector column names, such as f1, f2,...	-	-
topN	Optional. The number of the closest vectors to output.	[1, +∞]	5
distanceType	Optional. The distance calculation method.	euclidean, cosine, and manhattan	euclidean
distanceThreshold	Optional. The distance threshold. Only the distances between two vectors that do not exceed this threshold are output.	(0, +∞)	∞
lifecycle	Optional. The lifecycle of the output table.	A positive integer	No lifecycle is set by default.
coreNum	Optional. The number of cores.	A positive integer	Automatically calculated.
memSizePerCore	Optional. The memory size of each core.	A positive integer	Automatically calculated.

Examples

The output table contains the original_id, near_id, distance, and rank columns.

original_id	near_id	distance	rank
hello	hi	0.2	1
hello	xxx	xx	2
Man	Woman	0.3	1
Man	xx	xx	2
..	...	...	...

4.4.9.11. Document similarity

This algorithm calculates the similarity between two text documents by comparing the similarities of documents or sentences separated by spaces. This algorithms functions similar to how the similarity of strings is calculated.

PAI command

```
PAI -name doc_similarity
-project algo_public
-DinputTableName="pai_test_doc_similarity"
-DoutputTableName="pai_test_doc_similarity_output"
-DinputSelectedColName1="col0"
-DinputSelectedColName2="col1"
```

Parameters

Parameter	Description	Valid values	Default value
inputTableName	Required. The name of the input table.	-	-
outputTableName	Required. The name of the output table.	-	-
inputSelectedColName1	Optional. The name of the first column for similarity calculation.	-	By default, the first string type column in the table is selected.
inputSelectedColName2	Optional. The name of the second column for similarity calculation.	-	The name of the second string type column in the table is selected by default.

Parameter	Description	Valid values	Default value
inputAppendColNames	Optional. The names of columns appended to the output table.	-	No column is appended by default.
inputTablePartitions	Optional. The partitions selected from the input table.	-	The whole table is selected by default.
outputColName	Optional. The name of the similarity column in the output table. The column name can be up to 128 characters in length and can contain letters, digits, and underscores (_). It must start with a letter.	-	output
method	Optional. The similarity calculation method.	levenshtein, levenshtein_sim, lcs, lcs_sim, ssk, cosine, simhash_hamming, and simhash_hamming_sim	levenshtein_sim
lambda	Optional. The weight of the matching word pair. This parameter takes effect if similarityType is set to ssk.	(0, 1)	0.5
k	Optional. The length of the substring. This parameter takes effect if similarityType is set to ssk or cosine.	(0, 100)	2
kVec	Optional. The number of MinHash instances.	A positive integer	2
b	Optional. The number of buckets.	A positive integer	1
seed	Optional. The random seed used in a MinHash instance.	A positive integer	0
lifecycle	Optional. The lifecycle of the output table.	A positive integer	No lifecycle is set by default.
coreNum	Optional. The number of cores.	A positive integer	Automatically calculated.

Parameter	Description	Valid values	Default value
memSizePerCore	Optional. The memory size of each core. Unit: MB.	A positive integer in the range of (0, 65536)	Automatically calculated.

Examples

- SQL statement to generate data:

```
drop table if exists pai_doc_similarity_input;
create table pai_doc_similarity_input as
select * from (
select 0 as id,
"Beijing and Shanghai" as col0,
"Beijing and Shanghai" as col1 from dual union all
select 1 as id,
"Beijing and Shanghai" as col0,
"Beijing, Shanghai, and Hong Kong" as col1 from dual )tmp;
```

- PAI command

```
drop table if exists pai_doc_similarity_output;
PAI -name doc_similarity
-project algo_public
-DinputTableName=pai_doc_similarity_input
-DoutputTableName=pai_doc_similarity_output
-DinputSelectedColName1=col0
-DinputSelectedColName2=col1
-Dmethod=levenshtein_sim
-DinputAppendColNames=id,col0,col1;
```

- Input description: pai_doc_similarity_input

ID	col0	col1
1	Beijing and Shanghai	Beijing, Shanghai, and Hong Kong
0	Beijing and Shanghai	Beijing and Shanghai

- Output description: pai_doc_similarity_output

ID	col0	col1	Output
1	Beijing and Shanghai	Beijing, Shanghai, and Hong Kong	0.6666666666666667

ID	col0	col1	Output
0	Beijing and Shanghai	Beijing and Shanghai	1.0

4.4.9.12. PMI

Mutual information (MI) is a measure of information in the information theory. It can be regarded as the amount of information contained in a random variable about another variable, or the reduction in uncertainty of a random variable due to the known random variable.

This algorithm is used to count the co-occurrence of all words in several documents and calculate the point mutual information (PMI). PMI definition: `PMI(x,y)=ln(p(x,y)/(p(x)p(y)))=ln(#(x,y)D/(#x#y))`.

- `#(x,y)` indicates the number of pair(x,y).
- D indicates the total number of pairs.
- If x and y appear in the same window, the output is #x+=1;#y+=1;#(x,y)+=1.

PAI command

```
PAI -name PointwiseMutualInformation
  -project algo_public
  -DinputTableName=maple_test_pmi_basic_input
  -DdocColName=doc
  -DoutputTableName=maple_test_pmi_basic_output
  -DminCount=0
  -DwindowSize=2
  -DcoreNum=1
  -DmemSizePerCore=110;
```

Parameters

Parameter	Description	Valid values	Default value
inputTableName	Required. The name of the input table.	Table name	-
outputTableName	Required. The name of the output table.	Table name	-
docColName	Required. The name of the document column after word splitting, where words are separated with spaces.	Column name	-

Parameter	Description	Valid values	Default value
windowSize	Optional. The window size. For example, the value 5 refers to the five words adjacent on the right of the current word. Words that appear in the window are considered related to the current word.	[1, sentence length]	The whole row is selected by default.
minCount	The minimum word truncation frequency. Words that appear for a number of times less than this value are filtered out.	[0, 2e63]	5
inputTablePartitions	Optional. The partitions selected from the input table for training, in the format of `partition_name=value`. To specify multiple partitions, use the following format: `name1=value1/name2=value2`. Separate multiple partitions with commas (,).	Partition name	All partitions are selected by default.
lifecycle	Optional. The lifecycle of the output table.	A positive integer	No lifecycle is set by default.
coreNum	Optional. The number of cores.	This parameter is used with memSizePerCore. The value must be a positive integer in the range of [1, 9999].	Automatically calculated.
memSizePerCore	The memory size of each core. Unit: MB.	A positive integer in the range of [1024, 65536]	Automatically calculated.

Examples

- **Data generation**

doc:string
w1 w2 w3 w4 w5 w6 w7 w8 w8 w9
w1 w3 w5 w6 w9

doc:string
w0
w0 w0
w9 w1 w9 w1 w9

- PAI command

```
PAI -name PointwiseMutualInformation
  -project algo_public
  -DinputTableName=maple_test_pmi_basic_input
  -DdocColName=doc
  -DoutputTableName=maple_test_pmi_basic_output
  -DminCount=0
  -DwindowSize=2
  -DcoreNum=1
  -DmemSizePerCore=110;
```

- Output description

Output table

word1	word2	word1_count	word2_count	co_occurrences_count	pmi
w0	w0	2	2	1	2.0794415416798357
w1	w1	10	10	1	-1.1394342831883648
w1	w2	10	3	1	0.06453852113757116
w1	w3	10	7	2	-0.08961215868968704
w1	w5	10	8	1	-0.916290731874155
w1	w9	10	12	4	0.06453852113757116
w2	w3	3	7	1	0.4212134650763035

word1	word2	word1_count	word2_count	co_occurrences_count	pmi
w2	w4	3	4	1	0.9808292530117262
w3	w4	7	4	1	0.13353139262452257
w3	w5	7	8	2	0.13353139262452257
w3	w6	7	7	1	-0.42608439531090014
w4	w5	4	8	1	0
w4	w6	4	7	1	0.13353139262452257
w5	w6	8	7	2	0.13353139262452257
w5	w7	8	4	1	0
w5	w9	8	12	1	-1.0986122886681098
w6	w7	7	4	1	0.13353139262452257
w6	w8	7	7	1	-0.42608439531090014
w6	w9	7	12	1	-0.9650808960435872
w7	w8	4	7	2	0.8266785731844679
w8	w8	7	7	1	-0.42608439531090014
w8	w9	7	12	2	-0.27193371548364418
w9	w9	12	12	2	-0.8109302162163288

4.4.9.13. Word frequency statistics

Based on the word splitting results, this component outputs the words in their original order and calculates the frequency that a word occurs in the document (docContent) specified by the document ID column (docId).

Parameter settings

Input parameters: docId column and docContent column generated by the Word Splitting component.

Two output parameters:

- Output port 1: The output table contains the id, word, and count columns.

  count: indicates the frequency that a word occurs in each document.

- Output port 2: The output table contains the id and word columns.

  The table output by the second output port lists words in order of occurrence in the document. The table does not calculate the frequency of the occurrence. Therefore, a word may have multiple table entries in the same document. The output table format is compatible with the Word2Vec component.

Examples

In the Alibaba Cloud word splitting data, the two columns in the output table are used as the input parameters for word frequency calculation.

- Select the docId column: id.
- Select the docContent column: After the word frequency calculation is performed, the result is displayed by output port 1 on this component.

PAI command

```
pai -name doc_word_stat
-project algo_public
-DinputTableName=doc_test_split_word
-DdocId=id
-DdocContent=content
-DoutputTableNameMulti=doc_test_stat_multi
-DoutputTableNameTriple=doc_test_stat_triple
-DinputTablePartitions="region=cctv_news"
```

Algorithm parameters

Parameters

Parameter	Description	Valid values	Default value
inputTableName	The name of the input table.	-	-

Parameter	Description	Valid values	Default value
docId	The name of the document ID column.	Only one column can be specified.	-
docContent	The name of the document content column.	Only one column can be specified.	-
outputTableNameMulti	The name of the output table that lists words in the document content after word splitting. Documents are specified by the docId column and their contents are specified by the docContent column. The words are listed in the order that they occur within the documents.	-	-
outputTableNameTriple	The name of the output table that lists the words and the frequency of the occurrence of these words in the documents. The documents are specified by the docId column and their contents are specified by the docContent column.	-	-
inputTablePartitions	Optional. The partitions selected from the input table for training, in the format of `partition_name=value`. To specify multiple partitions, use the following format: `name1=value1/name2=value2`. Separate multiple partitions with commas (,).	-	All partitions in the input table are selected by default.

4.4.9.14. TF-IDF

Term frequency-inverse document frequency (TF-IDF) is typically used as a weighting technology in information retrieval and text mining. TF-IDF is a statistical method to evaluate the importance of a word for a document in a collection or corpus. The importance of a word increases as the frequency that it occurs within the document increases. The importance decreases as the frequency that the word occurs in the corpus increases. TF-IDF is frequently used by search engines as a tool in scoring and ranking the correlation between documents and user queries.

- For more information, see TF-IDF in Wikipedia.
- The TF-IDF component is used to calculate the TF-IDF value of each word that appears in a collection of documents based on word frequency statistics.

Examples

The output table in the example of the word frequency statistics component is used as the input table for the TF-IDF component. The corresponding parameter settings are as follows:

- Select the document ID column: id
- Select the word column: word
- Select the word count column: count

The output table contains the following columns: docid, word, word_count (frequency that a certain word occurs in the current document), total_word_count (total number of words in the current document), doc_count (total number of documents that contain the current word), total_doc_count (total number of documents), tf, idf.

PAI command

```
pai -name tfidf
-project algo_public
-DinputTableName=rgdoc_split_triple_out
-DdocIdCol=id
-DwordCol=word
-DcountCol=count
-DoutputTableName=rg_tfidf_out;
```

Algorithm parameters

Parameters

Parameter	Description	Valid values	Default value
inputTableName	Required. The name of the input table.	Table name	-
inputTablePartitions	Optional. The partitions selected from the input table for word splitting.	This value must be in the `partition_name=value` format. To specify multiple partitions, use the following format: `name1=value1/name2=value2`. Separate multiple partitions with commas (,).	All partitions in the input table are selected by default.
docIdCol	Required. The name of the document ID column.	Only one column can be specified.	-
wordCol	Required. The name of the word column.	Only one column can be specified.	-

Parameter	Description	Valid values	Default value
countCol	Required. The name of the count column.	Only one column can be specified.	-
outputTableName	Required. The name of the output table.	Table name	-
outputTablePartition	The partitions in the output table.	Partition name	The output table is non-partitioned by default.

4.4.9.15. PLDA

Latent Dirichlet Allocation (LDA) is a topic model that outputs the topic of a document. It outputs the topic of each document based on probability distribution. LDA is an unsupervised learning algorithm that does not require a manually tagged training set. Instead, it only requires a set of documents and the number of topics (k). It is used in text mining, including text topic recognition, text classification, and text similarity calculation.

Parameter settings

Parameters

Parameter	Description
Topics	The number of topics output by LDA.
Alpha	The AlphaPrior Dirichlet distribution parameter of `P(z/d)`.
Beta	The AlphaPrior Dirichlet distribution parameter of `P(w/z)`.
Burn-in Iterations	The number of burn-in iterations. The parameter value must be less than the total number of iterations. The default value is 100.
Total Iterations	Optional. The total number of iterations. The parameter value must be a positive integer. The default value is 150.

Note z represents topics, w represents words, and d represents documents.

Input and output settings

- **Input:**

The data must be in the sparse matrix format. For more information about the format, see the data format description section. You can use the Convert Row, Column, and Value to KV Pair component to convert the data. Input format as shows the following picture.

```
| id          | features |
+-------------+----------+
| 2           | 38:3.0,39:1.0,40:3.0,41:1.0,42:1.0,43:2.0,44:1.0,45:1.0,46:1.0,47:1.0,48:1.0,49:2.0,50:1.0,51:1.0,52:1.0,53:1.0,54:1.0,55:1.0,5
6:1.0,57:1.0,58:1.0,59:1.0,60:1.0,61:1.0,62:1.0,63:1.0,64:1.0,65:1.0,66:1.0,67:1.0,68:1.0,69:1.0,70:1.0,71:1.0,72:1.0,73:1.0,74:1.0,75:1.0,76:
1.0,77:2.0 |
| 1           | 0:1.0,1:2.0,3:1.0,4:1.0,5:1.0,6:1.0,7:1.0,8:1.0,9:1.0,10:1.0,11:1.0,12:1.0,13:1.0,14:2.0,15:1.0,16:1.0,17:1.0,18:1.0,19:1.0,20:
1.0,21:1.0,22:1.0,23:1.0,24:1.0,25:1.0,26:1.0,27:1.0,28:1.0,29:1.0,30:1.0,31:1.0,32:1.0,33:1.0,34:1.0,35:1.0,36:2.0,39:2.0,77:3.0 |
+-------------+----------+
```

- Column 1: the ID of a document.
- Column 2: KV data of the word and how frequently it occurs.

- **Output**:

  The following tables are generated in sequence: topic-word frequency contribution table, P(w/z) table, P(z/w) table, P(d/z) table, P(z/d) table, and P(z) table.

  The following picture shows the output format of the topic-word frequency contribution table.

wordid	topic_0	topic_1
0	1	0
1	2	0
2	0	0
3	1	0
4	1	0
5	1	0
6	1	0
7	1	0
8	0	1
9	1	0
10	1	0
11	1	0

PAI command

```
pai -name PLDA
-project algo_public
-DinputTableName=lda_input
–DtopicNum=10
-topicWordTableName=lda_output;
```

Algorithm parameters

Parameters

Parameter	Description	Valid values	Default value
inputTableName	Required. The name of the input table.	Table name	-

Parameter	Description	Valid values	Default value
inputTablePartitions	Optional. The partitions selected from the input table for word splitting.	This value must be in the `partition_name=value` format. To specify multiple partitions, use the following format: `name1=value1/name2=value2`. Separate multiple partitions with commas (,).	All partitions in the input table are selected by default.
selectedColNames	Optional. The names of the columns selected from the input table for LDA.	Separate multiple columns with commas (,).	All columns in the input table are selected by default.
topicNum	Required. The number of topics.	[2, 500]	-
kvDelimiter	Optional. The delimiter used to separate the key and value.	Space, comma (,), and colon (:)	The default delimiter is a colon (:).
itemDelimiter	Optional. The delimiter used to separate keys.	Space, comma (,), and colon (:)	The default delimiter is a space.
alpha	Optional. The prior Dirichlet distribution parameter of P(z/d).	(0, ∞)	0.1
beta	Optional. The prior Dirichlet distribution parameter of P(w/z).	(0, ∞)	0.01
topicWordTableName	Required. The name of the topic-word frequency contribution table.	Table name	-
pwzTableName	Optional. The name of the P(w/z) table.	Table name	No P(w/z) table is output by default.
pzwTableName	Optional. The name of the P(z/w) table.	Table name	No P(z/w) table is output by default.
pdzTableName	Optional. The name of the P(d/z) table.	Table name	No P(d/z) table is output by default.
pzdTableName	Optional. The name of the P(z/d) table.	Table name	No P(z/d) table is output by default.

Parameter	Description	Valid values	Default value
pzTableName	Optional. The name of the P(z) table.	Table name	No P(z) table is output by default.
burnInIterations	Optional. The number of burn-in iterations.	A positive integer	This value must be smaller than the total number of iterations. The default value is 100.
totalIterations	Optional. The number of iterations.	A positive integer	150

4.4.9.16. Word2Vec

Word2Vec is an open-source algorithm used to convert words into vectors. By training neural networks, Word2Vec can map words to K-dimensional space vectors and map word vectors to semantics.

For information about the Google Word2Vec toolkit, visit https://code.google.com/p/word2vec/.

Parameter settings

- Dimension of Word Features: We recommend a value from 0 to 1000.
- Downsampling Threshold: We recommend a value from 1e-3 to 1e-5.
- Input: inputs a word column and a vocabulary.
- Output: generates a word vector table and a vocabulary.

PAI command

```
pai -name Word2Vec
-project algo_public
-DinputTableName=w2v_input
-DwordColName=word
-DoutputTableName=w2v_output;
```

Algorithm parameters

Parameters

Parameter	Description	Valid values	Default value
inputTableName	Required. The name of the input table.	Table name	-

Parameter	Description	Valid values	Default value
inputTablePartitions	Optional. The partitions selected from the input table for word splitting.	The parameter value must be in the `partition_name=value` format. To specify multiple partitions, use the following format: `name1=value1/name2=value2`. Separate multiple partitions with commas (,).	All partitions in the input table are selected by default.
wordColName	Required. The name of the word column. Each row in the word column contains a single word. `</s>` is used to break lines in the corpus.	Column name	-
inVocabularyTableName	Optional. The name of the input word list, which contains the wordcount output of inputTableName.	Table name	Word count is performed for the input table by default.
inVocabularyPartitions	Optional. The partitions in the input word list.	Partition name	By default, all partitions in the table specified by inVocabularyTableName are selected.
layerSize	Optional. The dimension of word features.	0 to 1000	100
cbow	Optional. The language model.	1: cbow. 0: skip-gram.	0
window	Optional. The size of the word window.	A positive integer	5
minCount	Optional. The minimum frequency of word truncation.	A positive integer	5
hs	Optional. This parameter specifies whether to use hierarchical softmax.	1: Hierarchical softmax is used. 0: Hierarchical softmax is not used.	1
negative	Optional. The negative sampling.	0: Negative sampling is unavailable. Recommended value range: 5 to 10.	0

Parameter	Description	Valid values	Default value
sample	Optional. The downward sampling threshold.	0 or smaller values: downward sampling is unavailable. Recommended value range: 1e-3 to 1e-5.	0
alpha	Optional. The initial learning rate.	A value greater than 0	0.025
iterTrain	Optional. The number of training iterations.	A value greater than or equal to 1	1
randomWindow	Optional. This parameter specifies whether to randomly set the size of the window.	1: The window size is randomly generated.The window size value will range from 1 to 5. 0: The window size is determined by the window parameter.	1
outVocabularyTableName	Optional. The name of the output word list.	Table name	No **Output Word List** is generated by default.
outVocabularyPartition	Optional. The partition in the output word list.	Partition name	The output word list is non-partitioned by default.
outputTableName	Required. The name of the output table.	Table name	-
outputPartition	Optional. The information about partitions in the output table.	Partition name	The output table is non-partitioned by default.

4.4.10. Network analysis

4.4.10.1. K-core

The k-core of a graph is the largest subgraph in which every vertex is connected to at least k other vertices within the subgraph. The coreness of a vertex is k if it belongs to the k-core but is not included in the (k+1)-core. Therefore, the coreness of a vertex whose degree is 1 must be 0. The graph coreness is equal to that of the vertex with the largest coreness.

Parameter settings

k: Required. The value of the coreness. Default value: 3.

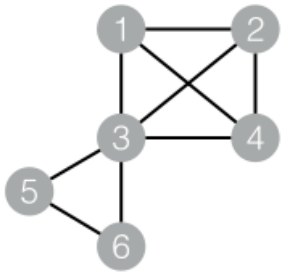
Examples - Testing data

SQL statement to generate data:

```
drop table if exists KCore_func_test_edge;
create table KCore_func_test_edge as
select * from (
select '1' as flow_out_id,
'2' as flow_in_id from dual  union all
select '1' as flow_out_id,
'3' as flow_in_id from dual  union all
select '1' as flow_out_id,
'4' as flow_in_id from dual  union all
select '2' as flow_out_id,
'3' as flow_in_id from dual  union all
select '2' as flow_out_id,
'4' as flow_in_id from dual  union all
select '3' as flow_out_id,
'4' as flow_in_id from dual  union all
select '3' as flow_out_id,
'5' as flow_in_id from dual  union all
select '3' as flow_out_id,
'6' as flow_in_id from dual  union all
select '5' as flow_out_id,
'6' as flow_in_id from dual )tmp;
```

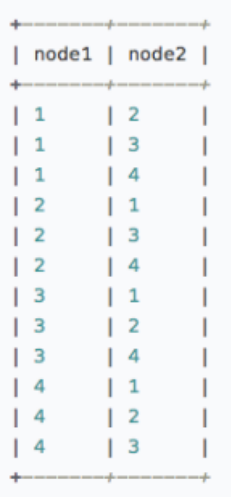
Graph structure shows the group structure.

Graph structure



Set K to 2. Output shows the output.

Output



node1	node2
1	2
1	3
1	4
2	1
2	3
2	4
3	1
3	2
3	4
4	1
4	2
4	3

PAI command

```
pai -name KCore
-project algo_public
-DinputEdgeTableName=KCore_func_test_edge
-DfromVertexCol=flow_out_id
-DtoVertexCol=flow_in_id
-DoutputTableName=KCore_func_test_result
-Dk=2;
```

Algorithm parameters

Parameters

Parameter	Description	Required	Default value
inputEdgeTableName	The name of the input edge table.	Yes	-
inputEdgeTablePartitions	The partitions selected from the input edge table.	No	The whole table is selected by default.
fromVertexCol	The start vertex column in the edge table.	Yes	-
toVertexCol	The end vertex column in the edge table.	Yes	-
outputTableName	The name of the output table.	Yes	-
outputTablePartitions	The partitions in the output table.	No	-

Parameter	Description	Required	Default value
lifecycle	The lifecycle of the output table.	No	-
workerNum	The number of workers.	No	-
workerMem	The memory size per worker.	No	4096
splitSize	The data split size.	No	64
k	The number of cores.	Yes	3

4.4.10.2. Single-source shortest path

The single-source shortest path (SSSP) refers to the shortest path between a vertex and all other vertices as calculated by the Dijkstra algorithm.

Parameter settings

Start Vertex ID: Required. The ID of the start vertex used to calculate the shortest paths.

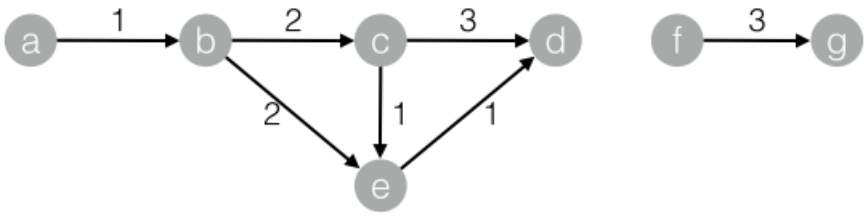
Examples - Testing data

SQL statement to generate data:

```
drop table if exists SSSP_func_test_edge;
create table SSSP_func_test_edge
as select
flow_out_id,flow_in_id,edge_weight from (
select "a" as flow_out_id,
"b" as flow_in_id,
1.0 as edge_weight from dual    union all
select "b" as flow_out_id,
"c" as flow_in_id,
2.0 as edge_weight from dual    union all
select "c" as flow_out_id,
"d" as flow_in_id,
1.0 as edge_weight from dual    union all
select "b" as flow_out_id,
"e" as flow_in_id,
2.0 as edge_weight from dual    union all
select "e" as flow_out_id,
"d" as flow_in_id,
1.0 as edge_weight from dual    union all
select "c" as flow_out_id,
"e" as flow_in_id,
1.0 as edge_weight from dual    union all
select "f" as flow_out_id,
"g" as flow_in_id,
3.0 as edge_weight from dual    union all
select "a" as flow_out_id,
"d" as flow_in_id,
4.0 as edge_weight from dual ) tmp ;
```

Graph structure shows the graph structure.

Graph structure



Output

```
+------------+------------+------------+--------------+
| start_node | dest_node  | distance   | distance_cnt |
+------------+------------+------------+--------------+
| a          | b          | 1.0        | 1            |
| a          | c          | 3.0        | 1            |
| a          | d          | 4.0        | 3            |
| a          | a          | 0.0        | 0            |
| a          | e          | 3.0        | 1            |
+------------+------------+------------+--------------+
```

PAI command

```
pai -name SSSP
-project algo_public
-DinputEdgeTableName=SSSP_func_test_edge
-DfromVertexCol=flow_out_id
-DtoVertexCol=flow_in_id
-DoutputTableName=SSSP_func_test_result
-DhasEdgeWeight=true
-DedgeWeightCol=edge_weight
-DstartVertex=a;
```

Algorithm parameters

Parameters

Parameter	Description	Required	Default value
inputEdgeTableName	The name of the input edge table.	Yes	-
inputEdgeTablePartitions	The partitions selected from the input edge table.	No	The whole table is selected by default.
fromVertexCol	The start vertex column in the input edge table.	Yes	-
toVertexCol	The end vertex column in the input edge table.	Yes	-
outputTableName	The name of the output table.	Yes	-
outputTablePartitions	The partitions in the output table.	No	-
lifecycle	The lifecycle of the output table.	No	-
workerNum	The number of workers.	No	-

Parameter	Description	Required	Default value
workerMem	The memory size per worker.	No	4096
splitSize	The data split size.	No	64
startVertex	The ID of the start vertex.	Yes	-
hasEdgeWeight	Specifies whether the edges in the input edge table have weights.	No	false
edgeWeightCol	The edge weight column in the input edge table.	No	-

4.4.10.3. PageRank

The PageRank algorithm is used to sort and calculate the rankings of web pages based on their link sources.

Features

The basic principle of the PageRank algorithm is as follows: The more web pages that direct to a web page, the more importance or higher quality the web page has. In addition to the number of links directing to a web page, the weight of the web page and the number of outgoing links are also considered during page ranking. For a social network of users, the edge weight is an important factor in addition to the influence of the users. For example, a Sina Weibo user is more likely to have influence on their family, friends, classmates, and colleagues than they will on followers with a weaker relationship. In the social network, the edge weight is equivalent to the user-to-user relationship strength index. The PageRank formula with connection weight is as follows:

$$W(A) = (1 - d) + d * (\sum_{i} W(i) * C(Ai))$$

In the formula, W(i) represents the weight of node i, C(A,i) represents the link weight, and d represents the damping coefficient. W is the influence index of each user and represents the node weight after the algorithm iteration becomes stable.

Parameter settings

Maximum Iterations: Optional. The number of iterations performed before the algorithm automatically converges. Default value: 30.

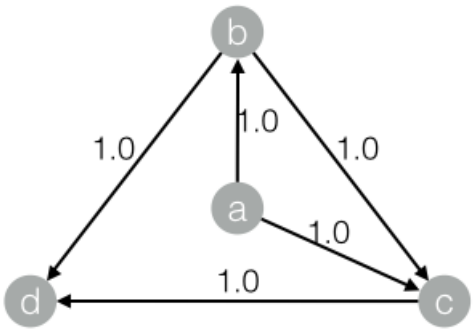
Examples - Testing data

SQL statement to generate data:

```
drop table if exists PageRankWithWeight_func_test_edge;
create table PageRankWithWeight_func_test_edge
as select * from (
select 'a' as flow_out_id,
'b' as flow_in_id,
1.0 as weight from dual    union all
select 'a' as flow_out_id,
'c' as flow_in_id,
1.0 as weight from dual    union all
select 'b' as flow_out_id,
'c' as flow_in_id,
1.0 as weight from dual    union all
select 'b' as flow_out_id,
'd' as flow_in_id,
1.0 as weight from dual    union all
select 'c' as flow_out_id,
'd' as flow_in_id,1.0 as weight from dual )tmp ;
```

Graph structure shows the graph structure.

Graph structure



Output

node	weight
a	0.0375
b	0.06938
c	0.12834
d	0.20556

PAI command

```
pai -name PageRankWithWeight
-project algo_public
-DinputEdgeTableName=PageRankWithWeight_func_test_edge
-DfromVertexCol=flow_out_id
-DtoVertexCol=flow_in_id
-DoutputTableName=PageRankWithWeight_func_test_result
-DhasEdgeWeight=true
-DedgeWeightCol=weight
-DmaxIter 100;
```

Algorithm parameters

Parameters

Parameter	Description	Required	Default value
inputEdgeTableName	The name of the input edge table.	Yes	-
inputEdgeTablePartitions	The partitions selected from the input edge table.	No	The whole table is selected by default.
fromVertexCol	The start vertex column in the input edge table.	Yes	-
toVertexCol	The end vertex column in the input edge table.	Yes	-
outputTableName	The name of the output table.	Yes	-
outputTablePartitions	The partitions in the output table.	No	-
lifecycle	The lifecycle of the output table.	No	-
workerNum	The number of workers.	No	-
workerMem	The memory size per worker.	No	4096
splitSize	The data split size.	No	64
hasEdgeWeight	Specifies whether the edges in the input edge table have weights.	No	false

Parameter	Description	Required	Default value
edgeWeightCol	The edge weight column in the input edge table.	No	-
maxIter	The maximum number of iterations.	No	30

4.4.10.4. Label propagation clustering

Graph clustering is used to divide a graph into subgraphs based on the topology of the graph so that the links between the nodes in a subgraph are more than the links between the subgraphs. The label propagation algorithm (LPA) is a graph-based semi-supervised machine learning algorithm. The labels of a node (community) depend on those of the neighboring nodes. The degree of dependence is determined by the similarity between nodes. Data becomes stable by iterative propagation update.

Parameters

Maximum Iterations: Optional. The maximum number of iterations. Default value: 30.

Examples - Testing data

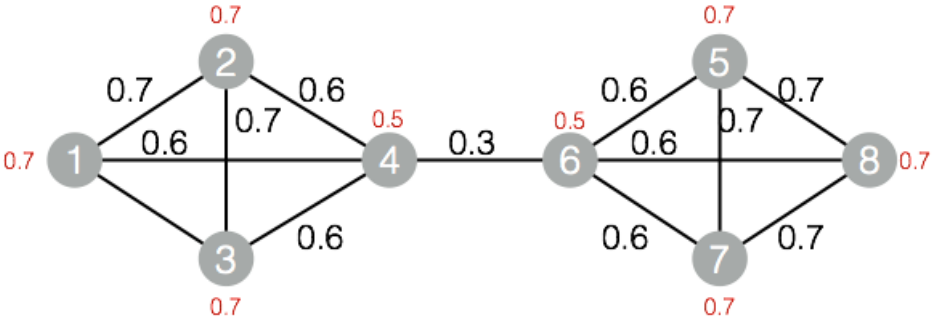
SQL statement to generate data:

```
drop table if exists LabelPropagationClustering_func_test_edge;
create table LabelPropagationClustering_func_test_edge
as select * from (
select '1' as flow_out_id,
'2' as flow_in_id,
0.7 as edge_weight from dual    union all
select '1' as flow_out_id,
'3' as flow_in_id,
0.7 as edge_weight from dual    union all
select '1' as flow_out_id,
'4' as flow_in_id,
0.6 as edge_weight from dual    union all
select '2' as flow_out_id,
'3' as flow_in_id,
0.7 as edge_weight from dual    union all
select '2' as flow_out_id,
'4' as flow_in_id,
0.6 as edge_weight from dual    union all
select '3' as flow_out_id,
'4' as flow_in_id,
0.6 as edge_weight from dual    union all
```

```
select '4' as flow_out_id,
'6' as flow_in_id,
0.3 as edge_weight from dual    union all
select '5' as flow_out_id,
'6' as flow_in_id,
0.6 as edge_weight from dual    union all
select '5' as flow_out_id,
'7' as flow_in_id,
0.7 as edge_weight from dual    union all
select '5' as flow_out_id,
'8' as flow_in_id,
0.7 as edge_weight from dual    union all
select '6' as flow_out_id,
'7' as flow_in_id,
0.6 as edge_weight from dual    union all
select '6' as flow_out_id,
'8' as flow_in_id,
0.6 as edge_weight from dual    union all
select '7' as flow_out_id,
'8' as flow_in_id,
0.7 as edge_weight from dual )tmp ;
drop table if exists LabelPropagationClustering_func_test_node;
create table LabelPropagationClustering_func_test_node
as select * from (
select '1' as node,
0.7 as node_weight from dual    union all
select '2' as node,
0.7 as node_weight from dual    union all
select '3' as node,
0.7 as node_weight from dual    union all
select '4' as node,
0.5 as node_weight from dual    union all
select '5' as node,
0.7 as node_weight from dual    union all
select '6' as node,
0.5 as node_weight from dual    union all
select '7' as node,
0.7 as node_weight from dual    union all
select '8' as node,
0.7 as node_weight from dual )tmp ;
```

Group structure shows the group structure.

Group structure



Output

node	group_id
1	1
2	1
3	1
4	1
5	5
6	5
7	5
8	5

PAI command

```
pai -name LabelPropagationClustering
-project algo_public
-DinputEdgeTableName=LabelPropagationClustering_func_test_edge
-DfromVertexCol=flow_out_id
-DtoVertexCol=flow_in_id
-DinputVertexTableName=LabelPropagationClustering_func_test_node
-DvertexCol=node
-DoutputTableName=LabelPropagationClustering_func_test_result
-DhasEdgeWeight=true
-DedgeWeightCol=edge_weight
-DhasVertexWeight=true
-DvertexWeightCol=node_weight
-DrandSelect=true
-DmaxIter=100;
```

Algorithm parameters

Parameters

Parameter	Description	Required	Default value
inputEdgeTableName	The name of the input edge table.	Yes	-
inputEdgeTablePartitions	The partitions selected from the input edge table.	No	The whole table is selected by default.
fromVertexCol	The start vertex column in the input edge table.	Yes	-
toVertexCol	The end vertex column in the input edge table.	Yes	-
inputVertexTableName	The name of the input vertex table.	Yes	-
inputVertexTablePartitions	The partitions in the input vertex table.	No	The whole table is selected by default.
vertexCol	The vertex column in the input vertex table.	Yes	-
outputTableName	The name of the output table.	Yes	-
outputTablePartitions	The partitions in the output table.	No	-
lifecycle	The lifecycle of the output table.	No	-
workerNum	The number of workers.	No	-
workerMem	The memory size per worker.	No	4096
splitSize	The data split size.	No	64
hasEdgeWeight	Specifies whether the edges in the input edge table have weights.	No	false
edgeWeightCol	The edge weight column in the input edge table.	No	-
hasVertexWeight	Specifies whether the vertices in the input vertex table have weights.	No	false

Parameter	Description	Required	Default value
vertexWeightCol	The vertex weight column in the input vertex table.	No	-
randSelect	Specifies whether the maximum label value is to be randomly selected.	No	false
maxIter	The maximum number of iterations.	No	30

4.4.10.5. Label propagation classification

Label propagation classification is a semi-supervised classification algorithm. It uses the label information of labeled nodes to predict the label information for unlabeled nodes.

Features

During algorithm execution, the labels of each node are propagated to the neighboring nodes based on the similarity between the nodes. In each step of propagation, a node updates its labels based on the labels of the neighboring nodes so that the node is more similar to the neighboring nodes. The higher the similarity, the more labeling influences the neighboring nodes have on that node, and the easier it is for the labels to be propagated. During label propagation, the labels of the labeled data remain unchanged. These labels serve as sources for propagation to the unlabeled data.

After the iterations end, the probability distributions of similar nodes tend to be similar. These nodes can be classified into the same category. This completes the label propagation.

Parameter settings

Damping factor: The default value is 0.8. Convergence factor: The default value is 0.000001.

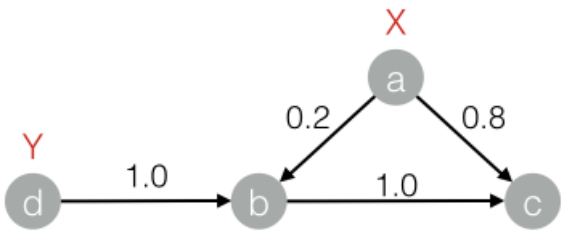
Examples - Testing data

SQL statement to generate data:

```
drop table if exists LabelPropagationClassification_func_test_edge;
create table LabelPropagationClassification_func_test_edge
as select * from (
select 'a' as flow_out_id,
'b' as flow_in_id,
0.2 as edge_weight from dual    union all
select 'a' as flow_out_id,
'c' as flow_in_id,
0.8 as edge_weight from dual    union all
select 'b' as flow_out_id,
'c' as flow_in_id,
1.0 as edge_weight from dual    union all
select 'd' as flow_out_id,
'b' as flow_in_id,
1.0 as edge_weight from dual )tmp ;
drop table if exists LabelPropagationClassification_func_test_node;
create table LabelPropagationClassification_func_test_node
as select * from (
select 'a' as node,
'X' as label,
1.0 as label_weight from dual    union all
select 'd' as node,
'Y' as label,
1.0 as label_weight from dual )tmp ;
```

Graph structure shows the graph structure.

Graph structure



Output

node	tag	weight
a	X	1.0
b	X	0.16667
b	Y	0.83333
c	X	0.53704
c	Y	0.46296
d	Y	1.0

PAI command

```
pai -name LabelPropagationClassification
-project algo_public
-DinputEdgeTableName=LabelPropagationClassification_func_test_edge
-DfromVertexCol=flow_out_id
-DtoVertexCol=flow_in_id
-DinputVertexTableName=LabelPropagationClassification_func_test_node
-DvertexCol=node
-DvertexLabelCol=label
-DoutputTableName=LabelPropagationClassification_func_test_result
-DhasEdgeWeight=true
-DedgeWeightCol=edge_weight
-DhasVertexWeight=true
-DvertexWeightCol=label_weight
-Dalpha=0.8
-Depsilon=0.000001;
```

Algorithm parameters

Parameters

Parameter	Description	Required	Default value
inputEdgeTableName	The name of the input edge table.	Yes	-
inputEdgeTablePartitions	The partitions selected from the input edge table.	No	The whole table is selected by default.
fromVertexCol	The start vertex column in the input edge table.	Yes	-
toVertexCol	The end vertex column in the input edge table.	Yes	-

Parameter	Description	Required	Default value
inputVertexTableName	The name of the input vertex table.	Yes	-
inputVertexTablePartitions	The partitions in the input vertex table.	No	The whole table is selected by default.
vertexCol	The vertex column in the input vertex table.	Yes	-
vertexLabelCol	The vertex label column in the input vertex table.	Yes	-
outputTableName	The name of the output table.	Yes	-
outputTablePartitions	The partitions in the output table.	No	-
lifecycle	The lifecycle of the output table.	No	-
workerNum	The number of workers.	No	-
workerMem	The memory size per worker.	No	4096
splitSize	The data split size.	No	64
hasEdgeWeight	Specifies whether the edges in the input edge table have weights.	No	false
edgeWeightCol	The edge weight column in the input edge table.	No	-
hasVertexWeight	Specifies whether the vertices in the input vertex table have weights.	No	false
vertexWeightCol	The vertex weight column in the input vertex table.	No	-
alpha	The damping coefficient.	No	0.8
epsilon	The convergence coefficient.	No	0.000001

Parameter	Description	Required	Default value
maxIter	The maximum number of iterations.	No	30

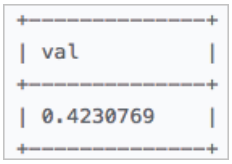
4.4.10.6. Modularity

Modularity is used to measure the structure of the community network. It measures the closeness of the communities divided from a network structure. A value larger than 0.3 represents an obvious community structure.

Examples - Testing data

For more information, see Label propagation clustering.

Output



```
+-------------+
| val         |
+-------------+
| 0.4230769   |
+-------------+
```

PAI command

```
pai -name Modularity
-project algo_public
-DinputEdgeTableName=Modularity_func_test_edge
-DfromVertexCol=flow_out_id
-DfromGroupCol=group_out_id
-DtoVertexCol=flow_in_id
-DtoGroupCol=group_in_id
-DoutputTableName=Modularity_func_test_result;
```

Algorithm parameters

Parameters

Parameter	Description	Required	Default value
inputEdgeTableName	The name of the input edge table.	Yes	-
inputEdgeTablePartitions	The partitions selected from the input edge table.	No	The whole table is selected by default.
fromVertexCol	The start vertex column in the input edge table.	Yes	-

Parameter	Description	Required	Default value
fromGroupCol	The start vertex group in the input edge table.	Yes	-
toVertexCol	The end vertex column in the input edge table.	Yes	-
toGroupCol	The end vertex group in the input edge table.	Yes	-
outputTableName	The name of the output table.	Yes	-
outputTablePartitions	The partitions in the output table.	No	-
lifecycle	The lifecycle of the output table.	No	-
workerNum	The number of workers.	No	-
workerMem	The memory size per worker.	No	4096
splitSize	The data split size.	No	64

4.4.10.7. Maximum connected subgraph

In an undirected graph G, vertex A is connected to vertex B if a path exists between the two vertices. Graph G contains several subgraphs. Each vertex is connected to other vertices in the same subgraph. Vertices in different subgraphs are not connected. In this case, the subgraphs of graph G are called maximum connected subgraphs.

Features

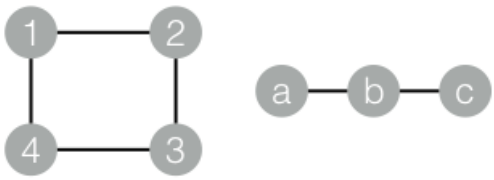
Examples - Testing data

SQL statement to generate data:

```
drop table if exists MaximalConnectedComponent_func_test_edge;
create table MaximalConnectedComponent_func_test_edge
as select * from (
select '1' as flow_out_id,
'2' as flow_in_id from dual  union all
select '2' as flow_out_id,
'3' as flow_in_id from dual  union all
select '3' as flow_out_id,
'4' as flow_in_id from dual  union all
select '1' as flow_out_id,
'4' as flow_in_id from dual  union all
select 'a' as flow_out_id,
'b' as flow_in_id from dual  union all
select 'b' as flow_out_id,
'c' as flow_in_id from dual )tmp;
drop table if exists MaximalConnectedComponent_func_test_result;
create table MaximalConnectedComponent_func_test_result (  node string,  grp_id string );
```

Graph structure shows the graph structure.

Graph structure



Output

node	grp_id
1	4
2	4
3	4
4	4
a	c
b	c
c	c

PAI command

```
pai -name MaximalConnectedComponent
-project algo_public
-DinputEdgeTableName=MaximalConnectedComponent_func_test_edge
-DfromVertexCol=flow_out_id
-DtoVertexCol=flow_in_id
-DoutputTableName=MaximalConnectedComponent_func_test_result;
```

Algorithm parameters

Parameters

Parameter	Description	Required	Default value
inputEdgeTableName	The name of the input edge table.	Yes	-
inputEdgeTablePartitions	The partitions selected from the input edge table.	No	The whole table is selected by default.
fromVertexCol	The start vertex column in the input edge table.	Yes	-
toVertexCol	The end vertex column in the input edge table.	Yes	-
outputTableName	The name of the output table.	Yes	-
outputTablePartitions	The partitions in the output table.	No	-
lifecycle	The lifecycle of the output table.	No	-
workerNum	The number of workers.	No	-
workerMem	The memory size per worker.	No	4096
splitSize	The data split size.	No	64

4.4.10.8. Vertex clustering coefficient

This coefficient is used to calculate the peripheral density of a vertex in an undirected graph G. The density of a star network is 0, and that of a fully meshed network is 1.

Parameter settings

maxEdgeCnt: Optional. If the node degree is larger than the value of this parameter, sampling is required. Default value: 500.

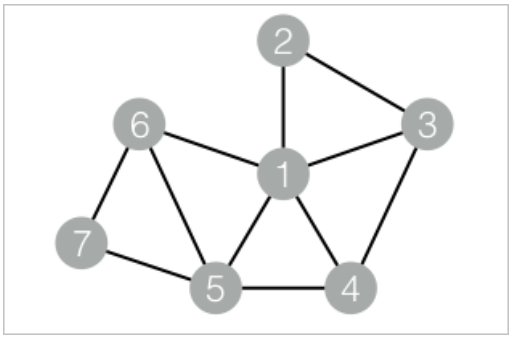
Examples - Testing data

SQL statement to generate data:

```
drop table if exists NodeDensity_func_test_edge;
create table NodeDensity_func_test_edge
as select * from (
select '1' as flow_out_id,
'2' as flow_in_id from dual  union all
select '1' as flow_out_id,
'3' as flow_in_id from dual  union all
select '1' as flow_out_id,
'4' as flow_in_id from dual  union all
select '1' as flow_out_id,
'5' as flow_in_id from dual  union all
select '1' as flow_out_id,
'6' as flow_in_id from dual  union all
select '2' as flow_out_id,
'3' as flow_in_id from dual  union all
select '3' as flow_out_id,
'4' as flow_in_id from dual  union all
select '4' as flow_out_id,
'5' as flow_in_id from dual  union all
select '5' as flow_out_id,
'6' as flow_in_id from dual  union all
select '5' as flow_out_id,
'7' as flow_in_id from dual  union all
select '6' as flow_out_id,
'7' as flow_in_id from dual )tmp;
drop table if exists NodeDensity_func_test_result;
create table NodeDensity_func_test_result (  node string,  node_cnt bigint,  edge_cnt bigint,  density doub
le,  log_density double );
```

Graph structure shows the graph structure.

Graph structure



Output

```
1,5,4,0.4,1.45657
2,2,1,1.0,1.24696
3,3,2,0.66667,1.35204
4,3,2,0.66667,1.35204
5,4,3,0.5,1.41189
6,3,2,0.66667,1.35204
7,2,1,1.0,1.24696
```

PAI command

```
pai -name NodeDensity
-project algo_public
-DinputEdgeTableName=NodeDensity_func_test_edge
-DfromVertexCol=flow_out_id
-DtoVertexCol=flow_in_id
-DoutputTableName=NodeDensity_func_test_result
-DmaxEdgeCnt=500;
```

Algorithm parameters

Parameters

Parameter	Description	Required	Default value
inputEdgeTableName	The name of the input edge table.	Yes	-
inputEdgeTablePartitions	The partitions selected from the input edge table.	No	The whole table is selected by default.
fromVertexCol	The start vertex column in the input edge table.	Yes	-
toVertexCol	The end vertex column in the input edge table.	Yes	-

Parameter	Description	Required	Default value
outputTableName	The name of the output table.	Yes	-
outputTablePartitions	The partitions in the output table.	No	-
lifecycle	The lifecycle of the output table.	No	-
maxEdgeCnt	If the node degree is larger than the value of this parameter, sampling is required.	No	500
workerNum	The number of workers.	No	-
workerMem	The memory size per worker.	No	4096
splitSize	The data split size.	No	64

4.4.10.9. Edge clustering coefficient

This coefficient is used to calculate the peripheral density of each edge in an undirected graph G.

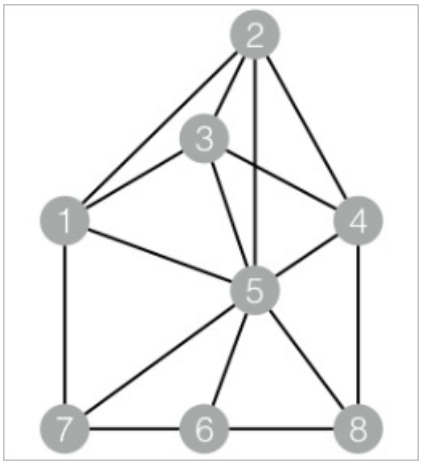
Examples - Testing data

SQL statement to generate data:

```
drop table if exists EdgeDensity_func_test_edge;
create table EdgeDensity_func_test_edge
as select * from (
select '1' as flow_out_id,
'2' as flow_in_id from dual  union all
select '1' as flow_out_id,
'3' as flow_in_id from dual  union all
select '1' as flow_out_id,
'5' as flow_in_id from dual  union all
select '1' as flow_out_id,
'7' as flow_in_id from dual  union all
select '2' as flow_out_id,
'5' as flow_in_id from dual  union all
select '2' as flow_out_id,
'4' as flow_in_id from dual  union all
select '2' as flow_out_id,
'3' as flow_in_id from dual  union all
select '3' as flow_out_id,
'5' as flow_in_id from dual  union all
select '3' as flow_out_id,
'4' as flow_in_id from dual  union all
select '4' as flow_out_id,
'5' as flow_in_id from dual  union all
select '4' as flow_out_id,
'8' as flow_in_id from dual  union all
select '5' as flow_out_id,
'6' as flow_in_id from dual  union all
select '5' as flow_out_id,
'7' as flow_in_id from dual  union all
select '5' as flow_out_id,
'8' as flow_in_id from dual  union all
select '7' as flow_out_id,
'6' as flow_in_id from dual  union all
select '6' as flow_out_id,
'8' as flow_in_id from dual )tmp;
drop table if exists EdgeDensity_func_test_result;
create table EdgeDensity_func_test_result (  node1 string,  node2 string,  node1_edge_cnt bigint,  node2_
edge_cnt bigint,  triangle_cnt bigint,  density double );
```

Graph structure shows the graph structure.

Graph structure



Output

```
1,2,4,4,2,0.5
2,3,4,4,3,0.75
2,5,4,7,3,0.75
3,1,4,4,2,0.5
3,4,4,4,2,0.5
4,2,4,4,2,0.5
4,5,4,7,3,0.75
5,1,7,4,3,0.75
5,3,7,4,3,0.75
5,6,7,3,2,0.66667
5,8,7,3,2,0.66667
6,7,3,3,1,0.33333
7,1,3,4,1,0.33333
7,5,3,7,2,0.66667
8,4,3,4,1,0.33333
8,6,3,3,1,0.33333
```

PAI command

```
pai -name EdgeDensity
-project algo_public
-DinputEdgeTableName=EdgeDensity_func_test_edge
-DfromVertexCol=flow_out_id
-DtoVertexCol=flow_in_id
-DoutputTableName=EdgeDensity_func_test_result;
```

Algorithm parameters

Parameters

Parameter	Description	Required	Default value
inputEdgeTableName	The name of the input edge table.	Yes	-

Parameter	Description	Required	Default value
inputEdgeTablePartitions	The partitions selected from the input edge table.	No	The whole table is selected by default.
fromVertexCol	The start vertex column in the input edge table.	Yes	-
toVertexCol	The end vertex column in the input edge table.	Yes	-
outputTableName	The name of the output table.	Yes	-
outputTablePartitions	The partitions in the output table.	No	-
lifecycle	The lifecycle of the output table.	No	-
workerNum	The number of workers.	No	-
workerMem	The memory size per worker.	No	4096
splitSize	The data split size.	No	64

4.4.10.10. Counting triangle

All triangles can be output to an undirected graph G.

Parameter settings

maxEdgeCnt: Optional. If the node degree is larger than the value of this parameter, sampling is required. Default value: 500.

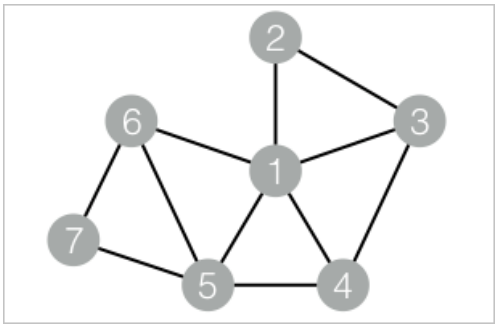
Examples - Testing data

SQL statement to generate data:

```
drop table if exists TriangleCount_func_test_edge;
create table TriangleCount_func_test_edge
as select * from (
select '1' as flow_out_id,
'2' as flow_in_id from dual  union all
select '1' as flow_out_id,
'3' as flow_in_id from dual  union all
select '1' as flow_out_id,
'4' as flow_in_id from dual  union all
select '1' as flow_out_id,
'5' as flow_in_id from dual  union all
select '1' as flow_out_id,
'6' as flow_in_id from dual  union all
select '2' as flow_out_id,
'3' as flow_in_id from dual  union all
select '3' as flow_out_id,
'4' as flow_in_id from dual  union all
select '4' as flow_out_id,
'5' as flow_in_id from dual  union all
select '5' as flow_out_id,
'6' as flow_in_id from dual  union all
select '5' as flow_out_id,
'7' as flow_in_id from dual  union all
select '6' as flow_out_id,
'7' as flow_in_id from dual )tmp;
drop table if exists TriangleCount_func_test_result;
create table TriangleCount_func_test_result (  node1 string,  node2 string,  node3 string );
```

Graph structure shows the graph structure.

Graph structure



Output

```
1,2,3
1,3,4
1,4,5
1,5,6
5,6,7
```

PAI command

```
pai -name TriangleCount
-project algo_public
-DinputEdgeTableName=TriangleCount_func_test_edge
-DfromVertexCol=flow_out_id
-DtoVertexCol=flow_in_id
-DoutputTableName=TriangleCount_func_test_result;
```

Algorithm parameters

Parameters

Parameter	Description	Required	Default value
inputEdgeTableName	The name of the input edge table.	Yes	-
inputEdgeTablePartitions	The partitions selected from the input edge table.	No	The whole table is selected by default.
fromVertexCol	The start vertex column in the input edge table.	Yes	-
toVertexCol	The end vertex column in the input edge table.	Yes	-
outputTableName	The name of the output table.	Yes	-
outputTablePartitions	The partitions in the output table.	No	-
lifecycle	The lifecycle of the output table.	No	-
maxEdgeCnt	If the node degree is larger than the value of this parameter, sampling is required.	No	500
workerNum	The number of workers.	No	-
workerMem	The memory size per worker.	No	4096

Parameter	Description	Required	Default value
splitSize	The data split size.	No	64

4.4.10.11. Tree depth

In a tree network, this component outputs the depth of each node in a tree and the tree ID.

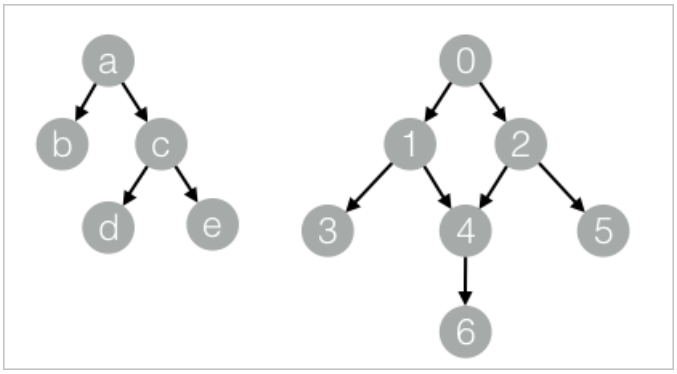
Examples - Testing data

SQL statement to generate data:

```
drop table if exists TreeDepth_func_test_edge;
create table TreeDepth_func_test_edge
as select * from (
select '0' as flow_out_id,
'1' as flow_in_id from dual    union all
select '0' as flow_out_id,
'2' as flow_in_id from dual    union all
select '1' as flow_out_id,
'3' as flow_in_id from dual    union all
select '1' as flow_out_id,
'4' as flow_in_id from dual    union all
select '2' as flow_out_id,
'4' as flow_in_id from dual    union all
select '2' as flow_out_id,
'5' as flow_in_id from dual    union all
select '4' as flow_out_id,
'6' as flow_in_id from dual    union all
select 'a' as flow_out_id,
'b' as flow_in_id from dual    union all
select 'a' as flow_out_id,
'c' as flow_in_id from dual    union all
select 'c' as flow_out_id,
'd' as flow_in_id from dual    union all
select 'c' as flow_out_id,
'e' as flow_in_id from dual )tmp;
drop table if exists TreeDepth_func_test_result;
create table TreeDepth_func_test_result (   node string,   root string,   depth bigint );
```

Graph structure shows the graph structure.

Graph structure



Output

```
0,0,0
1,0,1
2,0,1
3,0,2
4,0,2
5,0,2
6,0,3
a,a,0
b,a,1
c,a,1
d,a,2
e,a,2
```

PAI command

```
pai -name TreeDepth
-project algo_public
-DinputEdgeTableName=TreeDepth_func_test_edge
-DfromVertexCol=flow_out_id
-DtoVertexCol=flow_in_id
-DoutputTableName=TreeDepth_func_test_result;
```

Algorithm parameters

Parameters

Parameter	Description	Required	Default value
inputEdgeTableName	The name of the input edge table.	Yes	-
inputEdgeTablePartitions	The partitions selected from the input edge table.	No	The whole table is selected by default.
fromVertexCol	The start vertex column in the input edge table.	Yes	-

Parameter	Description	Required	Default value
toVertexCol	The end vertex column in the input edge table.	Yes	-
outputTableName	The name of the output table.	Yes	-
outputTablePartitions	The partitions in the output table.	No	-
lifecycle	The lifecycle of the output table.	No	-
workerNum	The number of workers.	No	-
workerMem	The memory size per worker.	No	4096
splitSize	The data split size.	No	64

4.4.11. Tools

4.4.11.1. SQL script

You can use the SQL script editor to write SQL statements.

1. Drag and drop the **SQL Script** component onto the canvas.
2. Connect the input table to the **SQL Script** component, and then click **SQL Script**. The following configuration pane is displayed.
3. Write an SQL script in the text box.
   - An SQL script supports one to four inputs and one output.
   - You can write only one SQL statement.
   - The input data is automatically mapped to tables t1 through t4. You can directly call ${t1}, ${t2}, ${t3}, and ${t4} without specifying the table names.
   - The sample SQL script calculates the number of rows in the input table.

4.4.12. Financials

4.4.12.1. Binning

The Binning component performs data binning based on equal-width or equal-frequency.

PAI command

```
PAI -name binning
  -project algo_public
  -DinputTableName=input
  -DoutputTableName=output
```

Parameters

Parameter	Description	Valid value	Default
inputTableName	Required. The name of the input table.	Table name	N/A
outputTableName	Required. The name of the output table.	Table name	N/A
selectedColNames	Optional. The names of columns selected from the input table for data binning.	Column name	All columns are selected, except for the label column.
labelColumn	Optional. The name of the column that stores the labels.	Column name	No label column is selected.
validTableName	Required when the binning mode (binningMethod) is set to auto. The name of the table used for calibration.	Table name	No table is specified for calibration.
validTablePartitions	Optional. The partitions selected from the calibration table.	Partition name	The whole table is selected.
inputTablePartitions	Optional. The partitions selected from the input table.	Partition name	The whole table is selected.
inputBinTableName	Optional. The name of the input binning table.	Table name	No binning table is specified.
selectedBinColNames	Optional. The names of the columns selected from the binning table.	Column name	No column is selected.
positiveLabel	Optional. The value used to represent positive samples.	N/A	1
nDivide	Optional. The number of bins.	A positive integer	10

Parameter	Description	Valid value	Default
colsNDivide	Optional. The numbers of bins customized for specified columns. Example: col0:3,col2:5. Columns specified in the colsNDivide parameter but not included in the selectedColNames parameter are also processed by the Binning component. For example, if selectedColNames is set to col0,col1 and colsNDivide is set to col0:3,col2:5, data binning is perform based on col0:3,col1:10,col2:5.	N/A	No custom binning rule is specified.
isLeftOpen	Optional. The type of the interval, which can be left-open, right-closed or left-closed, right-open.	true and false	true
stringThreshold	Optional. The discrete value threshold. Values below this threshold are put into other bins.	N/A	No discrete value threshold is set.
colsStringThreshold	Optional. The thresholds for specified columns. Specify the values in the same format of the colsNDivide parameter.	N/A	No threshold is set.
binningMethod	Optional. The binning mode.	quantile (equal-frequency), bucket (equal-width), and auto (automatic binning). If you select auto, monotonic binning is used based on equal-frequency.	quantile
lifecycle	Optional. The lifecycle of the output table.	A positive integer	No lifecycle is set.
coreNum	Optional. The number of cores.	A positive integer	Automatically calculated.

Parameter	Description	Valid value	Default
memSizePerCore	Optional. The memory size per core.	A positive integer	Automatically calculated.

Constraints

Binning constraints must be used together with the Scorecard Training component. You can add constraints to the weight of each dummy variable when the Binning component discretizes features and transforms them into dummy variables. The definitions of the constraints are as follows:

- Ascending order: adds weights to the dummy variables of a feature based on the index values in ascending order. This means that dummy variables with higher index values have larger weights.
- Descending order: adds weights to the dummy variables of a feature based on the index values in descending order. This means that dummy variables with lower index values have lighter weights.
- Same weight: the weights of two dummy variables of a feature must be the same.
- Set weight to 0: sets the weight of a dummy variable to 0.
- Set weight to a specified value: sets the weight of a dummy variable to a floating point value.
- WOE order: adds weights to the dummy variables of a feature based on the WOE values in ascending order. This means that dummy variables with higher WOE values have larger weights.

4.4.12.2. Data conversion

Parameters

Parameter	Description
inputFeatureTableName	Required. The name of the input feature table.
inputBinTableName	Required. The name of the binning result table.
inputFeatureTablePartitions	Optional. The partitions selected from the feature table. By default, all partitions are selected.
outputTableName	Required. The name of the output table.
featureColNames	Optional. The names of the features selected from the input feature table. By default, all columns are selected.
metaColNames	Optional. The names of the columns to be reserved in the output table without data conversion. By default, no column is reserved. You can specify columns such as label and sample_id.
transformType	Optional. The type of data conversion. Valid values: normalize (normalization), dummy (discretization), and woe (WOE transformation). The default is dummy.

Parameter	Description
itemDelimiter	Optional. The delimiter used to separate features. By default, commas (,) are used. Only data discretization supports this parameter.
kvDelimiter	Optional. The delimiter used to separate keys and values. By default, colons (:) are used. Only data discretization supports this parameter.
lifecycle	Optional. The lifecycle of the output table. By default, no lifecycle is set.
coreNum	Optional. The number of cores. By default, the number of cores is automatically calculated.
memSizePerCore	Optional. The memory size per core in megabytes. By default, the memory size per core is automatically calculated.

instance

PAI command

```
PAI -name data_transform
-project algo_public
-DinputFeatureTableName=feature_table
-DinputBinTableName=bin_table
-DoutputTableName=output_table
-DmetaColNames=label
-DfeatureColNames=feaname1,feaname2
```

Normalization

The Normalization component transforms variable values to a scale of 0 to 1. Missing values are imputed with zeros. The algorithm is as follows:

```
if feature_raw_value == null or feature_raw_value == 0 then
  feature_norm_value = 0.0
else
  bin_index = FindBin(bin_table, feature_raw_value)
  bin_width = round(1.0 / bin_count * 1000) / 1000.0
  feature_norm_value = 1.0 - (bin_count - bin_index - 1) * bin_width
```

Output format

Normalization and WOE conversion tables output regular tables.

Dummy variable conversion in discretization outputs a table that contains KV pairs. The output variables are in the format of [${feaname}]\_bin\_${bin_id}. Taking variable sns as an example:

- If the variable sns is put into the second bin, the output variable is `[sns]_bin_2`.
- If the variable sns does not have a value, it is put into an empty bin. The output variable is `[sns]_bin_null`.
- If the variable sns has a value but it cannot be put into any of the predefined bins, it is put into the else bin. The output variable is `[sns]_bin_else`.

4.4.12.3. Scorecard training

The scorecard is a modeling tool widely used for credit score evaluation. It uses binning to discretize variables, and then uses linear models (logistic regression or linear regression) to train a model. The model training process includes feature selection and score transformation. The scorecard also allows you to add constraints to the variables during model training.

> **Note** If you use the scorecard without binning, the entire model training process is equivalent to logistic regression or linear regression.

Feature engineering

The main difference between the scorecard and normal linear models is that the scorecard performs feature engineering before it trains linear models. The Scorecard component provides two methods for feature engineering. You must use binning to discretize the features first no matter which method you choose. One of the methods is to use one hot encoding to encode the variable binning results, and then generate N dummy variables. N represents the number of bins. The other method is to use Weight of Evidence (WOE) transformation. It replaces the original value of a variable with the WOE value of the bin where the variable is placed.

> **Note** You can add constraints for each variable when you transform variables to dummy variables.

Score transformation

In the credit score evaluation scenario, you must use linear transformation to transform the odds of the samples in the prediction results to credit scores as follows:

```
log(odds) = \sum(wx) = a scaled_score + b
```

The parameters in the formula are as follows:

- scaledValue: specifies a base point to be scaled.
- odds: specifies an odd level.
- pdo: specifies the points to double the odds.

For example, if the scaledValue, odds, and pdo parameters are set to 800, 50, and 25, the two vectors that determine the score scale are as follows:

```
log(40) = a * 800 + b
log(80) = a * 825 + b
```

Calculate the values of a and b, and then perform a linear transformation to obtain the scores.

The scaling information is specified in JSON format by using the -Dscale parameter as follows:

```
{"scaledValue":800,"odds":50,"pdo":25}
```

The three parameters must be set at the same time.

Add constraints

You can add constraints for variables during scorecard training. You can set the score of a bin to a fixed value, set a proportion between the scores of two bins, or limit the scores of bins. For example, you can sort the scores of the bins by WOE. The implementation of constraints depends on the underlying optimization algorithms with constraints. You can set a constraint in the Binning component. After you set the parameters, the component generates a constraint in JSON format, and then passes the constraint to the component connected to it. The supported constraints are as follows:

- <: sorts the weights of the variables in ascending order.
- >: sorts the weights of the variables in descending order.
- =: sets the weights of the variables to a fixed value.
- %: sets a proportion between the weights of two variables.
- UP: sets an upper limit for the weights of the variables.
- LO: sets a lower limit for the weights of the variables.

A constraint is stored in a table as a JSON string. The table contains only one row and one column.

```
{
  "name": "feature0",
  "<": [
    [0,1,2,3]
  ],
  ">": [
    [4,5,6]
  ],
  "=": [
    "3:0","4:0.25"
  ],
  "%": [
    ["6:1.0","7:1.0"]
  ]
}
```

Built-in constraints

Every original variable has a default constraint. The average score of the population in a variable must be 0. Based on this constraint, the scaled_weight in the intercept options of the scorecard model equals the average score of the entire population.

Optimization algorithms

In the advanced options of the Scorecard component, you can select optimization algorithms to be used in model training. The supported optimization algorithms are as follows:

- L-BFGS
- Newton's Method
- Barrier Method
- SQP

L-BFGS is a first-order optimization algorithm for processing large amounts of feature data. Newton's Method is a classic tier-2 optimization algorithm. It is fast in regression and accurate. However, it is not suitable for processing large amounts of feature data because it needs to calculate the second-order Hessian Matrix. The two algorithms do not have any constraints. When these algorithms are selected, the system automatically ignores the constraints.

If you do not want the system to ignore the constraints, select Barrier Method or SQP. Barrier Method and SQP are second-order optimization algorithms. When no constraint is set, they are equivalent to Newton's Method. Barrier Method and SQP have minor differences in performance and accuracy. We recommend that you choose SQP. If you are not familiar with optimization algorithms, we recommend that you choose the Auto-selected by default option. The system will automatically select an optimization algorithm based on the amount of the data and the constraints.

Feature selection

The Scorecard component supports stepwise feature selection. Stepwise is a combination of forward selection and backward selection. Each time the system selects a new variable by forward selection and adds it to the model, it must perform a backward selection. The backward selection starts with the variables in the model, and eliminates the ones with significance not meeting the requirements. Stepwise feature selection supports various types of target functions and feature transformation methods. Therefore, stepwise feature selection also supports multiple selection standards. Currently, the following standards are supported:

- Marginal contribution: It can be applied to all target functions and feature engineering methods.
- Score test: It only supports WOE transformation and logistic regression without feature engineering.
- F test: It only supports WOE transformation and linear regression without feature engineering.

Marginal contribution

The marginal contribution is the difference between the target functions of Model A without Variable X and target functions of Model B with Variable X after both models are trained. It is the marginal contribution of Variable X to all the other variables in Model B. In the scenario of transforming variables to dummy variables by feature engineering, the marginal contribution of Variable X is the difference between the target functions of all dummy variables in Model A without Variable X and target functions of all dummy variables in Model B with Variable X. Therefore, using marginal contribution to select features is supported by all feature engineering methods.

Marginal contribution makes feature selection more open-ended. It is not restricted to a certain type of models. Only variables that contribute to the target functions are passed to the model. Marginal contribution has certain disadvantages when compared with statistical significance. Typically, statistical significance chooses 0.05 as its threshold. Marginal contribution does not provide a recommended threshold for beginners. We recommend that you set the threshold to 10E-5.

Score test

Score test is only suitable for feature selection in logistic regression. During a forward selection, a model with only intercept options is trained first. In each subsequent regression, the score chi-squares of the variables that have not been passed to the model are calculated. The variable with the largest score chi-square is passed to the model. The P-value corresponds to the largest score chi-square is also calculated based on chi-square distribution. If the P-value is greater than the given SLENTRY value, feature selection is complete.

After the forward selection is complete, a backward selection is performed for the variable passed to the model. The Wald chi-square of the variable and the corresponding P-value are calculated. If the P-value is greater than the given SLSTAY value, the variable is removed from the model. The system then starts a new regression.

F test

F test is only suitable for feature selection in linear regression. During a forward selection, a variable with only intercept options is trained first. In each subsequent regression, the F-values of the variables that have not been passed to the model are calculated. F-value calculation is similar to marginal contribution calculation. Both of them need to train two models to calculate the F-value of a variable. The F-value fits the F distribution. The corresponding P-value can be calculated based on the probability density function of the F distribution. If the P-value is greater than the given SLENTRY value, the variable is not passed to the model, and the forward selection is complete.

The backward selection process uses the F-value to calculate the significance of the variable in a way similar to a score test.

Forcibly selected variables

Before you perform feature selection, you can specify variables to be forcibly passed to the model. The specified variables are passed to the model regardless of their significance. No forward selection or backward selection is performed for these variables.

The number of regressions and significance levels (SLENTRY and SLSTAY) are defined by using a JSON string in the -Dselected parameter as follows:

```
{"max_step":2, "slentry": 0.0001, "slstay": 0.0001}
```

If the -Dselected parameter is left empty or max_step is set to 0, no feature selection is performed.

Model report

The Scorecard component outputs data to a model report. The model report contains basic model evaluation statistics, such as the binning information, binning constraints, WOE values, and marginal contribution information. The following table lists the fields contained in the model report:

Field	Type	Description
feaname	string	The name of the feature.
binid	bigint	The ID of a bin.
bin	string	The description of the bin, which indicates the interval of the bin.

Field	Type	Description
constraint	string	The constraints of the bin specified for model training.
weight	double	The weight of a binning variable. For a non-scorecard model without binning, this field indicates the weight of a model variable.
scaled_weight	double	For score transformation in scorecard training, this field indicates the score linearly transformed from the weight of a binning variable.
woe	double	A statistical indicator. It indicates the WOE value of a bin in the training set.
contribution	double	A statistical indicator. It indicates the marginal contribution value of a bin in the training set.
total	bigint	A statistical indicator. It indicates the total number of samples in a bin in the training set.
positive	bigint	A statistical indicator. It indicates the number of positive samples in a bin in the training set.
negative	bigint	A statistical indicator. It indicates the number of negative samples in a bin in the training set.
percentage_pos	double	A statistical indicator. It indicates the proportion between positive samples in a bin and total positive samples in the training set.
percentage_neg	double	A statistical indicator. It indicates the proportion between negative samples in a bin and total negative samples in the training set.
test_woe	double	A statistical indicator. It indicates the WOE value of a bin in the testing set.

Field	Type	Description
test_contribution	double	A statistical indicator. It indicates the marginal contribution value of a bin in the testing set.
test_total	bigint	A statistical indicator. It indicates the total number of samples in a bin in the testing set.
test_positive	bigint	A statistical indicator. It indicates the number of positive samples in a bin in the testing set.
test_negative	bigint	A statistical indicator. It indicates the number of negative samples in a bin in the testing set.
test_percentage_pos	double	A statistical indicator. It indicates the proportion between positive samples in a bin and total positive samples in the testing set.
test_percentage_neg	double	A statistical indicator. It indicates the proportion between negative samples in a bin and total negative samples in the testing set.

Algorithm parameters

Parameter	Description	Valid value	Default
inputTableName	Required. The input table that contains features.	N/A	N/A
inputTablePartitions	Optional. The partitions selected from the input table.	N/A	The whole table is selected.
inputBinTableName	Optional. The binning result table. If this parameter is set, the system automatically discretizes the original features based on the binning rules in the binning result table.	N/A	N/A

Parameter	Description	Valid value	Default
featureColNames	Optional. The names of feature columns selected from the input table.	N/A	All columns in the input table are selected by default, except for the label column.
labelColName	Required. The names of the target columns.	N/A	N/A
outputTableName	Required. The name of the output table.	N/A	N/A
inputConstraintTableName	Optional. A constraint. The constraint is a JSON string stored in a cell of a table.	N/A	
optimization	Optional. The optimization algorithm.	lbfgs, newton, barrier_method, sqp, and auto. Currently, only the sqp and barrier_method algorithms support constraints. If you set the value to auto, the system automatically selects an optimization algorithm based on the input data and corresponding parameters. We recommend that you set the value to auto if you are unfamiliar with the listed optimization algorithms.	auto
loss	Optional. The type of the loss function.	logistic_regression and least_square.	logistic_regression
iterations	Optional. The maximum number of regressions.	N/A	100
l1Weight	Optional. The weight of the L1 regularization parameter. Currently, only lbfgs supports l1weight.	N/A	0
l2Weight	Optional. The weight of the L2 regularization parameter.	N/A	0

Parameter	Description	Valid value	Default
m	Optional. The number of regressions performed by L-BFGS. Only L-BFGS supports this parameter.	N/A	10
scale	Optional. The weight scaling information of the scorecard.	N/A	Null
selected	Optional. Feature selection in scorecard training.	N/A	Null
convergenceTolerance	Optional. The convergence tolerance.	N/A	1e-6
positiveLabel	Optional. The category of positive samples.	N/A	1
lifecycle	Optional. The lifecycle of the output table.	N/A	No lifecycle is set.
coreNum	Optional. The number of vCores.	N/A	Automatically calculated.
memSizePerCore	Optional. The memory size per core.	N/A	Automatically calculated.

4.4.12.4. Scorecard prediction

The Scorecard Prediction component predicts credit scores based on the input data. It uses a model generated by a model training component. Supported model training components include the Scorecard Training, Logistic Regression for Binary Classification (in the Financials folder), and Linear Regression (in the Financials folder) components.

Input parameters

The Scorecard Prediction component has the following parameters:

- **Feature Column**: specifies the feature columns to be used for predicting credit scores. By default, all columns are selected.
- **Columns Reserved in Result Table**: specifies the columns to be appended to the prediction result table without any changes, such as the ID column and target column.
- **Output Variable Score**: specifies whether to output the score of each variable. The final score equals the score in the intercept option plus the scores of all variables.

Score table

The following is an example of the score table output by the component.

The first column churn is the column appended to the result table from the input table. The data in this column does not affect the prediction results. The remaining three columns display the prediction results. The definitions of these columns are as follows:

Column name	Type	Description
prediction_score	Double	The predicted scores column. In a linear model, the feature values and model weight values are summed up or multiplied to obtain the predicted scores. In a scorecard model, if score transformation is performed, the transformed scores are input into this column.
prediction_prob	Double	The probability values of positive samples in binary classification. The probability values are transformed from the original scores (before score transformation) by using the sigmoid function.
prediction_detail	String	The probability values of positive and negative samples described in JSON strings. Value 0 represents negative and value 1 represents positive. Example: { “0” :0.1813110520,” 1” :0.8186889480}.

PAI command

```
pai -name=lm_predict
  -project=algo_public
  -DinputFeatureTableName=input_data_table
  -DinputModelTableName=input_model_table
  -DmetaColNames=sample_key,label
  -DfeatureColNames=fea1,fea2
  -DoutputTableName=output_score_table
```

Algorithm parameters

Parameter	Description	Valid value	Default
inputFeatureTableName	Required. The name of the input table that stores feature data.	N/A	N/A

Parameter	Description	Valid value	Default
inputFeatureTablePartitions	Optional. The partitions selected from the input table.	N/A	The whole table is selected.
inputModelTableName	Required. The name of the model table.	N/A	N/A
featureColNames	Optional. The names of the feature columns selected from the input table.	N/A	All columns are selected.
metaColNames	Optional. The names of the columns to be reserved in the result table.	N/A	The meta column is excluded. You can specify columns such as label and sample_id.
outputFeatureScore	Optional. It specifies whether to output variable scores to the result table.	true and false	false
outputTableName	Required. The name of the result table.	N/A	N/A
lifecycle	Optional. The lifecycle of the result table.	N/A	No lifecycle is set.
coreNum	Optional. The number of cores.	N/A	Automatically calculated.
memSizePerCore	Optional. The memory size per core.	N/A	Automatically calculated.

4.4.12.5. PSI

Population stability index (PSI) is an important metric to identify a shift in two samples of a population. For example, you can use it to measure whether the changes in the population within two months are stable. A PSI value smaller than 0.1 indicates insignificant changes. A PSI value between 0.1 and 0.25 indicates minor changes. A PSI value greater than 0.25 indicates major changes in the population.

When the changes in a population over time are unstable, you can use charts to identify the changes. You can use binning to discretize variables into multiple bins, calculate the number and proportion of the samples in each bin, and then display the statistics in a chart, as shown in the following figure.

This method can directly show whether a variable in two samples changes significantly. However, the shift in these changes cannot be measured by using this method. This means that the population stability cannot be automatically monitored. To resolve this issue, you can use the PSI component. Before you use the PSI component, you must use the Binning component to discretize the data. The formula for calculating PSI values is as follows:

Examples

The following figure shows a use case of the PSI component. The PSI component is connected to the Binning component and two sample datasets. You only need to specify the columns for PSI calculation in the PSI component.

Result

PAI command

```
PAI -name psi
-project algo_public
-DinputBaseTableName=psi_base_table
-DinputTestTableName=psi_test_table
-DoutputTableName=psi_bin_table
-DinputBinTableName=pai_index_table
-DfeatureColNames=fea1,fea2,fea3
-Dlifecycle=7
```

Algorithm parameters

Parameter	Description	Valid value	Default
inputBaseTableName	Required. The name of the base table. The shift of the population is calculated based on the samples in the base and test tables.	N/A	N/A
inputBaseTablePartitions	Optional. The partitions in the base table.	N/A	The whole table is selected.
inputTestTableName	Required. The name of the test table. The shift of the population is calculated based on the samples in the base and test tables.	N/A	N/A
inputTestTablePartitions	Optional. The partitions in the test table.	N/A	The whole table is selected.
inputBinTableName	Required. The name of the binning result table.	N/A	N/A
featureColNames	Optional. The features specified for PSI calculation.	N/A	All features are selected.
outputTableName	Required. The name of the output table (PSI statistics).	N/A	N/A

Parameter	Description	Valid value	Default
lifecycle	Optional. The lifecycle of the output table.	N/A	No lifecycle is set.
coreNum	Optional. The number of cores.	N/A	Automatically calculated.
memSizePerCore	Optional. The memory size per core.	N/A	Automatically calculated.

4.5. OpenAPI

4.5.1. Query PMML models

Operation name

ListPMMLModels

Description

You can call this operation to query PMML models by project ID, experiment ID, or owner.

Request parameters

Parameter	Type	Required	Example	Description
OnwerId	String	Yes	11769368777159105	The UID of a model owner.
ProjectId	Long	Yes	10009	The ID of a project.
ExperimentId	Long	No	4294	The ID of an experiment.
Action	String	Yes	ListPMMLModels	The operation that you want to perform. Set the value to ListPMMLModels.

Response parameters

Parameter	Type	Description
Experiments	List<ExperimentModelInfo>	An array of experiment properties returned.
Experiment	ExperimentModelInfo	The returned experiment information.

ExpId	Long	The ID of the experiment to which the models belong.
Models	List<ModelInfo >	An array of model properties returned.
Model	ModelInfo	The returned model information.
Name	String	The display name of the model.
Owner	String	The ID of the model owner.
Description	String	The description of the model.
ModelId	String	The ID of the model.
ModelName	String	The name of the underlying model generated by the corresponding algorithm.
CreateTime	Date	The time when the model was generated.
ExperimentId	String	The ID of the experiment from which the model is generated.
UpdateTime	Date	The time when the model was updated.
Project	String	The name of the project to which the model belongs.
ProjectId	String	The ID of the project to which the model belongs.
Action	String	The name of the API operation.
AccessKeyId	String	The AccessKey ID provided to you by Alibaba Cloud.
Signature	String	The signature string.
SignatureMethod	String	The signing method.
SignatureVersion	String	The version of the signature encryption algorithm.
SignatureNonce	String	A unique, random number used to prevent replay attacks.
Timestamp	String	The timestamp of the request.

Version	String	The version number of the API. The value must be in the YYYY-MM-DD format.
Format	String	The language of the response.

Sample requests

```
http://pop.pai.idst.inter.env8d.com/?Action=ListPMMLModels&ProjectId=10009&Version=2019-09-25&ExperimentId=4294&OnwerId=11769368777159105&<Common request parameters>
```

Sample responses

```
<ListPMMLModelsResponse>
<Experiments>
<Experiment>
<ExpId>4294</ExpId>
<Models>
<Model>
<Name>Logistic regression for binary classification-1-Model</Name>
<Owner>11769368777159105</Owner>
<Description>Logistic regression for binary classification-1-Model</Description>
<ModelId>6119</ModelId>
<ModelName>xlab_m_logisticregressi_51466_v0</ModelName>
<CreateTime>2019-09-23 17:06:42</CreateTime>
<ExperimentId>4294</ExperimentId>
<UpdateTime>2019-09-26 19:33:03</UpdateTime>
<Project>pai_emr</Project>
<ProjectId>10009</ProjectId>
</Model>
<Model>
<Name>Random forest1-AUC-0</Name>
<Owner>11769368777159105</Owner>
<Description>Random forest1-AUC-0</Description>
<ModelId>6200</ModelId>
<ModelName>xlab_m_random_forests_1_51463_v0_m_0</ModelName>
<CreateTime>2019-09-26 12:38:12</CreateTime>
<ExperimentId>4294</ExperimentId>
<UpdateTime>2019-09-26 12:38:12</UpdateTime>
<Project>pai_emr</Project>
<ProjectId>10009</ProjectId>
</Model>
```

```
</Models>
</Experiment>
</Experiments>
<RequestId>0a948186156950036564347 43d0059</RequestId>
<ErrMsg>Successful</ErrMsg>
<ErrCode>success</ErrCode>
</ListPMMLModelsResponse>{
 "ListPMMLModelsResponse": {
  "Experiments": {
   "Experiment": {
    "ExpId": "4294",
    "Models": {
     "Model": [
      {
       "Name": "Logistic regression for binary classification-1-Model",
       "Owner": "11769368777159105",
       "Description": "Logistic regression for binary classification-1-Model",
       "ModelId": "6119",
       "ModelName": "xlab_m_logisticregressi_51466_v0",
       "CreateTime": "2019-09-23 17:06:42",
       "ExperimentId": "4294",
       "UpdateTime": "2019-09-26 19:33:03",
       "Project": "pai_emr",
       "ProjectId": "10009"
      },
      {
       "Name": "Random forest1-AUC-0",
       "Owner": "11769368777159105",
       "Description": "Random forest1-AUC-0",
       "ModelId": "6200",
       "ModelName": "xlab_m_random_forests_1_51463_v0_m_0",
       "CreateTime": "2019-09-26 12:38:12",
       "ExperimentId": "4294",
       "UpdateTime": "2019-09-26 12:38:12",
       "Project": "pai_emr",
       "ProjectId": "10009"
      }
     ]
    }
   }
  },
```

```
  "RequestId": "0a948186156950036564347 43d0059",
  "ErrMsg": "Successful",
  "ErrCode": "success"
 }
}
```


4.5.2. Query detailed information about a PMML model

Operation name

DescribePMMLMode

Description

You can call this operation to query detailed information about a model.

Request parameters

Parameter	Type	Required	Example	Description
ModelId	Integer	Yes	6200	The ID of the model.
Action	String	Yes	DescribePMMLMode	The operation that you want to perform. Set the value to DescribePMMLMode.

Response parameters

Parameter	Type	Description
Models	List<ModelInfo >	An array of model properties returned.
Model	ModelInfo	Detailed information about the model.
Name	String	The display name of the model.
Owner	String	The ID of the model owner.
Description	String	The description of the model.
ModelId	String	The ID of the model.

Parameter	Type	Description
ModelName	String	The name of the underlying model generated by the algorithm.
CreateTime	Date	The time when the model was generated.
ExperimentId	String	The ID of the experiment from which the model is generated.
UpdateTime	Date	The time when the model was updated.
Project	String	The name of the project to which the model belongs.
ProjectId	String	The ID of the project to which the model belongs.

Sample requests

```
http://pop.pai.idst.inter.env8d.com/?Action=DescribePMMLMode&ModelId=6200&<Common request parameters>
```

Sample responses

<DescribePMMLModeResponse>
<Data>
<ModelInfo>
<Name>Logistic regression for binary classification-1-Model</Name>
<Owner>11769368777159105</Owner>
<ModelId>6119</ModelId>
<Description>Logistic regression for binary classification-1-Model</Description>
<ModelName>xlab_m_logisticregressi_51466_v0</ModelName>
<CreateTime>2019-09-23 17:06:42</CreateTime>
<UpdateTime>2019-09-26 19:33:03</UpdateTime>
<ExperimentId>4294</ExperimentId>
<Project>pai_emr</Project>
<ProjectId>10009</ProjectId>
</ModelInfo>
</Data>
<RequestId>0a944153156949926868668173d0065</RequestId>
<ErrMsg>Successful</ErrMsg>
<ErrCode>success</ErrCode>
</DescribePMMLModeResponse>{
 "DescribePMMLModeResponse": {
  "Data": {
   "ModelInfo": {
    "Name": "Logistic regression for binary classification-1-Model",
    "Owner": "11769368777159105",
    "ModelId": "6119",
    "Description": "Logistic regression for binary classification-1-Model",
    "ModelName": "xlab_m_logisticregressi_51466_v0",
    "CreateTime": "2019-09-23 17:06:42",
    "UpdateTime": "2019-09-26 19:33:03",
    "ExperimentId": "4294",
    "Project": "pai_emr",
    "ProjectId": "10009"
   }
  },
  "RequestId": "0a944153156949926868668173d0065",
  "ErrMsg": "Successful",
  "ErrCode": "success"
 }

4.5.3. Download PMML models

4.5.3.1. Generate a download URL for a model

Operation name

GeneratePMMLModelUrl

Description

You can call this operation to generate a download URL for a PMML model. The API call is executed asynchronously. After you call this operation, the system creates a download URL generation task in the background, and returns the task ID to you. You can then use the task ID to query the status of the task. If the task is successfully executed, the URL (OSS endpoint) of the model is returned.

Request parameters

Parameter	Type	Required	Example	Description
ModelId	Integer	Yes	6200	The ID of the model.
Action	String	Yes	GeneratePMMLModelUrl	The operation that you want to perform. Set the value to GeneratePMMLModelUrl.

Response parameters

Parameter	Type	Description
Data	Data	The returned data.
JobId	String	The ID of the download URL generation task.

Sample requests

```
http://pop.pai.idst.inter.env8d.com/?Action=GeneratePMMLModelUrl&ModelId=6200&<Common request parameters>
```

Sample responses

```
<GeneratePMMLModelUrlResponse>
<Data>
<JobId>
asynUploadModel2Oss_395fd769-1568-4015-8aa8-a56b2e0da11c
</JobId>
</Data>
<RequestId>0a9481861569501305435669 7d0059</RequestId>
<ErrMsg>Successful</ErrMsg>
<ErrCode>success</ErrCode>
</GeneratePMMLModelUrlResponse>{
 "GeneratePMMLModelUrlResponse": {
  "Data": {
   "JobId": "
asynUploadModel2Oss_395fd769-1568-4015-8aa8-a56b2e0da11c
"
  },
  "RequestId": "0a9481861569501305435669 7d0059",
  "ErrMsg": "Successful",
  "ErrCode": "success"
 }
}
```


4.5.3.2. Query a model URL generation task

Operation name

QueryAsynJobStatus

Description

You can call this operation to query the status of a URL generation task. If the task is successfully executed, the URL (OSS endpoint) of the model is returned.

Request parameters

Parameter	Type	Required	Example	Description
JobId	String	Yes	asynUploadModel2Oss_395fd769-1568-4015-8aa8-a56b2e0da11c	The ID of the task to be queried. The task ID is returned after you call the GeneratePMMLModelUrl operation.

Parameter	Type	Required	Example	Description
Action	String	Yes	QueryAsynJobStatus	The operation that you want to perform. Set the value to QueryAsynJobStatus.

Response parameters

Parameter	Type	Description
Data	Data	The returned data.
Status	String	The status of the task. Valid values: done, failed, and running.
Info	String	The URL of the model is returned if the task is successfully executed. An error message is returned if the system fails to execute the task.

Sample requests

```
http://pop.pai.idst.inter.env8d.com/?Action=QueryAsynJobStatus&JobId=asynUploadModel2Oss_395fd769-1568-4015-8aa8-a56b2e0da11c&<Common request parameters>
```

Sample responses

```
<QueryAsynJobStatusResponse>
<Data>
<Status>done</Status>
<Info>
<![ CDATA[
http://pai-global-oss.oss-cn-qingdao-env8d-d01-a.intra.env8d.com/xlab_m_random_forests_1_51463_v0_m_0-%E9%9A%8F%E6%9C%BA%E6%A3%AE%E6%9E%971-AUC-0.pmml?Expires=1569501906&OSSAccessKeyId=yMPdrqaNstzXKsNY&Signature=uRM1OFDZeDNzZo%2BjG87s09uUd6****
]]>
</Info>
</Data>
<RequestId>0a9481861569501342195757 9d0059</RequestId>
<ErrMsg>Successful</ErrMsg>
<ErrCode>success</ErrCode>
</QueryAsynJobStatusResponse>{
 "QueryAsynJobStatusResponse": {
  "Data": {
   "Status": "done",
   "Info": "
http://pai-global-oss.oss-cn-qingdao-env8d-d01-a.intra.env8d.com/xlab_m_random_forests_1_51463_v0_m_0-%E9%9A%8F%E6%9C%BA%E6%A3%AE%E6%9E%971-AUC-0.pmml?Expires=1569501906&OSSAccessKeyId=yMPdrqaNstzXKsNY&Signature=uRM1OFDZeDNzZo%2BjG87s09uUd6****
"
  },
  "RequestId": "0a9481861569501342195757 9d0059",
  "ErrMsg": "Successful",
  "ErrCode": "success"
 }
}
```

4.5.4. SDKs

Alibaba Cloud SDKs

```
https://developer.aliyun.com/sdk?spm=5176.10695662.1kquk9v2l.2.1e734735x9Gptc&aly_as=m3lFQpXP<dependency>
<groupId>com.aliyun</groupId>
<artifactId>aliyun-java-sdk-core</artifactId>
<version>{$version}</version></dependency>
```

SDK use case

Example: call an RPC API operation.

```
import com.aliyuncs.CommonRequest;
import com.aliyuncs.CommonResponse;
import com.aliyuncs.DefaultAcsClient;
import com.aliyuncs.IAcsClient;
import com.aliyuncs.exceptions.ClientException;
import com.aliyuncs.exceptions.ServerException;
import com.aliyuncs.profile.DefaultProfile;
public class Sample {
  public static void main(String[] args) {
    // Create a default ACS client and initialize it.
    DefaultProfile profile = DefaultProfile.getProfile(
      "<your-region-id>",       // The region ID.
      "<your-access-key-id>",    // The AccessKey ID.
      "<your-access-key-secret>"); // The AccessKey secret.
    IAcsClient client = new DefaultAcsClient(profile);
    // Create an API request and configure parameters.
    CommonRequest request = new CommonRequest();
    request.setDomain("ecs.aliyuncs.com");
    request.setVersion("2014-05-26");
    request.setAction("DescribeInstanceStatus");
    request.putQueryParameter("PageNumber", "1");
    request.putQueryParameter("PageSize", "30");
    try {
      CommonResponse response = client.getCommonResponse(request);
      System.out.println(response.getData());
    } catch (ServerException e) {
      // TODO Auto-generated catch block
      e.printStackTrace();
    } catch (ClientException e) {
      // TODO Auto-generated catch block
      e.printStackTrace();
    }
  }
}
```

Example: call an RESTful API operation.

```
import com.aliyuncs.CommonRequest;
import com.aliyuncs.CommonResponse;
import com.aliyuncs.DefaultAcsClient;
import com.aliyuncs.IAcsClient;
import com.aliyuncs.exceptions.ClientException;
import com.aliyuncs.exceptions.ServerException;
import com.aliyuncs.profile.DefaultProfile;
public class Sample {
  public static void main(String[] args) {
    // Create a default ACS client and initialize it.
    DefaultProfile profile = DefaultProfile.getProfile(
      "<your-region-id>",       // The region ID.
      "<your-access-key-id>",    // The AccessKey ID.
      "<your-access-key-secret>"); // The AccessKey secret.
    IAcsClient client = new DefaultAcsClient(profile);
    // Create an API request and configure parameters.
    CommonRequest request = new CommonRequest();
    request.setDomain("cs.aliyuncs.com");
    request.setVersion("2015-12-15");
    request.setUriPattern("/clusters");
    try {
      CommonResponse response = client.getCommonResponse(request);
      System.out.println(response.getData());
    } catch (ServerException e) {
      // TODO Auto-generated catch block
      e.printStackTrace();
    } catch (ClientException e) {
      // TODO Auto-generated catch block
      e.printStackTrace();
    }
  }
}
```

SDK parameters

The domain must be in the pop.${pai_domain} format. Set the pai_domain parameter to the domain shown in the Machine Learning Platform for AI.

The version must be 2019-09-25.

The Action string specifies an API operation.

The QueryParameter string specifies API request parameters, excluding the action parameter.

Example:

```
CommonRequest request = new CommonRequest();
request.setDomain("pop.${pai_domain}");
request.setVersion("2019-09-25");
request.setAction("DescribePMMLMode");
request.putQueryParameter("ModelId", "***");
```

4.6. EAS user guide

4.6.1. EAS overview

Elastic Algorithm Service (EAS) allows you to deploy machine learning models, such as PMML, PAI-OfflineModel, TensorFlow, and Caffe models, as services. You can also develop custom online services based on the API standards defined by EAS. You can simply use a JSON file to describe the service that you want to deploy, such as the path of the model, the region where the service is deployed, and the resources used by the service. After the JSON file is prepared, you can use the eascmd client or Alibaba Cloud SDK for Java to deploy it as an online service. The service can be accessed from the production environment and Internet. EAS supports various regions and different types of hardware resources (CPUs and GPUs).

4.6.2. Client

You can use the eascmd client to create, delete, view, and modify services. The eascmd client is stored in the Object Storage Service (OSS) bucket eas-utils. You can use wget or curl to download eascmd.

4.6.3. User authentication

Deployed model services use JSON Web Token (JWT) for user authentication. You can run the following command in eascmd to configure the AccessKey information.

```
./eascmd64 config -i <AccessKeyId> -k <AccessKeySecret> -e {{Domain name of EAS}}
//New users can use the admin account to pass authentication.
./eascmd64 config -i admin -k admin -e {{Domain name of EAS}}
```

4.6.4. Upload files

When you create a service, you must specify the HTTP addresses of the model and processor files. You can store the model and processor files on any HTTP servers.

4.6.5. Create a service

You can run the `create` command to create a service. When you create a service, you must specify the HTTP URLs of the model and processor files to be used by the service. You can upload the files to Object Storage Service (OSS) and specify their OSS paths.

```
eascmd create [service_desc_json]
```

The service_desc_json file contains service information and metadata configurations. The metadata configurations only contain cluster deployment information, such as the region where the cluster is deployed and the required resources. Example:

> **Note** When you run the test command to debug the service, the metadata configurations are ignored.

```
{
 "name": "mnist_saved_model_example",
 "generate_token": "true",
 "model_path": "http://eas-data.oss-cn-shanghai.aliyuncs.com/models%2Fmnist_saved_model.tar.gz",
 "processor": "tensorflow_cpu",
 "metadata": {
  "instance": 1,
  "cpu": 1,
 }
}
```

The parameters in the JSON file are described as follows:

Key	Value
name	The name of the service. Service names are unique inside each region. You can specify the region in the metadata configurations.
generate_token	Specifies whether to generate a token. If the value is set to true, you must add the token to the HTTP header of the request that you send to the service. If the value is set to false, the service is accessible to the public. No authentication is required.
token	Optional. The token used for authenticating requests sent to the service. If you do not specify a token, the generate_token parameter automatically generates a token.
model_path	The path of the model file. For more information, see the note under this table.
model_entry	Optional. The input file of the model. If no input file is specified, the file specified by the model_path parameter is used. You can specify arbitrary files in this parameter. The path of the primary file will be passed to the Load() function in the processor.

Key	Value
model_config	Optional. The configuration of the model. The configuration can be in any text format. The configuration is passed to the second parameter of the LoadWithConfig() function in the processor.
processor	Optional. The built-in processor used to make predictions. When this parameter is specified, the processor_path, processor_entry, processor_mainclass, and processor_type parameters are ignored.
processor_path	Optional. The path of the processor. Only custom processors support this parameter. For more information about processor packages, see the note under this table.
processor_entry	The primary file of the processor. It contains the implementations of the Load() and Process() functions. This parameter is required when you develop a custom processor using the C or C++ language.
processor_mainclass	The primary file of the processor. It defines the main class in Java. This parameter is required when you develop a custom processor using Java.
processor_type	Optional. The language used to develop the processor. Only custom processors support this parameter. Currently, only C++, Java, and Python are supported.
metadata	The metadata of the service.

Note model_path and processor_path specify the inputs of the model and processor in the format of HTTP URLs or OSS paths. When you use the test command to debug the service on your local machine, local paths are supported.

When HTTP URLs are used, the required files must be packaged in the tar.gz, tar.bz2, or ZIP format.

Metadata descriptions

Category	Parameter	Description
	workers	Optional. The number of threads used by each instance to process requests in parallel. The default is 5.
	instance	The number of instances launched by the service.

Category	Parameter	Description
Common options	CPU	The number of CPUs required by each instance.
	gpu	The number of GPUs required by each instance.
	resource	The name of the resource group. If your service uses CPU resources, ignore this parameter. Supported GPU resource groups are P4_4CORE and P4_8CORE.
Advanced parameter (use with caution)	rpc.batching	Optional. It specifies whether to enable batching at the server end for GPU optimization. The default is false.
	rpc.keepalive	Optional. The maximum amount of time that it takes to process a single request. When the time expires, the server end returns a 408 error and disconnects from the client. The default is 5000 milliseconds.
	rpc.io_threads	Optional. The number of threads used by each instance to handle network inputs and outputs. The default is 4.
	rpc.max_batch_size	Optional. The maximum size of each batch when batching is enabled. The default is 16.
	rpc.max_batch_timeout	Optional. The maximum timeout of each batch when batching is enabled. The default is 50 milliseconds.

Category	Parameter	Description
	rpc.max_queue_size	Optional. The maximum size of the queue. The default is 64. When the queue is full, the server end returns a 450 error and closes the connection. The queue can prevent the server from being overloaded. It also can notify the client to send the request to other instances when the current instance is busy. For a queue that produces a long response time, you can set the size of the queue to a smaller value to prevent large amounts of pending requests from timing out.
	rpc.worker_threads	Optional. The number of threads used by each instance to process requests in parallel. This parameter is the same as the workers parameter. The default is 5.

Example:

```
{
 ...
"metadata": {
 "cpu": 4,
"rpc.max_queue_size": 32,
...
}
```

```
$ eascmd create pmml.json
[RequestId]: 1651567F-8F8D-4A2B-933D-F8D3E2DDEB2D
+------------------+-------------------------------------------------------------------------+
| Intranet Endpoint | http://pai-eas-vpc.cn-shanghai.aliyuncs.com/api/predict/savedmodel_exanple |
|          Token | YjQxZDYzZTBiZTZjMzQ5ZmE****             |
+------------------+-------------------------------------------------------------------------+
[OK] Creating api gateway
[OK] Building image [registry-vpc.cn-shanghai.aliyuncs.com/eas/savedmodel_exanple_cn-shanghai:v0.0.1-2
0190224001315]
[OK] Pushing image [registry-vpc.cn-shanghai.aliyuncs.com/eas/savedmodel_exanple_cn-shanghai:v0.0.1-2
0190224001315]
[OK] Waiting [Total: 1, Pending: 1, Running: 0]
[OK] Waiting [Total: 1, Pending: 1, Running: 0]
[OK] Service is running
```

4.6.6. Local debugging

Before you deploy the service to the cluster, you can use the local debugging feature to start a local service for debugging. This feature requires a Docker container and Internet access. You must install Docker on the machine where eascmd runs, and then run the following command to debug the service.

```
sudo eascmd test [service_desc_json]
```

Specify the JSON file used to deploy the service in this command. The following example shows how to run this command:

```
[xingke.***@mac-3:~/code/go/src/easgo]$ bin/eascmd test tf.json
[OK] Pulling image: registry.cn-shanghai.aliyuncs.com/eas/eas-worker-amd64:0.1.4
[OK] Pull image done
[OK] Creating container from: registry.cn-shanghai.aliyuncs.com/eas/eas-worker-amd64:0.1.4
[OK] Created container: e39176f85cf41a161bbb2896f76f1c0db0ad4f50e1d78a********
[OK] Serving At: [http://localhost:6942/api/predict/savedmodel_exanple]
[2019-02-24 00:16:27] [172.17.0.2] Fetching model from [http://eas-data.oss-cn-shanghai.aliyuncs.com/mode
ls%2Fflypig_scorecard.pmml]
[2019-02-24 00:16:27] [172.17.0.2] Fetching processor from [http://eas-data.oss-cn-shanghai.aliyuncs.com/ea
s-pmml-processor-0.1-jar-with-dependencies.jar]
[2019-02-24 00:16:28] [172.17.0.2] ----------------------------SERVICE LOG-------------------------------
...
[2019-02-24 00:16:30] [172.17.0.2] [INFO] Token: [WIzMFW5Jb8kckYj****]
...
[2019-02-24 00:16:30] [172.17.0.2] [INFO] Service start successfully
```

In this example, the command starts a local TensorFlow model service. The endpoint of the service is http://localhost:6942/api/predict/savedmodel_exanple.

4.6.7. Modify configurations

You can specify the -D parameter in the modify command to modify the metadata configurations, such as the instance, CPU, and memory configurations.

```
eascmd modify [service_name] -Dmetadata.[attr_name]=[attr_value]
```

For example, you can run the following command to set the number of instances to 10.

```
eascmd modify service_test -Dmetadata.instance=10
```

You can set multiple properties at a time. For example, you can set the number of instances to 10 and the memory size to 2,000 MB.

```
eascmd modify service_test -Dmetadata.instance=10 -Dmetadata.memory=2000
```

4.6.8. Modify a service

You can run the modify command to modify a deployed service.

```
eascmd modify [service_name] -s [service_desc_json]
```

> **Note** You cannot use this command to modify the region where the service is deployed. Note: If you only want to modify the resources used by the service, specify the metadata configurations in the service description file.

4.6.9. Delete a service

You can run the delete command to delete a service.

```
eascmd delete [service_name]
```

When you delete a service, you must specify the service name and the region where the service is deployed.

Examples:

```
$ eascmd delete savedmodel_exanple
Are you sure to delete the service [savedmodel_exanple] in [cn-shanghai]? [Y/n]
[RequestId]: 1651567F-8F8D-4A2B-933D-F8D3E2DDEB2D
[OK] Service [savedmodel_exanple] in region [cn-shanghai] is terminating
[OK] Service is terminating
[OK] Service is terminating
[OK] Service was deleted successfully
```

4.6.10. Switch service version

You can run the desc command to view the version of the current service and the latest version, and run the version command to switch the service to a version earlier than the latest version.

```
eascmd version [service_name] [version_id]
```

4.6.11. View service list

You can run the list(ls) command to view all services deployed by the current user.

```
$ eascmd ls
[RequestId]: 83945D4EED3E-4D35-A989-831E6BBA39F
+--------------------------+------------+----------+--------------------+--------------------+---------+--------+-----------------------
----------------+
|     SERVICENAME     | REGION   |INSTANCE|    CREATETIME    |    UPDATETIME    |STATUS |WEIGHT|
SERVICEPATH          |
+--------------------------+------------+----------+--------------------+--------------------+---------+--------+-----------------------
----------------+
| mnist_saved_model_example | cn-shanghai |      1 | 2019-02-21 16:35:41 | 2019-02-21 16:35:41 | Running |     0
| /api/predict/mnist_saved_model_example |
```

4.6.12. View service information

You can run the desc command to view detailed information about a deployed service.

```
eascmd desc [service_name]
```

Examples:

```
$ eascmd desc mnist_saved_model_example
+--------------------+-----------------------------------------------------------------------------------------------------------------+
|         Status | Running                                                                                                        |
|      ServiceName | mnist_saved_model_example                                                                                    |
|         Region | cn-shanghai                                                                                                    |
```

```
|       CreateTime | 2019-02-21 16:35:41                                    |
|       UpdateTime | 2019-02-21 16:35:41                                    |
|      AccessToken |                                                        |
|     PrivateToken | ZWNjMTNkNDExMmExNjZkYTM4YWQ5YTY****                     |
|    TotalInstance | 1                                                      |
|  RunningInstance | 1                                                      |
|  PendingInstance | 0                                                      |
|              CPU | 1                                                      |
|              GPU | 0                                                      |
|           Memory | 1000M                                                  |
|            Image | registry-vpc.cn-shanghai.aliyuncs.com/eas/mnist_saved_model_example_cn-shanghai:v0.0.1
-20190221163541       |
|           Weight | 0                                                      |
|    LatestVersion | 1                                                      |
|   CurrentVersion | 1                                                      |
|          Message | Service start successfully                             |
|    APIGatewayUrl | 1c3b37ea83c047efa0dc6df0cacb70d3-cn-shanghai.alicloudapi.com/EAPI_182848887922
2746_mnist_saved_model_example |
|  APIGatewayAppKey | 25641710                                              |
| APIGatewayAppSecret | 12562a7b8858bbba****                                |
|  IntranetEndpoint | http://pai-eas-vpc.cn-shanghai.aliyuncs.com/api/predict/mnist_saved_model_exampl
e                   |
|    ServiceConfig | {                                                      |
|                  |   "generate_token": "false",                           |
|                  |   "metadata": {                                        |
|                  |     "cpu": 1,                                          |
|                  |     "instance": 1,                                     |
|                  |     "memory": 1000,                                    |
|                  |     "region": "cn-shanghai"                            |
|                  |   },                                                   |
|                  |   "model_path":                                        |
|                  | "http://eas-data.oss-cn-shanghai.aliyuncs.com/models%2Fmnist_saved_model.tar.gz",
|
|                  |   "name":                                              |
|                  | "mnist_saved_model_example",                           |
|                  |   "processor":                                         |
|                  | "tensorflow_cpu"                                       |
|                  | }
```

4.6.13. View service processes

You can run the showworkers(w) command to view the status of the service processes.

```
eascmd w [service_name]
```

Examples:

```
$ eascmd w mnist_saved_model_example
[RequestId]: 4E905404-E617-4BD8-85D6-EC5C6A0D0211
+--------------+----------------+---------------------+----------+---------+-------+--------+
|  INNERIP   |    HOSTIP    |     STARTAT     | RESTARTS | STATUS  | READY | REASON |
+--------------+----------------+---------------------+----------+---------+-------+--------+
| 172.24.5.183 | 192.168.65.121 | 2019-02-21 16:35:58 |      0 | Running | [1/1] |      |
+--------------+----------------+---------------------+----------+---------+-------+--------+
```

4.6.14. Call the prediction service

To call a prediction service, you must use the HTTP URL generated when the prediction service is created. The URLs for local testing and online prediction are generated in the same format. The only difference is that they use different hosts. When you send a request to the URL, you must add a token to the HTTP header of the request. The token is generated when you create an image. The following example shows how to call the prediction service from curl. PMML model prediction:

```
$ curl http://{{The domain of EAS}}/api/predict/pmml_example -H 'Authorization: NGE3MzM4YmRhODZjMTE2
NmZjZjNlNTJlNDgyNzM3YzdjMmIwOD****==' -d '[{}]'
[{"prediction_score":0.0902926730924553}]
```

The processor defines the formats of the input and output of the prediction service.

4.6.15. Use Java or C++ to develop a model service

4.6.15.1. What are processors

Processors are program packages that contain the prediction logic. User requests are processed by processors and then returned to clients. A processor contains the logic for loading models and making predictions upon user requests. Machine Learning Platform for AI supports general processors: PMML and TensorFlow. If you want to customize the prediction logic, you must follow the processor development standards to develop a processor.

You can develop a processor in C, C++, and Java languages without the need to use an SDK. You only need to define the relevant classes and functions to develop a processor. This makes it easy for you to debug the processor offline.

4.6.15.2. C/C++ processor

If you use a C or C++ processor, you must define functions Load() and Process(). Function Load() is used to load the model during the initialization process. Function Process() is used to process service calls and return the processing results to clients. The two functions are declared as follows:

```
void *initialize(const char *model_entry, const char *model_config, int *state)
```

Parameter	Type	Description
model_entry	Input parameter	Specifies a model file. This parameter corresponds to the model_entry parameter in the configuration file when you deploy a model service. You can specify a file name or directory, for example, randomforest.pmml or ./model.
model_config	Input parameter	Specifies the custom model configurations. This parameter corresponds to the model_config parameter in the configuration file when you deploy a model service.
state	Output parameter	Indicates whether the model is loaded. Value 0 indicates that the model has been loaded.
N/A	Returned value	The momery address of the user-defined model variable. The value can be any data type.

```
int process(void *model_buf, const void *input_data, int input_size,
    void **output_data, int *output_size)
```

Parameter	Type	Description
model_buf	Input parameter	Specifies the memory address of the model returned by function initialize().
input_data	Input parameter	Specifies the input data. String data and binary data are supported.
input_size	Output parameter	Specifies the size of the input data.

Parameter	Type	Description
output_data	Output parameter	The data returned by the processor. You must allocate heap memory to the processor. The model will automatically release the memory.
output_size	Output parameter	The size of the data returned by the processor.
N/A	Returned value	If value 0 or 200 is returned, the model service is successfully called. This parameter can return HTTP error codes to clients. If the processor cannot recognize the HTTP error code, it automatically converts it to HTTP error code 400.

Examples

In the following example, no model data is loaded. The prediction service directy returns the request to the client.

```
#include <stdio.h>
#include <string.h>
extern "C" {
  void *initialize(const char *model_entry, const char *model_config, int *state)
  {
    *state = 0;
    return NULL;
  }
  int process(void *model_buf, const void *input_data, int input_size,
      void **output_data, int *output_size)
  {
    if (inputSize == 0) {
      const char *errmsg = "input data should not be empty";
      *outputData = strndup(errmsg, strlen(errmsg));
      *outputSize = strlen(errmsg);
      return 400;
    }
    *outputData = strndup((char *)inputData, inputSize);
    *outputSize = inputSize;
    return 200;
  }
}
```

The processor does not load any model data. It directly returns the input data to the client. You can use Makefile to compile the processor into a .so file.

```
CC=g++
CCFLAGS=-I./ -D_GNU_SOURCE -Wall -g -fPIC
LDFLAGS= -shared -Wl,-rpath=. /
OBJS=processor.o
TARGET=libpredictor.so
all: $(TARGET)
$(TARGET): $(OBJS)
    $(CC) -o $(TARGET) $(OBJS) $(LDFLAGS) -L./
%.o: %.cc
    $(CC) $(CCFLAGS) -c $< -o $@
clean:
    rm -f $(TARGET) $(OBJS)
```

If the processor is reliant on other .so files, package these files with the processor.so file, and then deploy the package.

4.6.15.3. Java processor

The Java processor also uses functions Load() and Process() besides constructors. You only need to define one class for the Java processor. The class is defined as follows:

```
package com.alibaba.eas;
import java.util.*;
public class TestProcessor {
 public TestProcessor(String modelEntry, String modelConfig) {
  /* Passes a model file name to the class and initializes the model. */
 }
 public void Load() {
  /* Loads the model information based on the specified model file name */
 }
 public String Process(String input) {
  /* Preprocesses the input data and outputs the processing results. Currently, only string type data can be i
nput and output */
 }
 public static void main(String[] args) {
  /* The main function is optional. It can be used for debugging on your local host. */
 }
}
```

If an exception occurs, the system automatically captures the exception, and returns an error message to the client. An HTTP 400 status code is also returned to the client. You can also customize the logic for capturing exceptions and return an error message to your client as follows:

```
try{
} catch (com.alibaba.fastjson.JSONException e) {
 throw new RuntimeException("bad json format, " + e.getMessage());
}
```

4.7. Automatic parameter tuning with AutoML

4.7.1. Automatic parameter tuning with AutoML

This topic describes the automatic parameter tuning feature of AutoML.

Parameter

1. Log in to machine learning console. In the left-side navigation pane, click **Experiments**.

2. Click an experiment to go to the canvas of the experiment.

   > **Note** This topic uses air quality prediction as an example.

3. In the upper-left corner of the canvas, choose **Auto ML > Auto Parameter Tuning**.
4. On the **Auto Parameter Tuning** page, select an algorithm for parameter tuning, and click **Next**.

   > **Note** You can select only one algorithm to tune at a time.

5. In the **Configure Parameter Tuning** module, set the **Parameter Tuning Method** parameter and click **Next**.

   Alibaba Cloud Machine Learning Platform for AI provides four **parameter tuning methods**. For more information, see Parameter adjustment method.

6. In the **Configure Model Output** module, set the model output parameters and click **Next**.

Parameter	Description
Evaluation Criteria	You can select one evaluation standard from the following four dimensions: **AUC**, **F1-score**, **PRECISION**, and **RECALL**.
Saved Models	You can save up to five models. The system ranks models based on the **Evaluation Criteria** setting you select and save the top ranked models according to the number entered in the **Saved Models** field.
Pass Down Model	This switch is turned on by default. If the switch is turned off, the model generated by the default parameters of the current component are passed down to the node of the subsequent component. If the switch is turned on, the optimal model generated by automatic parameter tuning are passed down to the node of the subsequent component.

7. In the upper-left corner of the canvas, click **Run** to run the automatic parameter tuning algorithm, as shown in the following figure.

   > **Note** After the preceding configuration is complete, the Auto ML switch of the related algorithm is turned on. You can turn the switch on or off as needed.

8. Right-click a model component and choose **Edit AutoML Parameters** from the shortcut menu to modify its AutoML configuration parameters.

Output model display

1. During parameter tuning, right-click the target model component and choose **Parameter Tuning Details** from the shortcut menu.
2. On the **AutoML-Parameter Tuning Details** page, click the **Metrics** tab to view the current tuning progress and the running status of each model.

3. You can sort candidate models according to indicators (**AUC**, **F1-score**, **Accuracy**, and **Recall Rate**).
4. In the **View Details** column, you can click **Log** or **Parameter** to view the logs and parameters of each candidate model.

Parameter tuning effect display

1. On the **AutoML-Parameter Tuning Details** page, you can click the **Charts** tab to view the **Model Evaluation and Comparison** and **Hyperparameter Iteration Result Comparison** charts.
2. You can view the growth trend of the evaluation indicators of updated parameters in the **Hyperparameter Iteration Result Comparison** chart.

Model storage

1. Log in to machine learning console. In the left-side navigation pane, click **Models**.
2. Click **Experiment Model** to open the experiment model folder.
3. Click the corresponding experiment folder to view the model saved with Auto ML.
4. (Optional) You can apply a model to other experiments by dragging the model to the canvas of the target experiment.

4.7.2. Parameter tuning methods

AutoML supports four parameter tuning methods.

Evolutionary Optimizer

Principle:

1. Randomly selects A parameter candidate sets (where A indicates the **number of exploration samples**).
2. Takes the N parameter candidate sets with higher evaluation indicators as the parameter candidate sets of the next iteration.
3. Continues the exploration within R times (where R indicates the **convergence coefficient**) as the standard deviation range around these parameters to explore new parameter sets. The new parameter sets replace the last A-N parameter sets by the evaluation indicator in the previous round.
4. Iterates the exploration for M rounds (where M indicates the **number of explorations**) until the optimal parameter set is found, according to the preceding logic.

Based on the preceding principle, the final number of models is A + (A - N) × M.

> **Note** The first value of N is A/2 - 1. During iteration, the default value is A/2 - 1 (rounded up).

Parameter	Description
Data Splitting Ratio	Splits input data sources into training and evaluation sets. 0.7 indicates that 70% of the data is used for model training and 30% for evaluation.

Parameter	Description
Exploration Samples	The number of parameter sets of each iteration. The higher the number, the greater the accuracy, the larger the calculation. This parameter must be set to a positive integer in the range of 5 to 30.
Explorations	The number of iterations. The higher the number of iterations, the greater the search accuracy, the larger the calculation. This parameter must be set to a positive integer in the range of 1 to 10.
Convergence Coefficient	Tunes the exploration ranges (R times the standard deviation range search). The smaller the range, the faster the convergence (however, optimal parameters may be missed). Valid values: 0.1 to 1 (one floating point after the decimal point).

Note You must enter the tuning range for each parameter. If the current parameter range is not configured, the parameter range is set by default.

Random Search

Principle:

1. Randomly selects a value for each parameter within the parameter range.
2. Enters random values into a set of parameters for model training.
3. Performs M rounds (where M indicates the **number of iterations**) and then sorts the output models.

Parameter	Description
Data Splitting Ratio	Splits input data sources into training and evaluation sets. 0.7 indicates that 70% of the data is used for model training and 30% for evaluation.
Iterations	The number of searches in the configured range. Valid values: 2 to 50.

Note You must enter the tuning range for each parameter. If the current parameter range is not configured, the parameter range is set by default.

Grid Search

Principle:

1. Splits the value range of each parameter into N segments (where N indicates the **number of split grids**).
2. Randomly takes a value from the N segments. Assuming that there are M parameters, N^M parameter sets can be combined.

3. According to the N^M parameter sets, N^M models are generated by training. The models are then sorted.

Parameter	Description
Data Splitting Ratio	Splits input data sources into training and evaluation sets. 0.7 indicates that 70% of the data is used for model training and 30% for evaluation.
Grids	The number of split grids. Valid values: 2 to 10.

Note You must enter the tuning range for each parameter. If the current parameter range is not configured, the parameter range is set by default.

Custom Parameters

- You can enumerate parameter candidate sets. The system then helps score all the combinations of the candidate sets.
- You can define enumeration ranges and separate parameters with commas (,). If the ranges are not configured, the default ranges of parameters are tuned.

4.8. Terms and acronyms

4.8.1. Terms

This topic lists the basic terms used in machine learning.

experiment

A user-created data mining workflow.

project

The basic object in MaxCompute. A project is also known as a workspace. A project contains other objects, such as tables and instances.

component

The minimum operating unit that you can invoke and execute on Apsara Stack Machine Learning Platform for AI. You can use components to import and export data, process data, analyze data, train models, and make predictions.

4.8.2. Acronyms

This topic describes the acronyms used in the Machine Learning Platform for AI User Guide.

MaxCompute

MaxCompute (formerly known as ODPS) is a data processing platform developed by Alibaba Cloud for large-scale data warehousing. MaxCompute can store and compute structured data in batches to meet the requirements of most big data modeling and analysis scenarios.

MaxCompute source and target tables

Tables are data storage objects in MaxCompute. Similar to relational database tables, tables in MaxCompute have a two-dimensional logical structure. A source table is the input of an algorithm node, while a target table is the output of an algorithm node.

5.Quick BI

5.1. What is Quick BI?

This topic describes the concept and features of Quick BI.

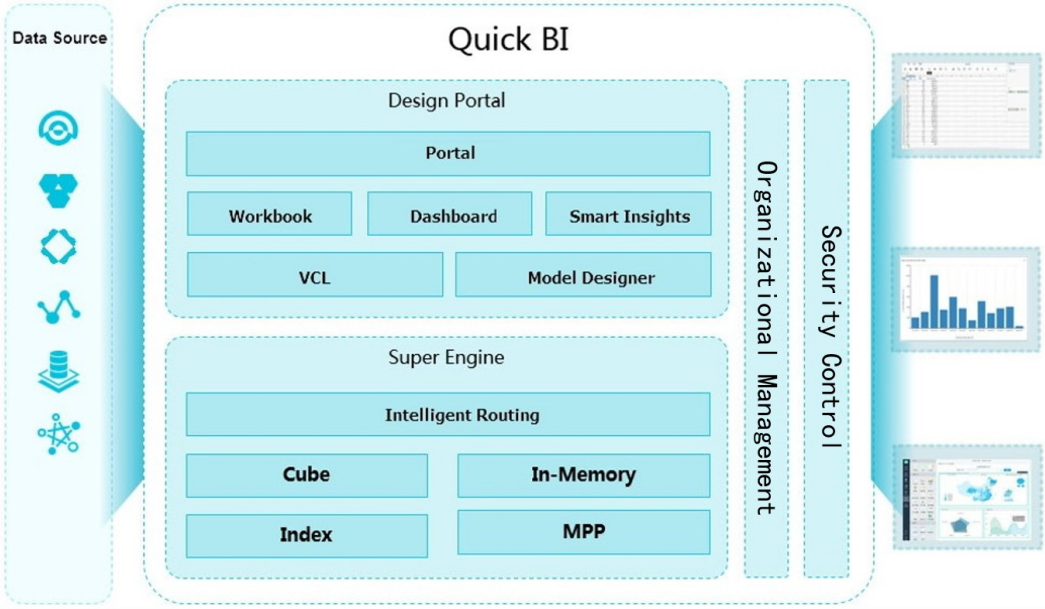
Quick BI is a flexible and lightweight self-service Business Intelligence (BI) tool based on cloud computing. It supports a wide range of data sources:

- MaxCompute (formerly known as ODPS), ApsaraDB for RDS, AnalyticDB for MySQL, and ApsaraDB for HybridDB for MySQL (formerly known as PetaData)
- MySQL and SQL Server databases deployed on ECS instances
- VPC data sources

Quick BI analyzes large amounts of data in real time and returns results within seconds. You do not need to preprocess the data. Quick BI analyzes terabytes of incremental data on a daily basis.

With an intelligent data modeling tool and a variety of visual chart tools, Quick BI significantly reduces data acquisition costs and makes it easier for you to use Quick BI features. This allows you to easily complete data analysis, self-service data acquisition, business data query, and report making.

Architecture



5.2. Log on to the Quick BI console

This topic describes how to log on to the Quick BI console.

Prerequisites

- Before logging on to the ASCM console, make sure that you have obtained the IP address or domain name of the ASCM console from the deployment personnel. The URL used to access the ASCM console is in the following format: https://[IP address or domain name of the ASCM console].
- We recommend that you use the Google Chrome browser.

Context

If you are using a RAM account, you can use the domain name to log on to the Quick BI console. If you are using an Apsara Stack tenant account, log on to the Quick BI console by performing the following steps:

Procedure

1. In the address bar, enter the access address of the Apsara Stack Cloud Management (ASCM) console, and press Enter.
2. Enter your username and password.

   Obtain the username and password for logging on to the console from the operations administrator.

   > **Note** When you log on to the ASCM console for the first time, you must change the password of your username as prompted. Due to security concerns, your password must meet the minimum complexity requirements: The password must be 8 to 20 characters in length and must contain at least two of the following character types: uppercase letters, lowercase letters, digits, and special characters such as exclamation points (!), at signs (@), number signs (#), dollar signs ($), and percent signs (%).

3. Click **Login** to go to the homepage of the ASCM console.
4. In the top navigation bar, choose **Product > Big Data** and click **Quick BI**.
5. Select an organization and a region from the drop-down lists and click **QuickBI** or **Quick BI Console** to go to the **Quick BI** system.
   - You can click **QuickBI** to go to the product page.
   - You can click **Quick BI Console** to go to the settings page. You can manage organization members and workspaces on this page.

     > **Note** If you use this method, the Apsara Stack tenant account quickbi_admin@aliyun.com is used to log on to the Quick BI console no matter which department you select.

5.3. Data modeling

5.3.1. Data modeling

Data modeling visualizes data and allows you to quickly identify and extract information. It also helps you make correct decisions based on data trends.

Steps of data modeling:

1. Create a data source.
2. Create a dataset.

5.3.2. Data sources

5.3.2.1. Overview

Datasets, workbooks, dashboards, and BI portals are all created based on data sources. Quick BI supports both cloud data sources and user-created data sources.

Cloud data sources include:

- MaxCompute
- MySQL
- SQL Server
- AnalyticDB
- HybridDB For MySQL
- AnalyticDB for PostgreSQL
- PostgreSQL
- PPAS
- Hive
- Data Lake Analytics
- Distribute Relational Database Service (DRDS)

> **Note** VPCs only support MySQL and SQL Server data sources.

User-created data sources include:

- MySQL
- SQL Server
- PostgreSQL
- Oracle
- Hive
- Vertica
- IBM DB2 LUW
- SAP IQ (Sybase IQ)
- SAP HANA

> **Note** You cannot check SQL Server data sources through views.

5.3.2.2. Cloud data sources

5.3.2.2.1. Add the IP addresses of a Quick BI cluster to a database whitelist

This topic describes how to add the IP addresses of a Quick BI cluster to a database whitelist.

Prerequisites

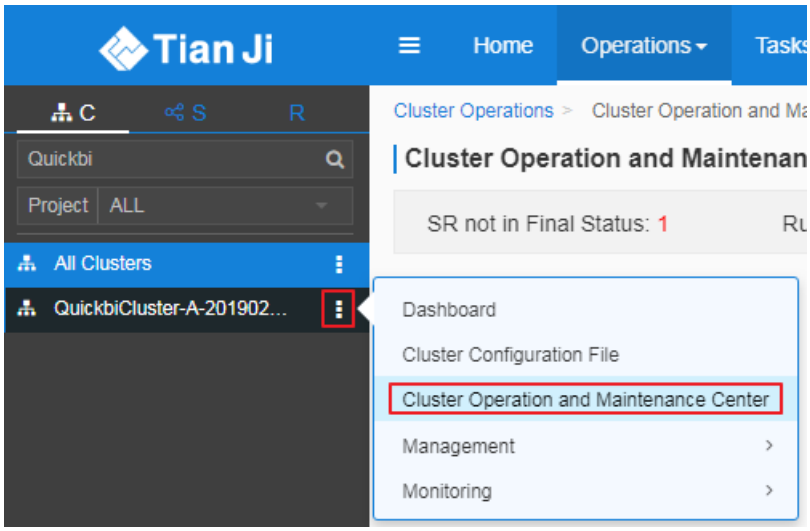
The Quick BI service is purchased.

Context

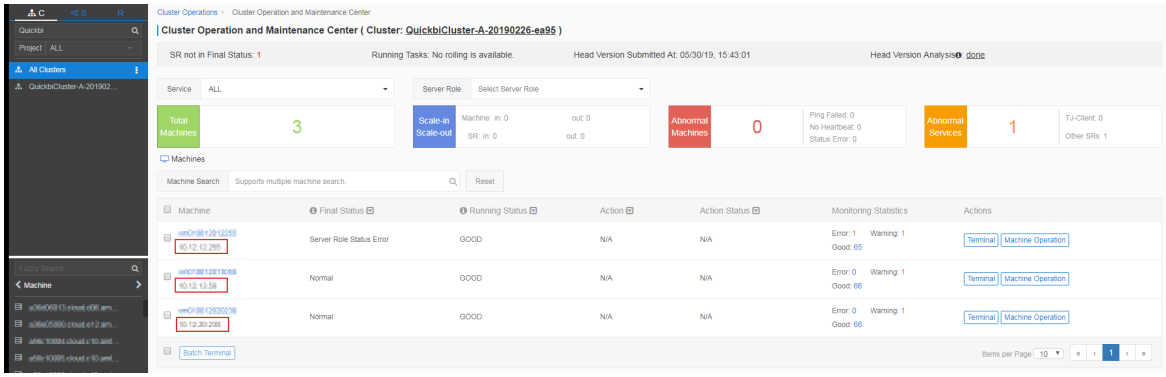
Given the limitations imposed by the whitelist of ApsaraDB for RDS, before you add some data sources in the Quick BI console, you must first query available IP addresses of machines and add them to the whitelist of ApsaraDB for RDS.

Procedure

1. On the homepage of Apsara Infrastructure Management Framework, enter the name of the Quick BI cluster in the search box to locate the Quick BI cluster.
2. Move the pointer over the More icon of the Quick BI cluster and select **Cluster Operation and Maintenance Center**.



3. Before you add the IP addresses of machines to the ApsaraDB for RDS whitelist, change the last octet to 0/24 for all the machine IP addresses in the cluster. For example, if an IP address is 10.10.10.10, change it to 10.10.10.0/24.



4. Add the IP addresses to the ApsaraDB for RDS whitelist. For more information, see "Configure a whitelist" in ApsaraDB for RDS User Guide.

5.3.2.2.2. Add a cloud MaxCompute data source

This topic describes how to add a cloud MaxCompute data source.

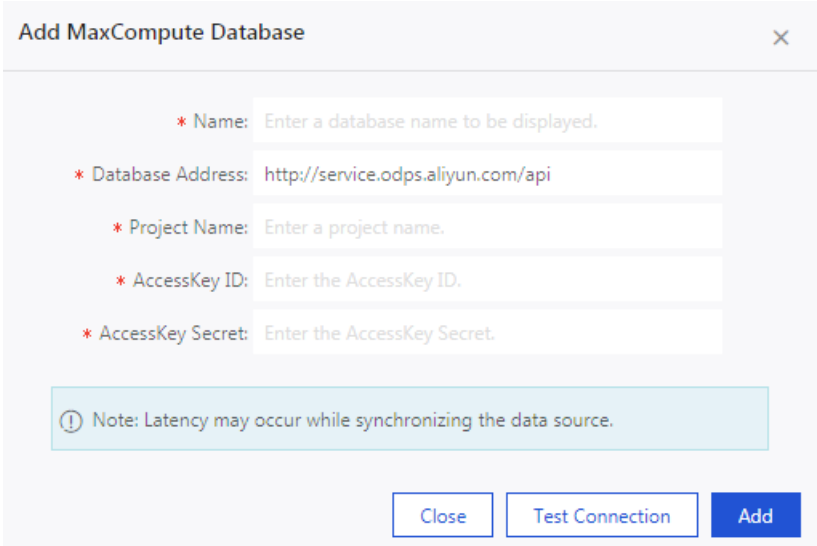
Prerequisites

- A MaxCompute (formerly known as ODPS) project is created in the big data computing service console.

- Parameter settings for connecting to the MaxCompute data source are obtained.

Procedure

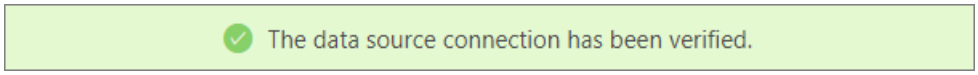
1. Create a data source.
2. Click **MaxCompute**. In the **Add MaxCompute Database** dialog box that appears, set the following parameters.



3. Set the parameters for connecting to the data source.

Parameter	Description
Name	The name of the data source that you want to display.
Database Address	The default database address.
Project Name	The name of the MaxCompute project.
AccessKey ID	The AccessKey ID used to identify a visitor.
AccessKey Secret	The AccessKey secret of the account that purchased the data source instance. The AccessKey secret is used to encrypt the signature string on the client and decrypt the signature string on the server for authentication. Keep the AccessKey secret confidential.

4. Click **Test Connection** to perform a data source connectivity test.



5. After the connection is established, click **Add**.

   After the data source is added, the Data Sources page appears. Tables under the data source are listed on the right side of the page.

5.3.2.2.3. Add a cloud MySQL data source

This topic describes how to add a cloud MySQL data source.

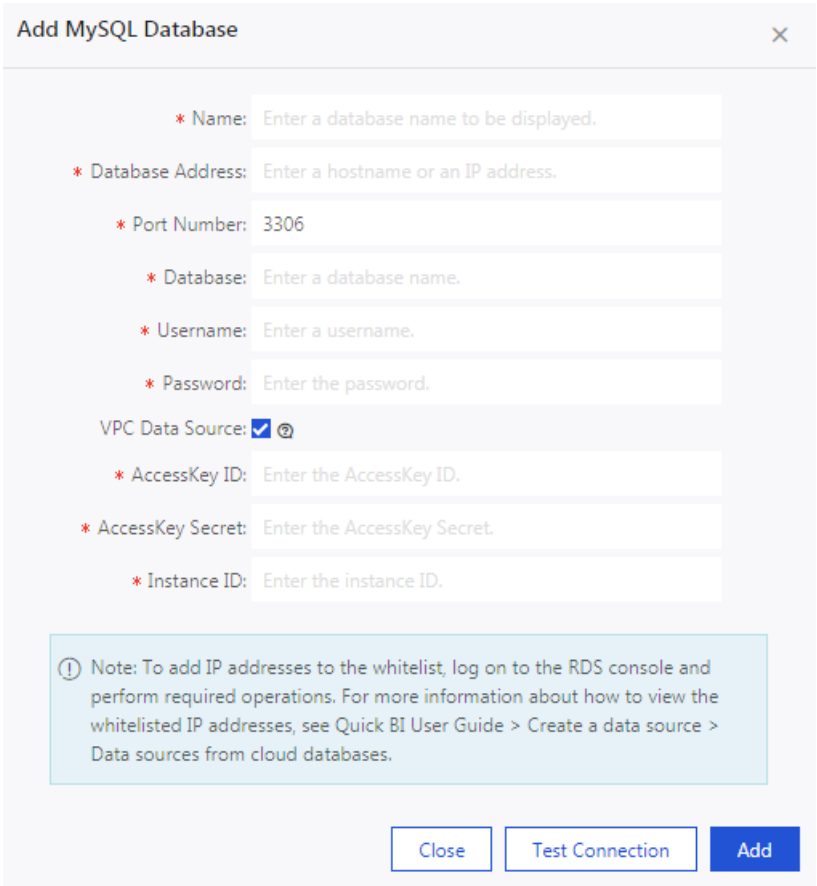
Prerequisites

1. An ApsaraDB for RDS for MySQL instance is created. For information about how to create an ApsaraDB for RDS instance, see "Create an instance" in ApsaraDB for RDS User Guide.
2. Available IP addresses of machines are obtained and added to the whitelist of the ApsaraDB for RDS instance. For information about how to query the IP addresses, see Add the IP addresses of a Quick BI cluster to a database whitelist. For information about how to add the IP addresses to the whitelist of the ApsaraDB for RDS instance, see "Configure a whitelist" in ApsaraDB for RDS User Guide.
3. Parameter settings for connecting to the MySQL data source are obtained.

Procedure

1. Create a data source.
2. Click **MySQL** and set the parameters for connecting to the data source.

   Add a MySQL data source



> **Note** If the data source is connected over a VPC, select **VPC Data Source** and set the relevant parameters.

Parameter	Description
Name	The name to be displayed for the connected data source, which is user-defined.
Database Address	The hostname or IP address of the database.
Port Number	The port number of the database. The default port is 3306.
Database	The name of the database to which you want to access.
Username	The username used to access the database.
Password	The password of the database user. Note If you do not know the username and password, contact your database administrator.
AccessKey ID	The AccessKey ID used to purchase the instance.
AccessKey Secret	The AccessKey secret used to purchase the instance.
Instance ID	The ID of the instance.

3. Click **Test Connection** to perform a data source connectivity test.
4. After the connection is established, click **Add**.

   After a data source is added, you cannot add it again. If you attempt to add a data source for the second time, an error message appears.

5.3.2.2.4. Add a cloud SQL Server data source

This topic describes how to add a cloud SQL Server data source.

Prerequisites

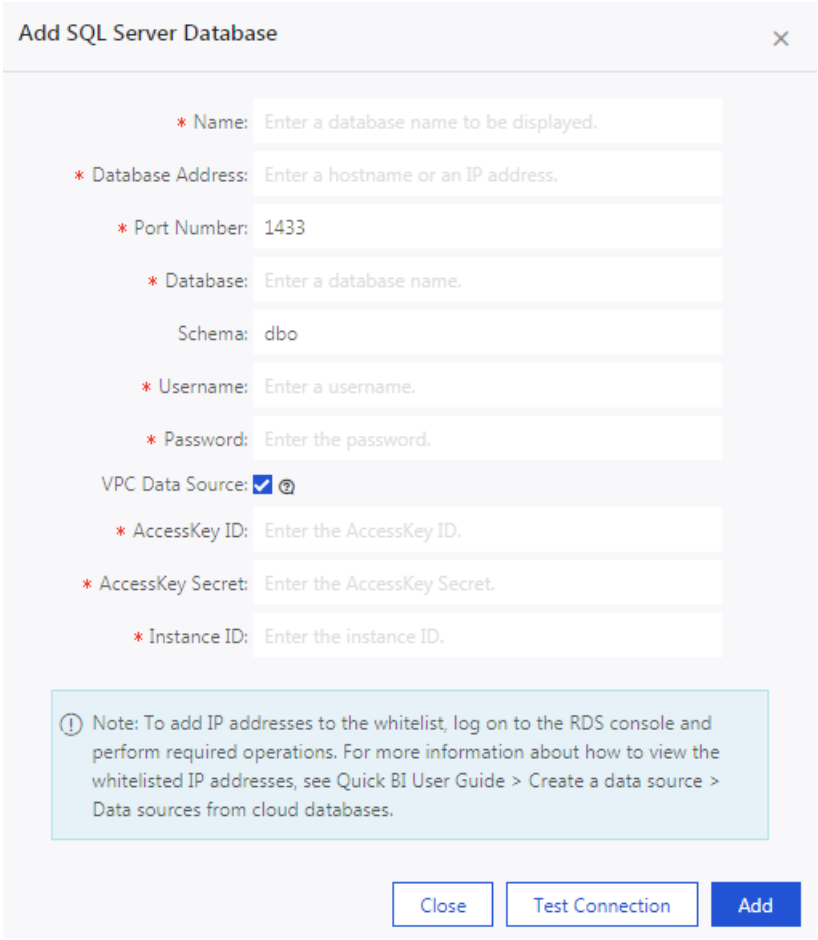
1. An ApsaraDB for RDS for SQL Server instance is created. For information about how to create an ApsaraDB for RDS instance, see "Create an instance" in ApsaraDB for RDS User Guide.
2. Available IP addresses of machines are obtained and added to the whitelist of the ApsaraDB for RDS instance. For information about how to query the IP addresses, see Add the IP addresses of a Quick BI cluster to a database whitelist. For information about how to add the IP addresses to the whitelist of the ApsaraDB for RDS instance, see "Configure a whitelist" in ApsaraDB for RDS User Guide.
3. Parameter settings for connecting to the SQL Server data source are obtained.

Context

The procedure for configuring an SQL Server data source is similar to that for configuring a MySQL data source. However, you must specify the configuration item Schema for the SQL Server data source.

Procedure

1. Create a data source.
2. Click **SQL Server** and set the parameters for connecting to the data source in the dialog box that appears.



> **Note** If the data source is connected over a VPC, select **VPC Data Source** and set the relevant parameters.

Parameter	Description
Name	The name to be displayed for the connected data source, which is user-defined.
Database Address	The hostname or IP address of the database.
Port Number	The port number of the database. The default port is 1433.
Database	The name of the database to which you want to access.
Schema	The database schema. The default schema is dbo.
Username	The username used to access the database.
Password	The password of the database user.

Parameter	Description
AccessKey ID	The AccessKey ID used to purchase the instance.
AccessKey Secret	The AccessKey secret used to purchase the instance.
Instance ID	The ID of the instance.

3. Click **Test Connection** to perform a data source connectivity test.
4. After the test connection is established, click **Add**.

5.3.2.2.5. Add a cloud AnalyticDB data source

This topic describes how to add a cloud AnalyticDB data source.

Prerequisites

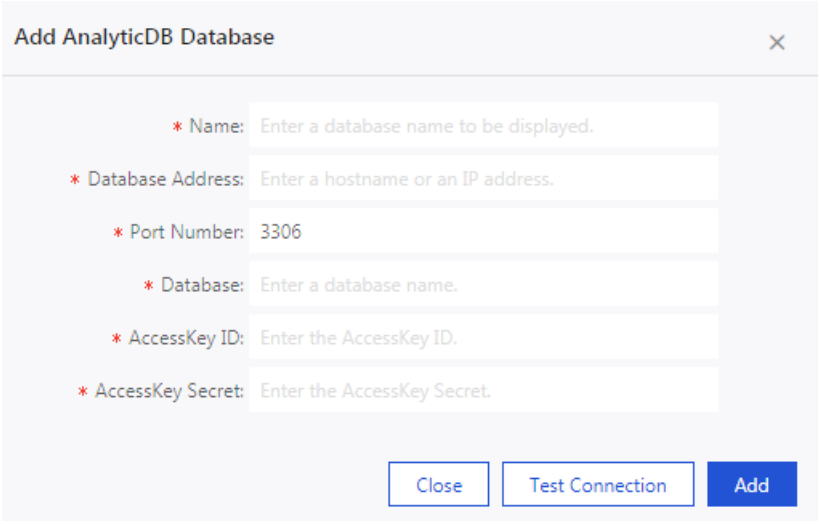
An AnalyticDB database is created in the AnalyticDB console, and parameter settings used to connect to the AnalyitcDB data source are obtained. For information about how to create an AnalyticDB database, see "Create a database" in AnalyticDB for MySQL User Guide.

Context

AnalyticDB for MySQL is formerly known as AnalyticDB.

Procedure

1. Create a data source.
2. Click **AnalyticDB** and set the parameters for connecting to the data source in the dialog box that appears.



Parameter	Description
Name	The name to be displayed for the connected data source, which is user-defined.
Database Address	The hostname or IP address of the database.

Parameter	Description
Port Number	The port number of the database.
Database	The name of the database to which you want to access.
AccessKey ID	The AccessKey ID used to identify a visitor.
AccessKey Secret	The AccessKey secret of the account that purchased the data source instance. The AccessKey secret is used to encrypt the signature string on the client and decrypt the signature string on the server for authentication. Keep the AccessKey secret confidential.

3. Click **Test Connection** to test the data source connectivity.
4. After the connection is established, click **Add**.

5.3.2.2.6. Add a cloud HybridDB for MySQL data source

This topic describes how to add a cloud HybridDB for MySQL data source.

Prerequisites

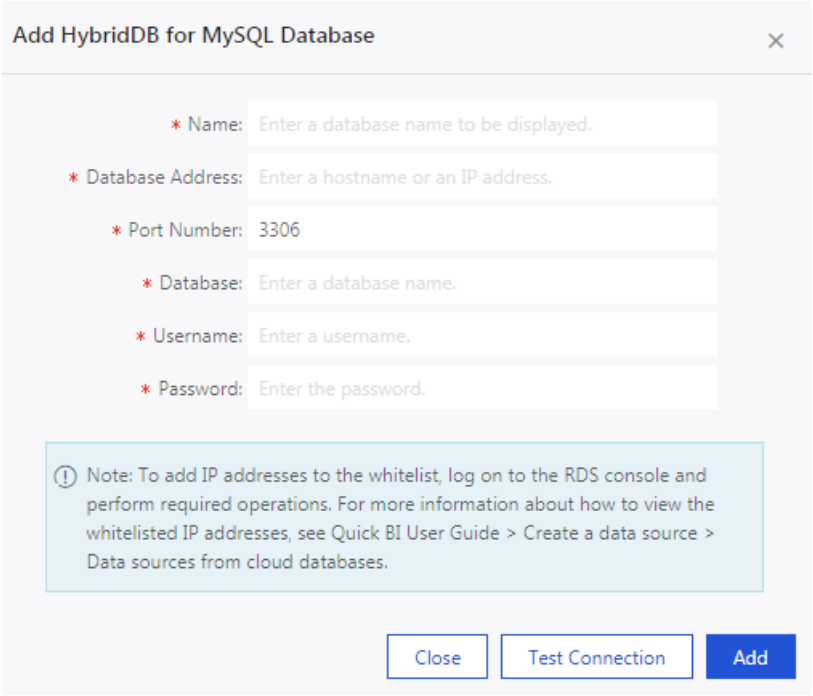
1. A HybridDB for MySQL instance is created.
2. The available machine IP addresses are obtained and added to a whitelist of the HybridDB for MySQL instance. For information about how to query the available IP addresses, see Add the IP addresses of a Quick BI cluster to a database whitelist.
3. Parameter settings used to connect to the HybridDB for MySQL data source are obtained.

Context

The procedure for adding a HybridDB for MySQL data source is similar to that for adding an SQL Server data source. The only difference is that the default port is the port specific to HybridDB for MySQL.

Procedure

1. Create a data source.
2. Click **HybridDB for MySQL** and set the parameters for connecting to the data source in the dialog box that appears.



Parameter	Description
Name	The name to be displayed for the connected data source, which is user-defined.
Database Address	The hostname or IP address of the database.
Port Number	The port number of the database. The default port is 3306.
Database	The name of the database to which you want to access.
Username	The username used to access the database.
Password	The password of the database user.

3. Click **Test Connection** to test the data source connectivity.
4. After the connection is established, click **Add**.

5.3.2.2.7. Add a cloud AnalyticDB for PostgreSQL data source

This topic describes how to add a cloud AnalyticDB for PostgreSQL data source.

Prerequisites

1. An AnalyticDB for PostgreSQL instance is created. For information about how to create an AnalyticDB for PostgreSQL instance, see "Create an instance" in AnalyticDB for PostgreSQL User Guide.
2. The available machine IP addresses are obtained and added to a whitelist of the AnalyticDB for PostgreSQL instance. For information about how to query the available IP addresses, see Add the IP

addresses of a Quick BI cluster to a database whitelist. For information about how to add the IP addresses to a whitelist of the AnalyticDB for PostgreSQL instance, see "Configure a whitelist" in AnalyticDB for PostgreSQL User Guide.

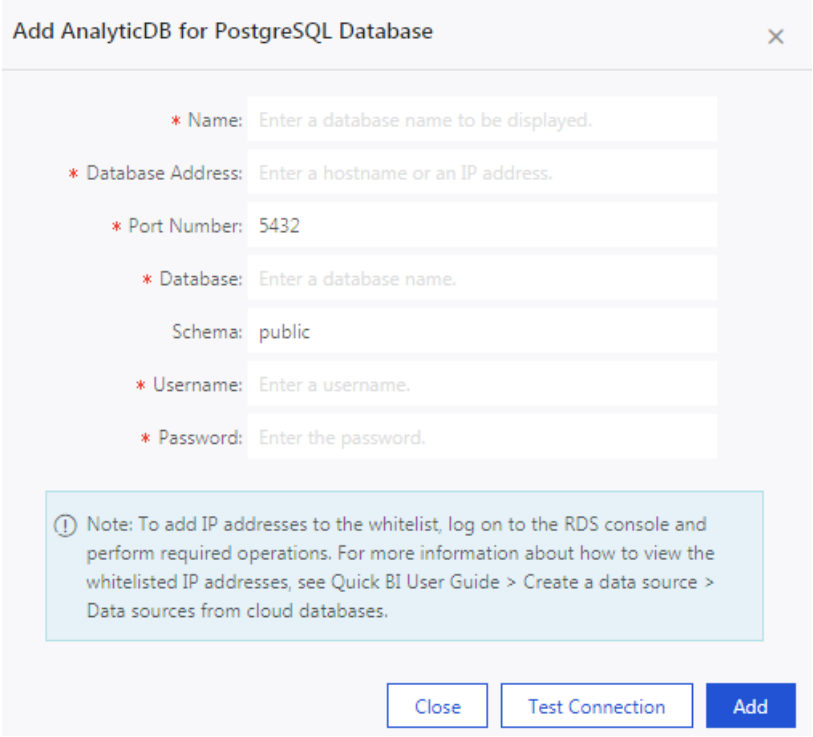
3. Parameter settings used to connect to the AnalyticDB for PostgreSQL data source are obtained.

Context

The procedure for adding an AnalyticDB for PostgreSQL data source is similar to that for adding an SQL Server data source. The only difference is that the default port is the port specific to AnalyticDB for PostgreSQL.

Procedure

1. Create a data source.
2. Click **AnalyticDB for PostgreSQL** and set the parameters for connecting to the data source in the dialog box that appears.



Parameter	Description
Name	The name to be displayed for the connected data source, which is user-defined.
Database Address	The hostname or IP address of the database.
Port Number	The port number of the database. The default port is 5432.
Database	The name of the database to which you want to access.
Schema	The default value is Public.
Username	The username used to access the database.

Parameter	Description
Password	The password of the database user.

3. Click **Test Connection** to test the data source connectivity.
4. After the connection is established, click **Add**.

5.3.2.2.8. Add a cloud PostgreSQL data source

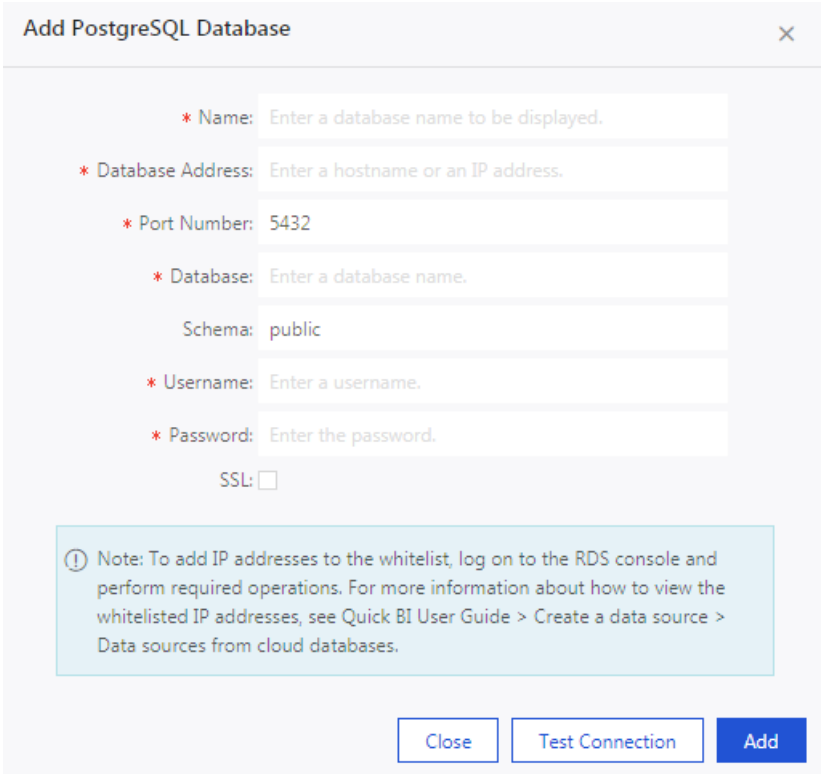
This topic describes how to add a cloud PostgreSQL data source.

Prerequisites

1. An RDS for PostgreSQL instance is created. For information about how to create an ApsaraDB for RDS instance, see "Create an instance" in ApsaraDB for RDS User Guide.
2. The available IP addresses are obtained and added to a whitelist of the ApsaraDB for RDS instance. For information about how to query the IP addresses, see Add the IP addresses of a Quick BI cluster to a database whitelist. For information about how to add the IP addresses to a whitelist of the ApsaraDB for RDS instance, see "Configure a whitelist" in ApsaraDB for RDS User Guide.
3. Parameter settings used to connect to the PostgreSQL data source are obtained.

Procedure

1. Create a data source.
2. Click **PostgreSQL** and set parameters for connecting to the data source in the dialog box that appears.



> **Note** If you select **SSH**, the data source supports MaxCompute Lightning, an interactive query service provided by MaxCompute.

Parameter	Description
Name	The name to be displayed for the connected data source, which is user-defined.
Database Address	The hostname or IP address of the database.
Port Number	The port number of the database. The default port is 5432.
Database	The name of the database to which you want to access.
Schema	The default value is Public.
Username	The username used to access the database.
Password	The password of the database user.

3. Click **Test Connection** to test the data source connectivity.
4. After the connection is established, click **Add**.

5.3.2.2.9. Add a cloud PPAS data source

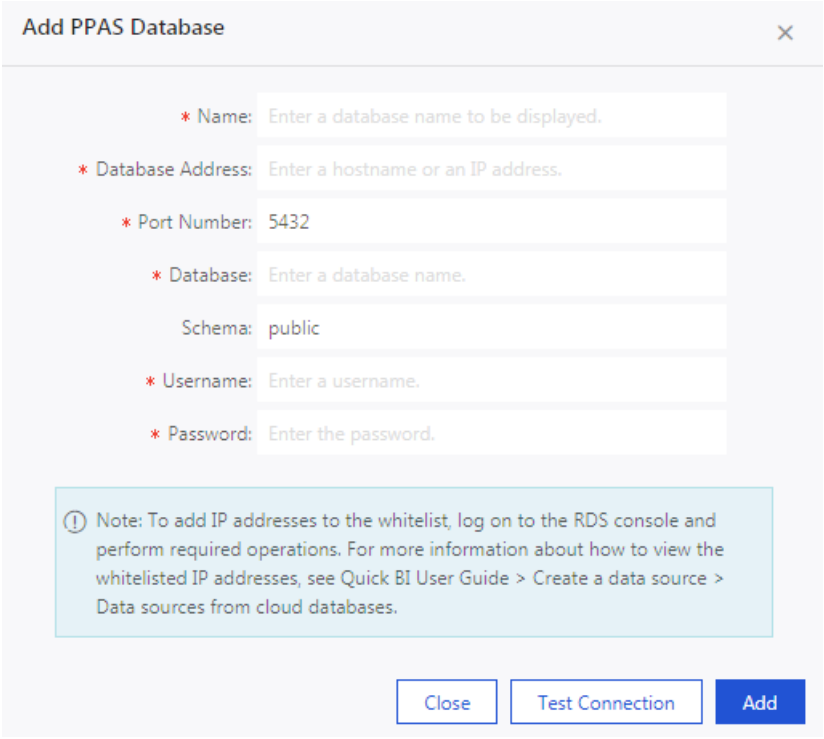
This topic describes how to add a cloud PPAS data source.

Prerequisites

1. An RDS for PPAS instance is created. For information about how to create an ApsaraDB for RDS instance, see "Create an instance" in ApsaraDB for RDS User Guide.
2. The available IP addresses are obtained and added to a whitelist of the ApsaraDB for RDS instance. For information about how to query the IP addresses, see Add the IP addresses of a Quick BI cluster to a database whitelist. For information about how to add the IP addresses to a whitelist of the ApsaraDB for RDS instance, see "Configure a whitelist" in ApsaraDB for RDS User Guide.
3. Parameter settings used to connect to the PPAS data source are obtained.

Procedure

1. Create a data source.
2. Click **PPAS** and set the parameters for connecting to the data source in the dialog box that appears.



Parameter	Description
Name	The name to be displayed for the connected data source, which is user-defined.
Database Address	The hostname or IP address of the database.
Port	The port number of the database. The default port is 5432.
Database	The name of the database to which you want to access.
Schema	The default value is Public.
Username	The username used to access the database.
Password	The password of the database user.

3. Click **Test Connection** to test the data source connectivity.
4. After the connection is established, click **Add**.

5.3.2.2.10. Add a cloud Hive data source

This topic describes how to add a cloud Hive data source.

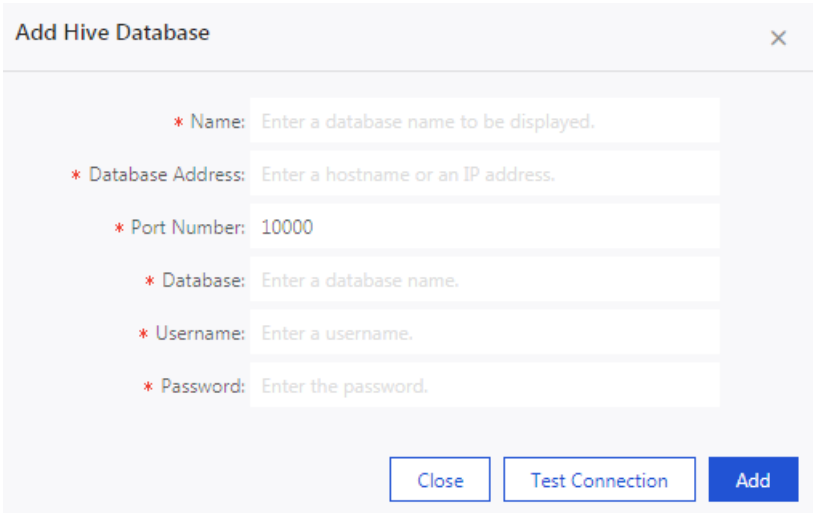
Prerequisites

Parameter settings used to connect to the Hive data source are obtained.

Procedure

1. Create a data source.

2. Click **Hive** and set the parameters for connecting to the data source in the dialog box that appears.



Parameter	Description
Name	The name to be displayed for the connected data source, which is user-defined.
Database Address	The hostname or IP address of the database.
Port Number	The port number of the database. The default port is 10000.
Database	The name of the database to which you want to access.
Username	The username used to access the database.
Password	The password of the database user.

3. Click **Test Connection** to test the data source connectivity.
4. After the connection is established, click **Add**.

5.3.2.2.11. Add a cloud Data Lake Analytics data source

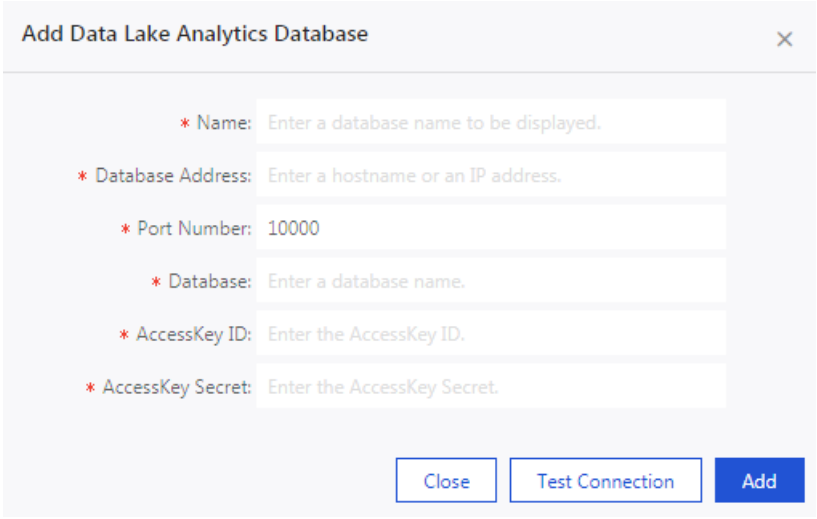
This topic describes how to add a cloud Data Lake Analytics (DLA) data source.

Prerequisites

Parameter settings used to connect to the cloud DLA data source are obtained.

Procedure

1. Create a data source.
2. Click **Data Lake Analytics** and set the parameters for connecting to the data source in the dialog box that appears.



Parameter	Description
Name	The name to be displayed for the connected data source, which is user-defined.
Database Address	The hostname or IP address of the database.
Port Number	The port number of the database. The default port is 10000.
Database	The name of the database to which you want to access.
AccessKey ID	The AccessKey ID used to purchase the instance.
AccessKey Secret	The AccessKey secret used to purchase the instance.

3. Click **Test Connection** to test the data source connectivity.
4. After the connection is established, click **Add**.

5.3.2.2.12. Add a cloud DRDS data source

This topic describes how to add a cloud Distributed Relational Database Service (DRDS) data source.

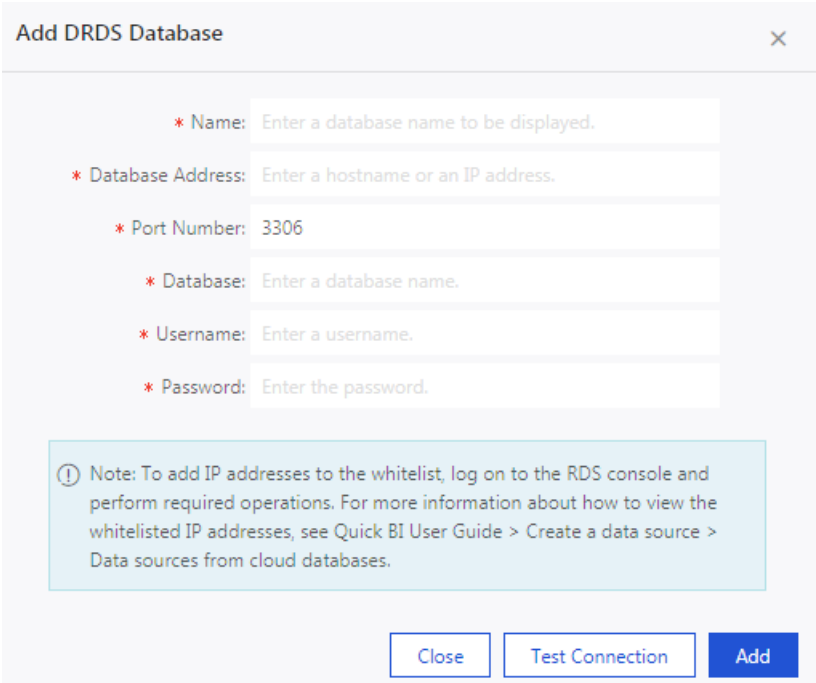
Prerequisites

1. A DRDS instance is created. For information about how to create a DRDS instance, see "Create an instance" in ApsaraDB for RDS User Guide.
2. The available IP addresses are obtained and added to a whitelist of the DRDS instance. For information about how to query the IP addresses, see Add the IP addresses of a Quick BI cluster to a database whitelist. For information about how to add the IP addresses to a whitelist of the DRDS instance, see "Configure a whitelist" in ApsaraDB for RDS User Guide.
3. Parameter settings used to connect to the DRDS data source are obtained.

Procedure

1. Create a data source.

2. Click **DRDS** and set the parameters for connecting to the data source in the dialog box that appears.



Parameter	Description
Name	The name to be displayed for the connected data source, which is user-defined.
Database Address	The hostname or IP address of the database.
Port Number	The port number of the database. The default port is 3306.
Database	The name of the database to which you want to access.
Username	The username used to access the database.
Password	The password of the database user.

3. Click **Test Connection** to test the data source connectivity.
4. After the connection is established, click **Add**.

5.3.2.3. User-created data sources

5.3.2.3.1. Add a user-created MySQL data source

This topic describes how to add a user-created MySQL data source.

Prerequisites

Parameter settings for connecting to the MySQL data source are obtained.

Context

The procedure for configuring a user-created MySQL data source is similar to that for configuring a cloud MySQL data source. You must perform the following steps to open the specified port of the firewall to allow Quick BI to access the MySQL database:

1. Run the following command to open the configuration file of the firewall:

```
vi /etc/sysconfig/iptables
```

2. Add the following command to the configuration file:

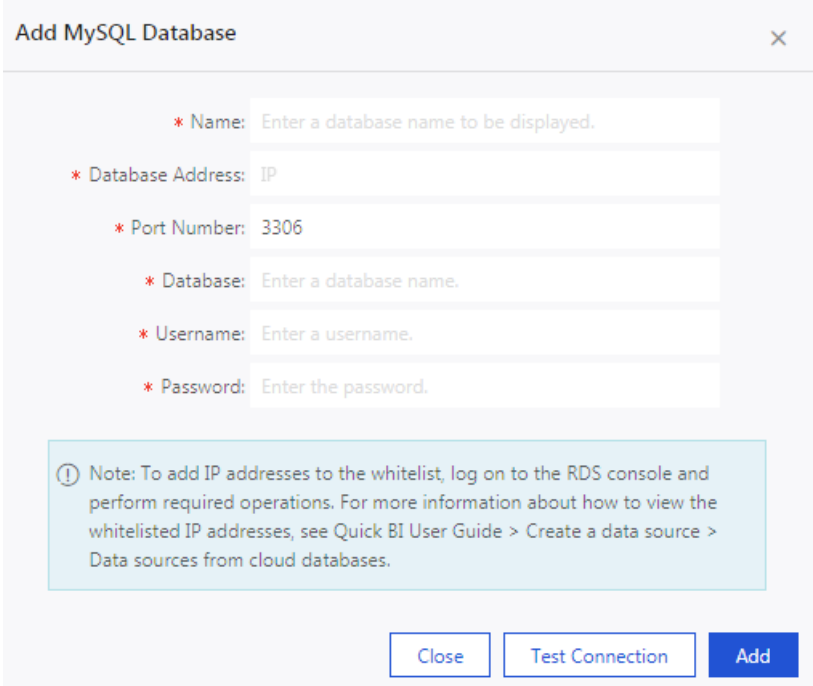
```
-A RH-Firewall-1-INPUT -m state -state NEW -m tcp -p tcp -dport 3306 -j
    ACCEPT
```

3. Run the following command to restart iptables:

```
service iptables restart
```

Procedure

1. Add a data source.
2. Click **MySQL** and set the parameters for connecting to the data source in the dialog box that appears.



Parameter	Description
Name	The name to be display for the connected data source.
Database Address	The hostname or IP address of the database.
Port Number	The port number of the database. The default port is 3306.
Database	The name of the database to which you want to access.

Parameter	Description
Username	The username used to access the database.
Password	The password of the database user.

3. Click **Test Connection** to test the data source connectivity.
4. After the connection is established, click **Add**.

5.3.2.3.2. Add a user-created SQL Server data source

This topic describes how to add a user-created SQL Server data source.

Prerequisites

Parameter settings for connecting to the SQL Server data source are obtained.

Context

The procedure for creating a user-created SQL Server data source is similar to that for creating a cloud SQL Server data source. You must use the following method to open the specific port of the firewall to allow Quick BI to access the SQL Server database:

1. Run the following command to open the configuration file of the firewall.

```
vi /etc/sysconfig/iptables
```

2. Add the following command to the configuration file:

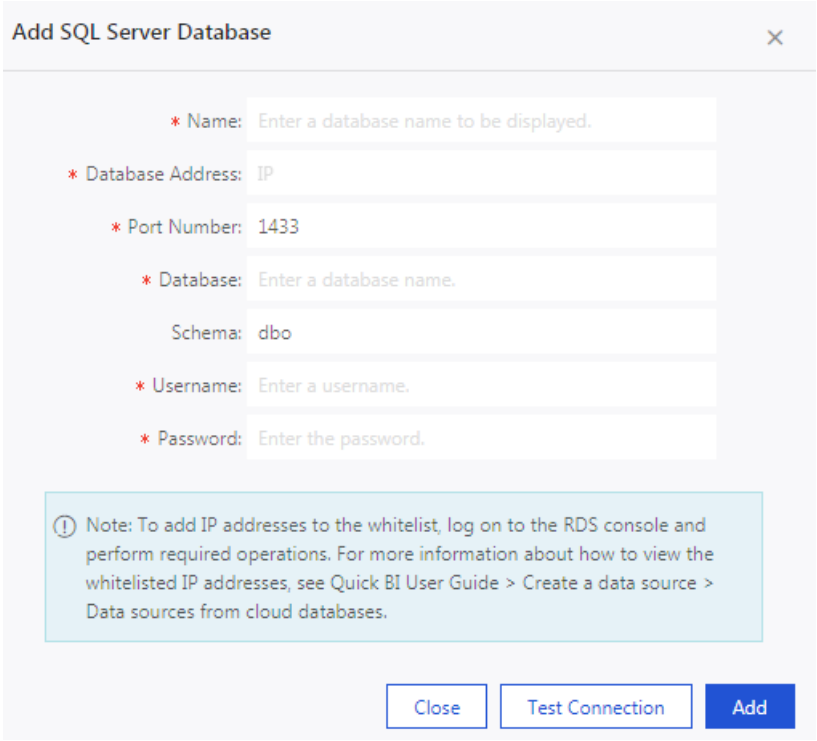
```
-A RH-Firewall-1-INPUT -m state -state NEW -m tcp -p tcp -dport 1433 -j
    ACCEPT
```

3. After the configuration is complete, run the following command to restart iptables:

```
service iptables restart
```

Procedure

1. On the Data Sources page, click Create Data Source in the upper-right corner. For more information, see Create a data source.
2. Click **SQL Server** and set the parameters for connecting to the data source in the dialog box that appears.



Parameter	Description
Name	The name you want to display for the data source.
Database Address	The hostname or IP address of the database.
Port Number	The port number of the database. The default port is 1433.
Database	The name of the database to which you want to access.
Schema	The schema of the database. The default value is dbo.
Username	The username used to access the database.
Password	The password of the database user.

3. Click **Test Connection** to perform a data source connectivity test.
4. After the connection is established, click **Add**.

> **Note** After a data source is added, you cannot add it again. If you attempt to add a data source for the second time, an error message appears.

5.3.2.3.3. Add a user-created PostgreSQL data source

This topic describes how to add a user-created PostgreSQL data source.

Prerequisites

Parameter settings for connecting to the PostgreSQL data source are obtained.

Context

The procedure for creating a user-created PostgreSQL data source is similar to that for creating an ApsaraDB RDS for PostgreSQL data source. To allow Quick BI to access the PostgreSQL data source, you must perform the following steps to open the specific port of the firewall:

1. Run the following command to open the configuration file of the firewall:

   ```
   vi /etc/sysconfig/iptables
   ```

2. Add the following command to the configuration file:

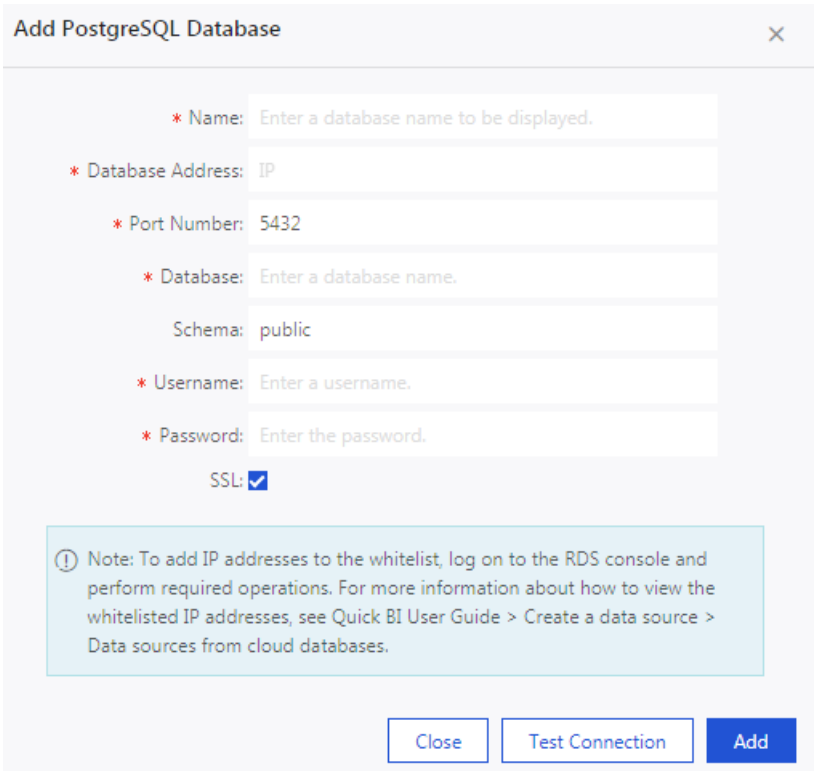
   ```
   -A RH-Firewall-1-INPUT -m state -state NEW -m tcp -p tcp -dport 5432 -j
         ACCEPT
   ```

3. After the configuration is complete, run the following command to restart iptables:

   ```
   service iptables restart
   ```

Procedure

1. On the Data Sources page, click Create Data Source in the upper-right corner. For more information, see Create a data source.
2. On the Add Data Source page, click the User-created Data Sources tab. Then, click **PostgreSQL** and set the parameters for connecting to the data source in the dialog box that appears.



> **Note** If you select the **SSL** check box, the data source supports MaxCompute Lightning, an interactive query service provided by MaxCompute.

Parameter	Description
Name	The name you want to display for the data source.
Database Address	The hostname or IP address of the database.
Port Number	The port number of the database. The default port is 5432.
Database	The name of the database to which you want to access.
Schema	The schema of the database. The default value is public.
Username	The username used to access the database.
Password	The password of the database user.

3. Click **Test Connection** to perform a data source connectivity test.
4. After the connection is established, click **Add**.

5.3.2.3.4. Add a user-created Oracle data source

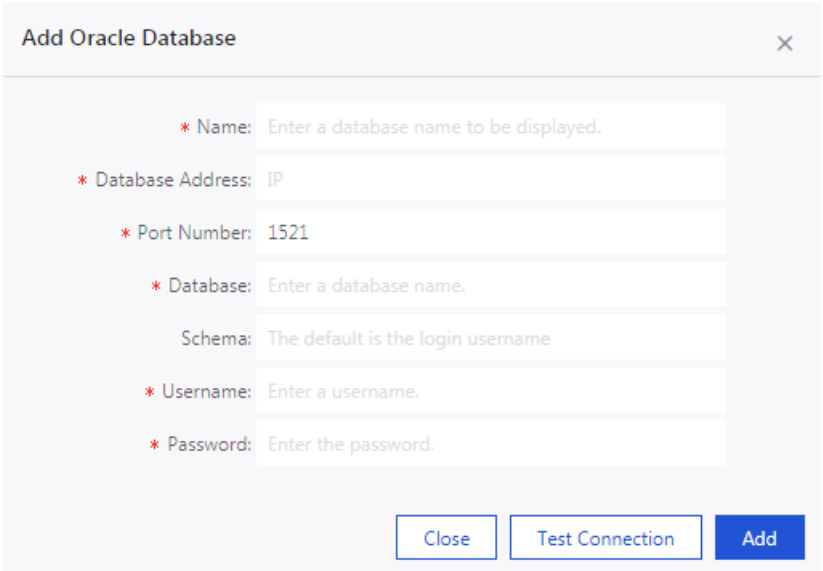
This topic describes how to add a user-created Oracle data source.

Prerequisites

Parameter settings for connecting to the Oracle data source are obtained.

Procedure

1. On the Data Sources page, click Create Data Source in the upper-right corner. For more information, see Create a data source.
2. On the Add Data Source page, click the User-created Data Sources tab. Then, click **Oracle** and set the parameters for connecting to the data source in the dialog box that appears.



Parameter	Description
Name	The name to be displayed for the connected data source.
Database Address	The hostname or IP address of the database.
Port Number	The port number of the database. The default port is 1521.
Database	The name of the database to which you want to access.
Schema	The schema of the database. The default value is public.
Username	The username used to access the database.
Password	The password of the database user.

3. Click **Test Connection** to perform a data source connectivity test.
4. After the connection is established, click **Add**.

5.3.2.3.5. Add a user-created Hive data source

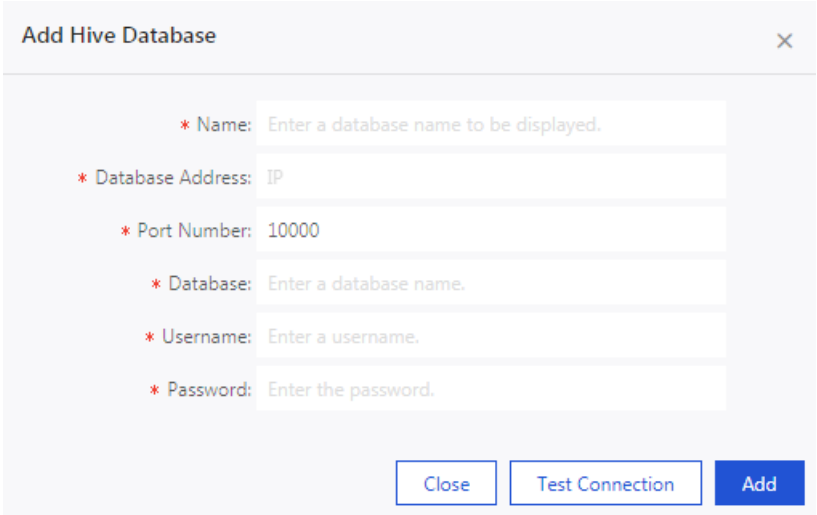
This topic describes how to add a user-created Hive data source.

Prerequisites

Parameter settings for connecting to the Hive data source are obtained.

Procedure

1. On the Data Sources page, click Create Data Source in the upper-right corner. For more information, see Create a data source.
2. On the Add Data Source page, click the User-created Data Sources tab. Then, click **Hive** and set the parameters for connecting to the data source in the dialog box that appears.



Parameter	Description
Name	The name to be displayed for the connected data source, which is user-defined.
Database Address	The hostname or IP address of the database.
Port Number	The port number of the database. The default port is 10000.
Database	The name of the database to which you want to access.
Username	The username used to access the database.
Password	The password of the database user.

3. Click **Test Connection** to perform a data source connectivity test.
4. After the connection is established, click **Add**.

5.3.2.3.6. Add a user-created Vertica data source

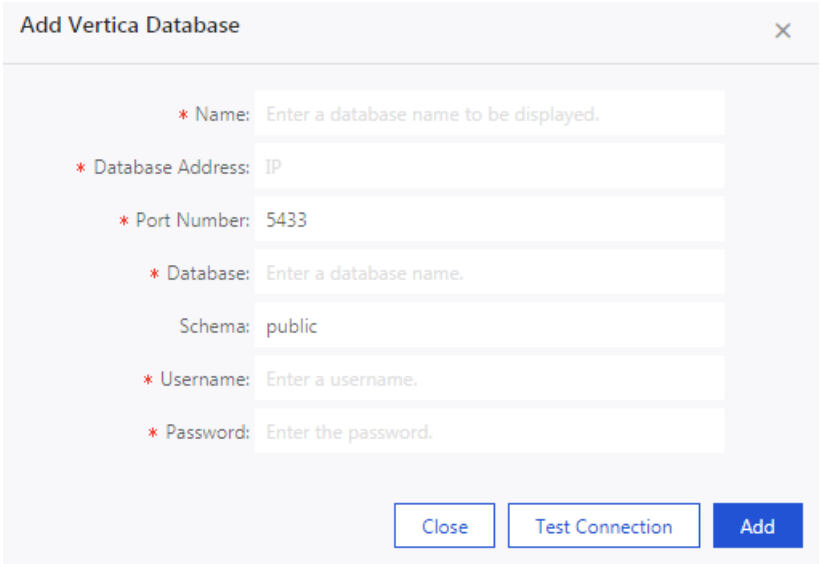
This topic describes how to add a user-created Vertical data source.

Prerequisites

Parameter settings for connecting to the Vertica data source are obtained.

Procedure

1. On the Data Sources page, click Create Data Source in the upper-right corner. For more information, see Create a data source.
2. On the Add Data Source page, click the User-created Data Sources tab. Then, click **Vertica** and set the parameters for connecting to the data source in the dialog box that appears.



Parameter	Description
Name	The name to be displayed for the connected data source.
Database Address	The hostname or IP address of the database.
Port Number	The port number of the database. The default port is 5433.
Database	The name of the database to which you want to access.
Schema	The schema of the database. The default value is public.
Username	The username used to access the database.
Password	The password of the database user.

3. Click **Test Connection** to perform a data source connectivity test.
4. After the connection is established, click **Add**.

5.3.2.3.7. Add a user-created IBM DB2 LUW data source

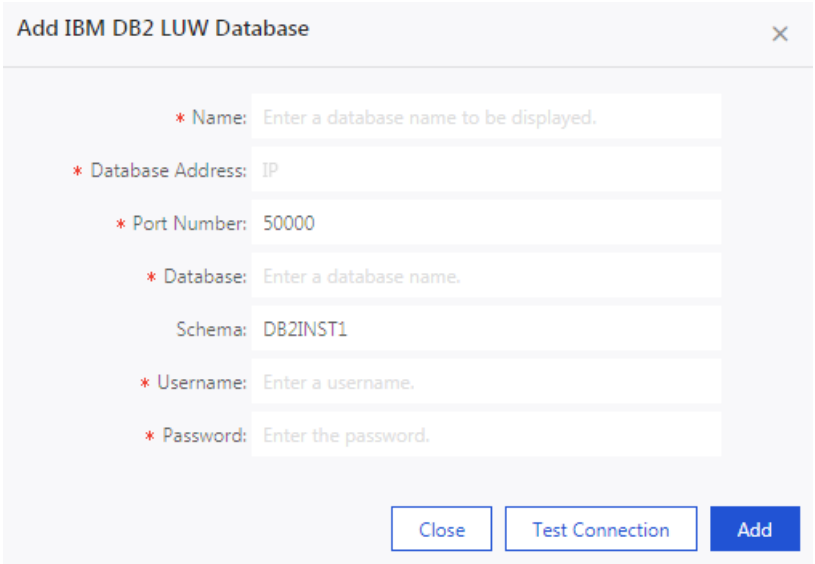
This topic describes how to add a user-created IBM DB2 LUW data source.

Prerequisites

Parameter settings for connecting to the IBM DB2 LUW data source are obtained.

Procedure

1. On the Data Sources page, click Create Data Source in the upper-right corner. For more information, see Create a data source.
2. On the Add Data Source page, click the User-created Data Sources tab. Then, click **IBM DB2 LUW** and set the parameters for connecting to the data source in the dialog box that appears.



Parameter	Description
Name	The name to be displayed for the connected data source.
Database Address	The hostname or IP address of the database.
Port Number	The port number of the database. The default port is 50000.
Database	The name of the database to which you want to access.
Schema	The schema of the database. The default value is DB2INST1.
Username	The username used to access the database.
Password	The password of the database user.

3. Click **Test Connection** to perform a data source connectivity test.
4. After the connection is established, click **Add**.

5.3.2.3.8. Add a user-created SAP IQ (Sybase IQ) data source

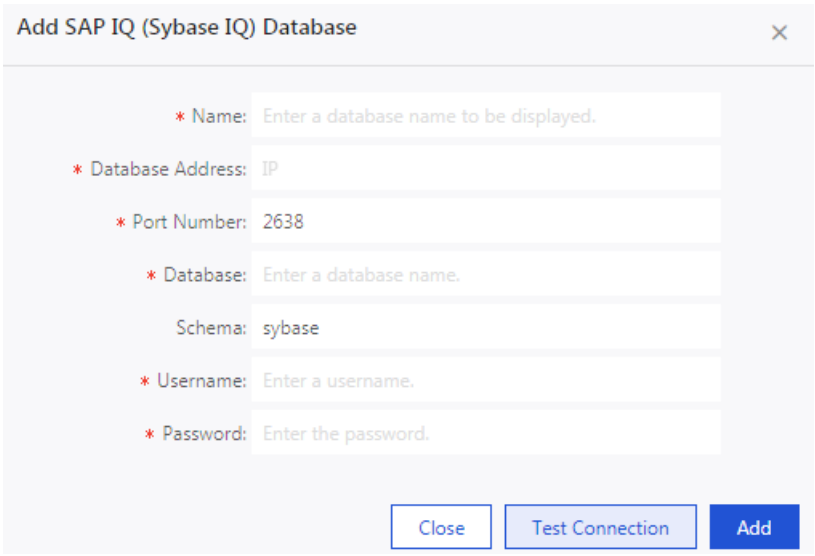
This topic describes how to add a user-created SAP IQ (Sybase IQ) data source.

Prerequisites

Parameter settings for connecting to the SAP IQ (Sybase IQ) data source are obtained.

Procedure

1. On the Data Sources page, click Create Data Source in the upper-right corner. For more information, see Create a data source.
2. On the Add Data Source page, click the User-created Data Sources tab. Then, click **SAP IQ (Sybase IQ)** and set the parameters for connecting to the data source in the dialog box that appears.



Parameter	Description
Name	The name to be displayed for the connected data source.
Database Address	The hostname or IP address of the database.
Port Number	The port number of the database. The default port is 2638.
Database	The name of the database to which you want to access.
Schema	The schema of the database. The default value is sybase.
Username	The username used to access the database.
Password	The password of the database user.

3. Click **Test Connection** to perform a data source connectivity test.
4. After the connection is established, click **Add**.

5.3.2.3.9. Add a user-created SAP HANA data source

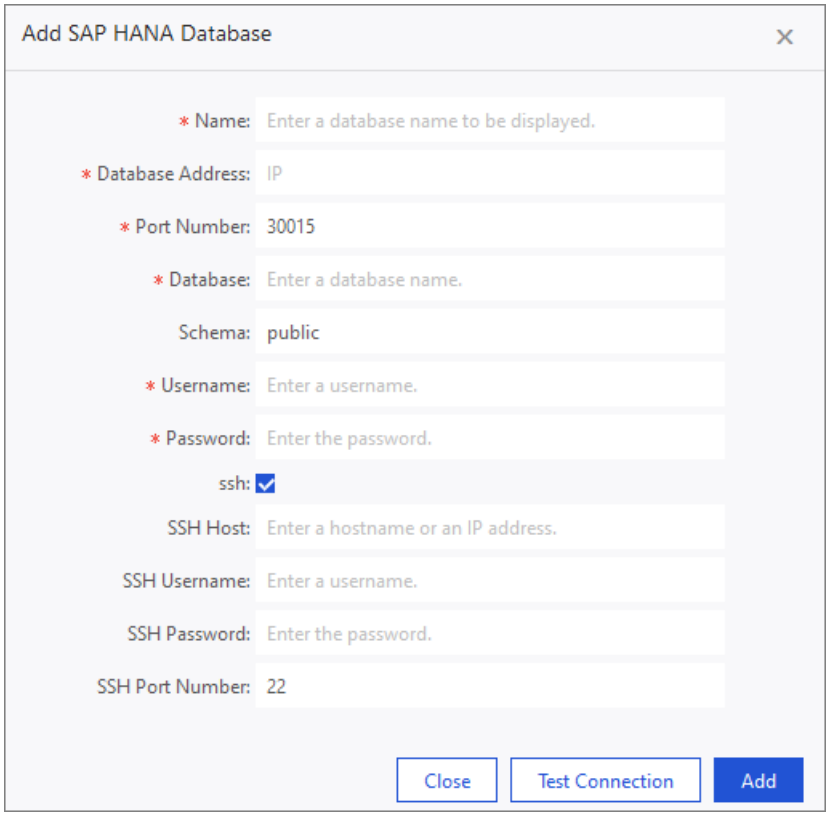
This topic describes how to add a user-created SAP HANA data source.

Prerequisites

Parameter settings for connecting to the SAP HANA data source are obtained.

Procedure

1. On the Data Sources page, click Create Data Source in the upper-right corner. For more information, see Create a data source.
2. On the Add Data Source page, click the User-created Data Sources tab. Then, click **SAP HANA** and set the parameters for connecting to the data source in the dialog box that appears.



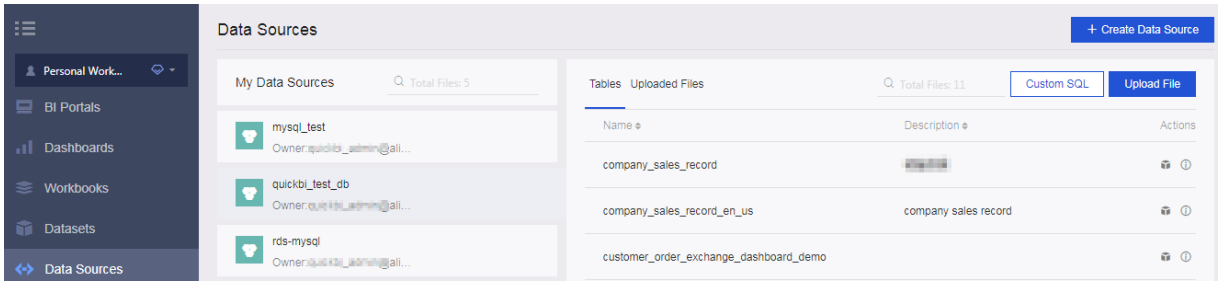
Parameter	Description
Name	The name to be displayed for the connected data source.
Database Address	The hostname or IP address of the database.
Port Number	The port number of the database. The default port is 30015.
Database	The name of the database to which you want to access.
Schema	The schema of the database. The default value is public.
Username	The username used to access the database.
Password	The password of the database user.

3. Click **Test Connection** to perform a data source connectivity test.
4. After the connection is established, click **Add**.

5.3.2.4. List of data sources

This topic describes the basic information about the Data Sources page.

You can manage data sources on the Data Sources page, including **create**, **edit**, and **delete** a data source.



5.3.2.5. Create a data source

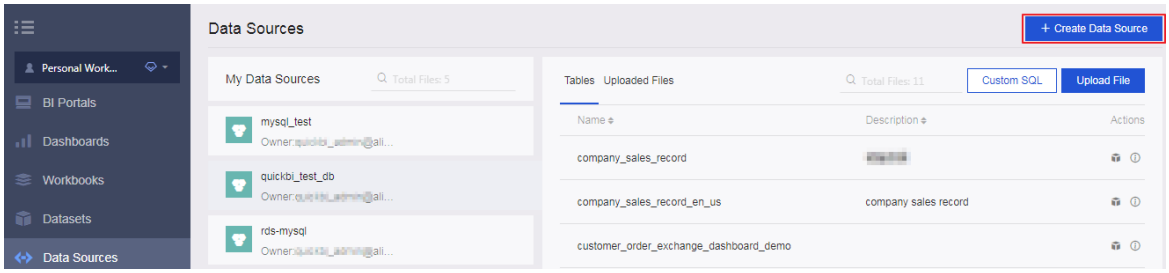
This topic describes how to create a data source.

Prerequisites

The Quick BI service is purchased.

Procedure

1. Log on to the Quick BI console.
2. Click the **Workspace** tab.
3. In the left-side navigation pane of the Workspace page, click **Data Sources**.
4. In the upper-right corner of the Data Sources page, click **Create Data Source**.



5. In the **Add Data Source** dialog box that appears, select the source for the data source.
   - If you want to create a data source from a cloud data source, click the **Cloud Data Sources** tab.
   - If you want to create a data source from a user-created data source, click the **User-created Data Sources** tab.
6. Select the data source type. In the dialog box that appears, enter the information required for connecting to the data source, and click **Add**.

5.3.2.6. Edit a data source

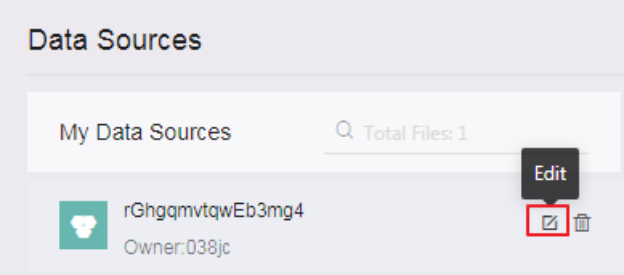
This topic describes how to edit a data source.

Prerequisites

The Quick BI service is purchased.

Procedure

1. Log on to the Quick BI console.
2. Click the **Workspace** tab.
3. In the left-side navigation pane of the Workspace page, click **Data Sources**.
4. Find the data source that you want to edit in the data source list.
5. Click the **Edit** icon to edit the data source.



5.3.2.7. Delete a data source

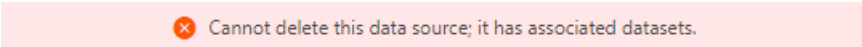
This topic describes how to delete a data source.

Prerequisites

The Quick BI service is purchased.

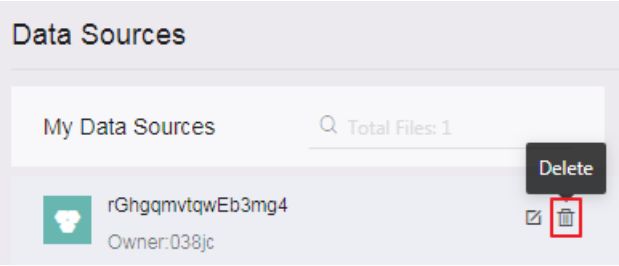
Context

If you have created a dataset based on a data source, you cannot delete the data source.



Procedure

1. Log on to the Quick BI console.
2. Click the **Workspace** tab.
3. In the left-side navigation pane of the Workspace page, click **Data Sources**.
4. Find the data source that you want to delete in the data source list.
5. Click the **Delete** icon to delete the data source.



5.3.2.8. Search for a data source

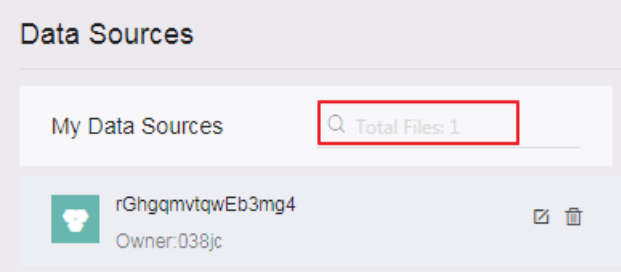
This topic describes how to search for a data source.

Prerequisites

The Quick BI service is purchased.

Procedure

1. Log on to the Quick BI console.
2. Click the **Workspace** tab.
3. In the left-side navigation pane of the Workspace page, click **Data Sources**.
4. Enter a keyword into the search box to search for the data source.



5. Click the **Search** icon to search for the data source.

5.3.2.9. Search for a table in a data source

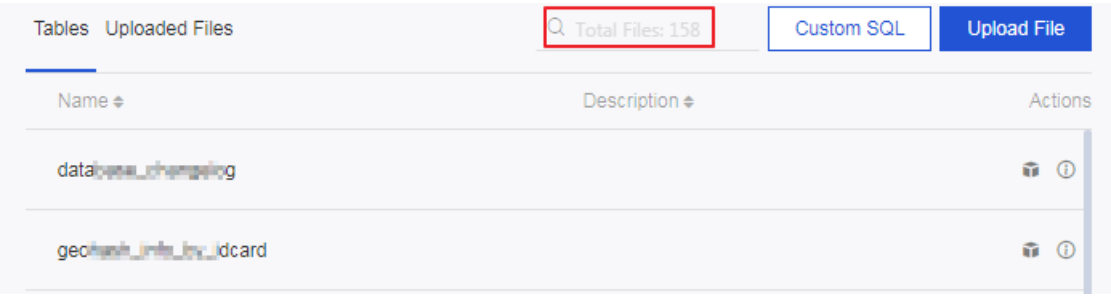
This topic describes how to search for a specific table under a data source.

Prerequisites

The Quick BI service is purchased.

Procedure

1. Log on to the Quick BI console.
2. Click the **Workspace** tab.
3. In the left-side navigation pane of the Workspace page, click **Data Sources**.
4. Select the target data source. All tables under the data source are listed on the right side of the page.
5. Enter a keyword in the search box to search for a table.



6. Click the **Search** icon to search for the table.

5.3.2.10. Query table details

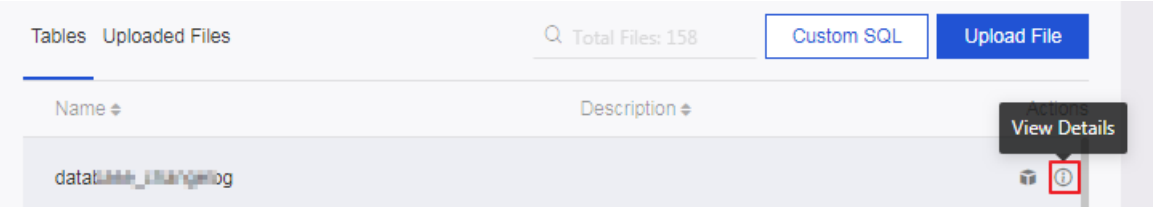
Quick BI allows you to query tables and table details under a data source.

Prerequisites

The Quick BI service is purchased.

Procedure

1. Log on to the Quick BI console.
2. Click the **Workspace** tab.
3. In the left-side navigation pane of the Workspace page, click **Data Sources**.
4. Select the target data source. All tables under the data source are listed on the right side of the page.
5. Find the target table and click the **View Details** icon to view the table details and fields.



5.3.2.11. Create a dataset by using an SQL statement for ad hoc query

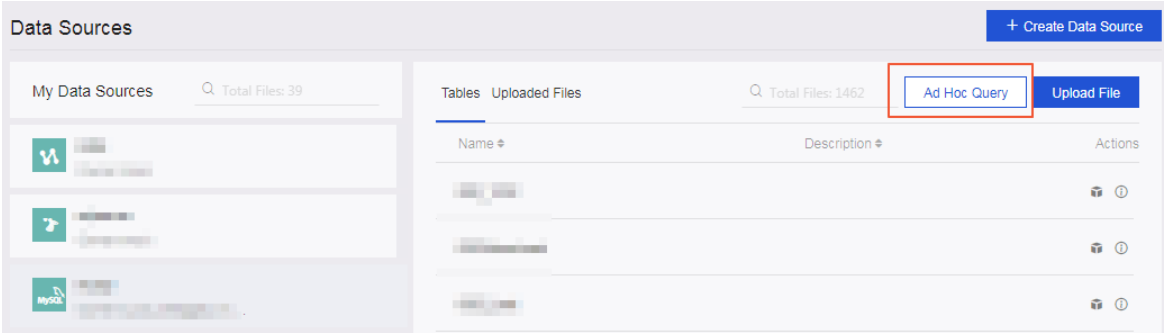
This topic describes how to create a dataset by using an SQL statement for ad hoc query to implement some complex logic for data modeling. Ad hoc queries support dynamic parameter passing to SQL statements. Modeling analysis based on dynamic parameter passing to SQL statements increases the depth of scenarios supported by Quick BI. This meets the requirements of complex data analysis scenarios.

Prerequisites

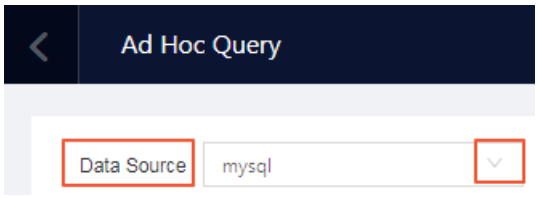
The Quick BI service is purchased.

Procedure

1. Log on to the Quick BI console.
2. Click the **Workspace** tab.
3. In the left-side navigation pane of the Workspace page, click **Data Sources**.
4. In the upper-right corner of the **Data Sources** page, click **Ad Hoc Query**.



5. On the **Ad Hoc Query** page, specify the data source.



6. Enter an SQL statement.

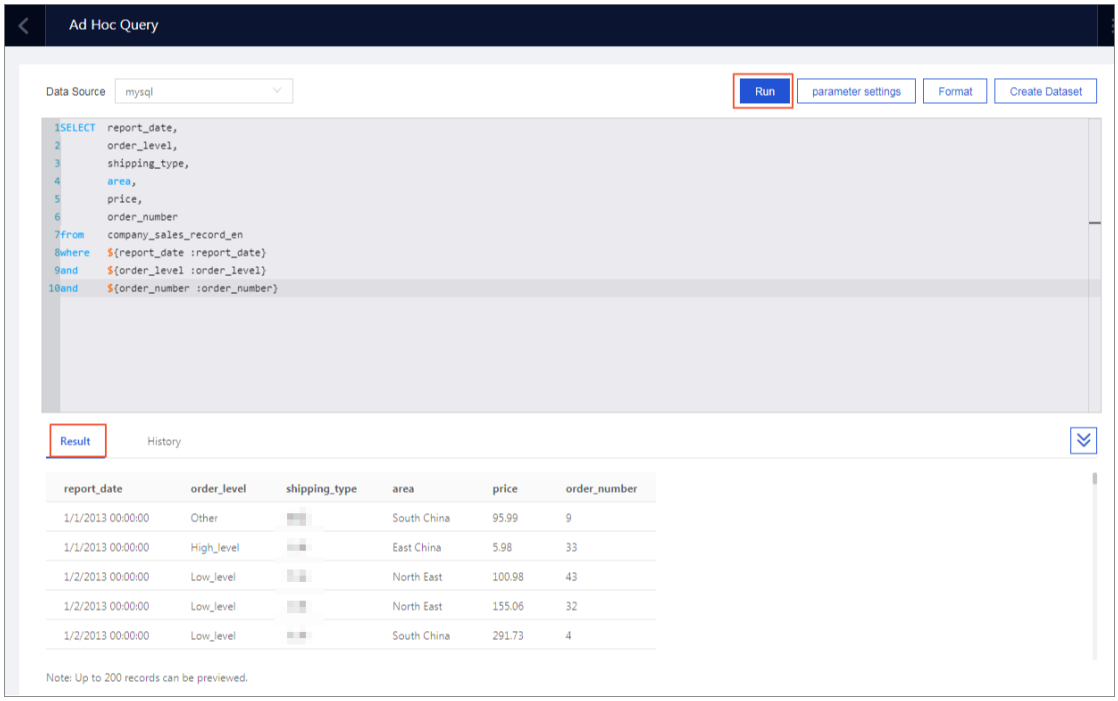
   Example:

```
SELECT report_date,
    order_level,
    shipping_type,
    area,
    price,
    order_number
from  company_sales_record
where  ${report_date :report_date}
and  ${order_level :order_level}
and  ${order_number :order_number}
```

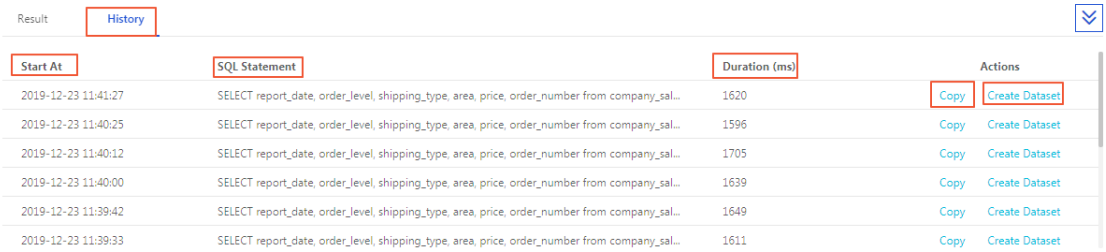
7. Click **Run** to execute the SQL statement.

   You can view the execution results on the Result tab.

   i. Click the **Result** tab.



ii. Click the **History** tab to view the execution time, SQL statement, and time consumed by the ad hoc query.



- Click **Copy** to copy the SQL statement and paste it into the SQL input box.
- Click **Create Dataset**. A dataset can be created by using the historical SQL statement.
- Click  to hide the execution results.

SQL statements for ad hoc queries support dynamic parameter passing. When you create an SQL model, you can append SQL parameters to the WHERE clause in the format of ${Physical field name:Parameter alias}. The parameters can be referenced by the filter bar widget.

> **Note** Parameter fields are not displayed in the dataset, but are displayed in the filter bar widget.

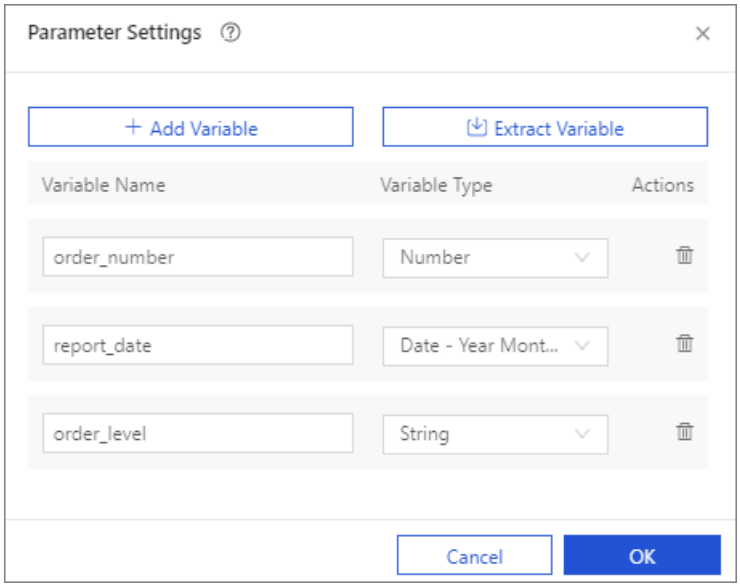
Example:

```
SELECT report_date,
    order_level,
    shipping_type,
    area,
    price,
    order_number
from  company_sales_record
where  ${report_date :report_date}
and   ${order_level :order_level}
and   ${order_number :order_number}
```

8. Set the parameters.

   You can add variables and modify variable types. Five variable types are supported: String, Number, Date -Year Month Date, Date -Year Month, and Date -Year.

   - Click **Add Variable** to add parameter aliases and variable types. A parameter alias must be added to the WHERE clause in the SQL statement in the format of ${Physical field name:Parameter variable name}.
   - Click **Extract Variable** to obtain the parameter aliases in the SQL statement. The default variable type is String, which can be modified.



- Click **Format** to format the SQL statement.

5.3.3. Datasets

5.3.3.1. Overview

You can use tables from data sources to create datasets. The following topics describe common operations on datasets, for example, create, edit, and query a dataset.

You can create a dataset by using the following methods:

- Create a dataset from a data source
- Create a dataset by uploading a CSV file
- Create a dataset by using custom SQL statements

5.3.3.2. Create datasets

5.3.3.2.1. Create a dataset from a data source

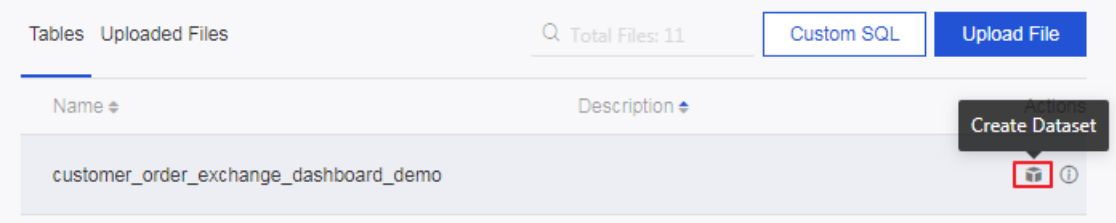
This topic describes how to create a dataset from a data source.

Prerequisites

The Quick BI service is purchased.

Procedure

1. Log on to the Quick BI console.
2. Click the **Workspace** tab.
3. In the left-side navigation pane of the Workspace page, click **Data Sources**.
4. On the Data Sources page, click the target data source. All tables under the data source are listed on the right side of the page.
5. Select a table and click the **Create Dataset** icon in the Actions column.



After the dataset is created, the **Datasets** page appears. The new dataset is displayed on the My Items tab and marked with New.

5.3.3.2.2. Create a dataset by uploading a CSV file

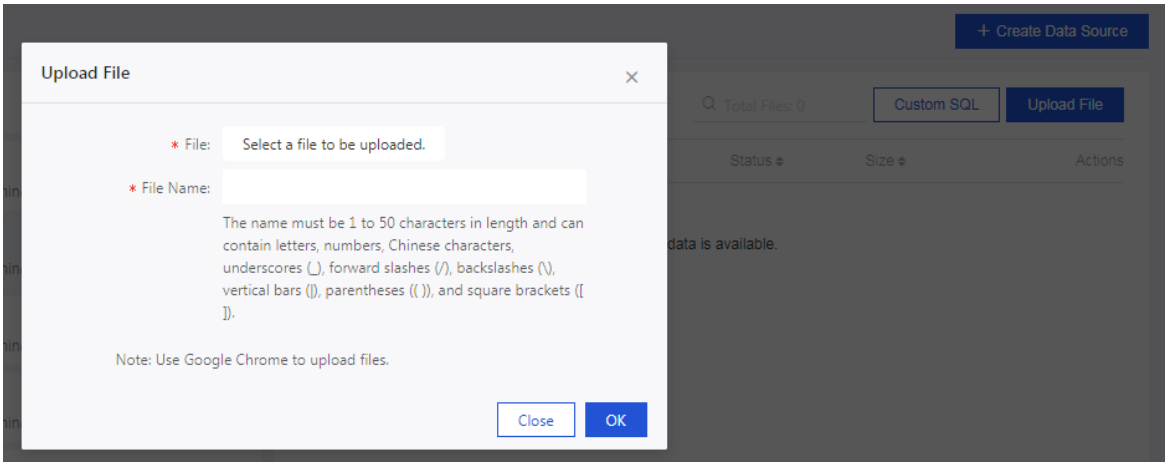
This topic describes how to create a dataset by uploading a CSV file.

Prerequisites

The Quick BI service is purchased.

Procedure

1. Log on to the Quick BI console.
2. Click the **Workspace** tab.
3. In the left-side navigation pane of the Workspace page, click **Data Sources**.
4. On the Data Sources page, select a data source and click **Upload File** in the upper-right corner.
5. In the **Upload File** dialog box that appears, select the target file, enter the file name, and click **OK**.



> **Note** After the file is uploaded, the Uploaded Files page appears.

6. On the Uploaded Files page, select the file that you have uploaded and click the **Create Dataset**

icon to create a dataset.

5.3.3.3. Specify a method to name dimensions and measures

Quick BI automatically creates datasets based on the metadata of physical tables and converts fields in the physical tables to dimensions or measures in datasets. Dimensions and measures are automatically named after the names or description of physical table fields.

Prerequisites

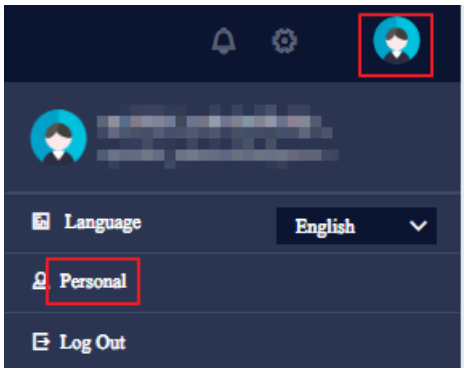
The Quick BI service is purchased.

Context

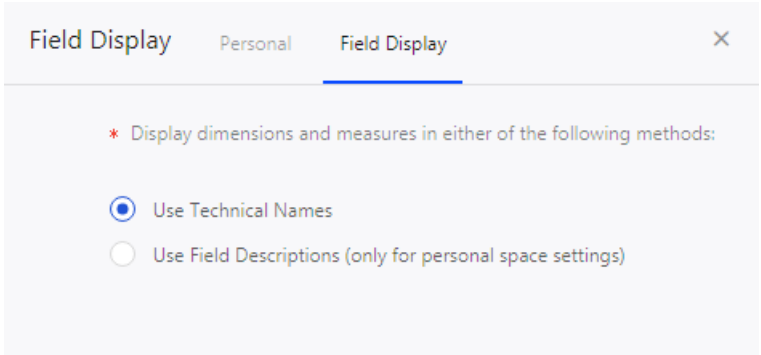
On the Datasets page, you can move the pointer over your avatar and select **Personal**. In the dialog box that appears, set the parameters based on your needs. After you set the parameters, dimensions and measures will be named based on your preference.

Procedure

1. Log on to the Quick BI console.
2. Move the pointer over your avatar and select **Personal**.



3. In the **Personal** dialog box that appears, click the **Field Display** tab and select a method to name dimensions and measures in datasets.



5.3.3.4. Edit a dataset

5.3.3.4.1. Edit a dimension

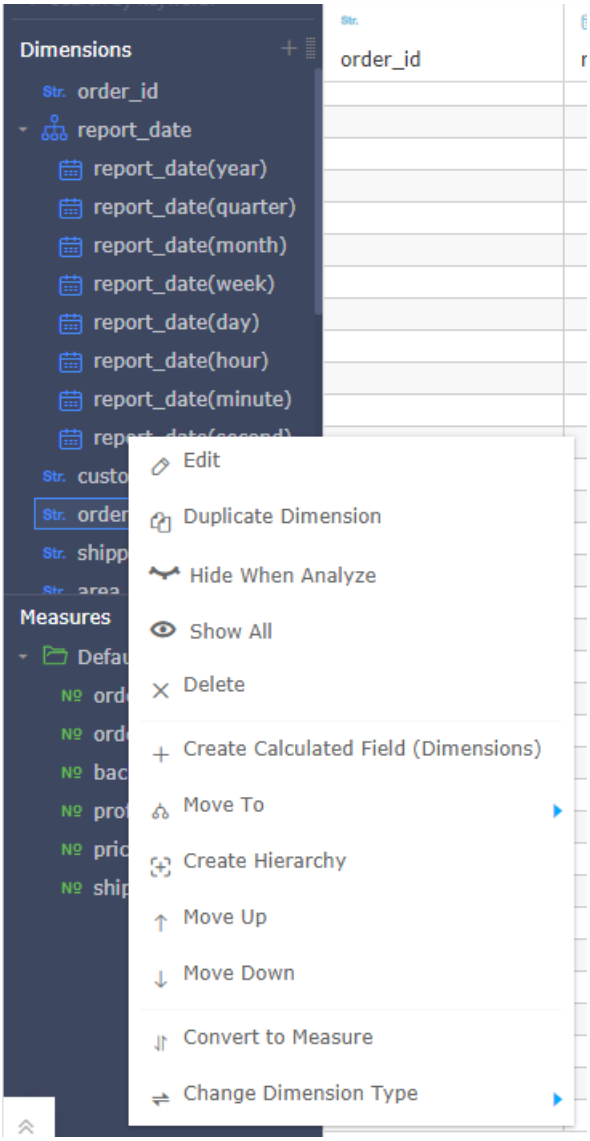
If the field data type of a dataset table is text or date, the field is classified as a dimension by the system. You can edit the field in the Dimensions list.

Prerequisites

The Quick BI service is purchased.

Procedure

1. Log on to the Quick BI console.
2. Click the **Workspace** tab.
3. In the left-side navigation pane of the Workspace page, click **Datasets**.
4. In the Datasets list, find the target dataset and click in the Actions column to go to the dataset edit page.
5. Select a field from the Dimensions list.
6. Right-click the field and select **Edit**. The field edit dialog box appears.



- **Edit**: You can edit the dimension name and description.
- **Duplicate Dimension**: You can duplicate the dimension. The name of the duplicate dimension ends with **Duplicate**.
- **Hide When Analyze**: You can hide the dimension as needed.
- **Show All**: You can display all dimensions.
- **Delete**: You can delete the dimension.
- **Create Calculated Field (Dimensions)**: You can create a dimension and customize the calculation method.
- **Move To**: You can move the dimension to a hierarchy for drilling.
- **Create Hierarchy**: You can create a hierarchy and move the dimension to the hierarchy.
- **Move Up or Move Down**: You can select Move Up or Move Down to move the dimension upwards or downwards, or drag it to the target position.
- **Convert to Measure**: You can convert the dimension to a measure.
- **Change Dimension Type**: You can change the type of the dimension to Default, Date/Time, Geo, String, or Number.

For example, you must change the type of the province and city dimensions to Geo when you create a bubble map or a colored map. Otherwise, the map cannot be displayed properly.

> Note
>
> - You can duplicate, hide, and delete dimensions at each hierarchy level.
> - After you select **Edit**, you can set the start date of a week for the week field in the dialog box that appears.

5.3.3.4.2. Edit a measure

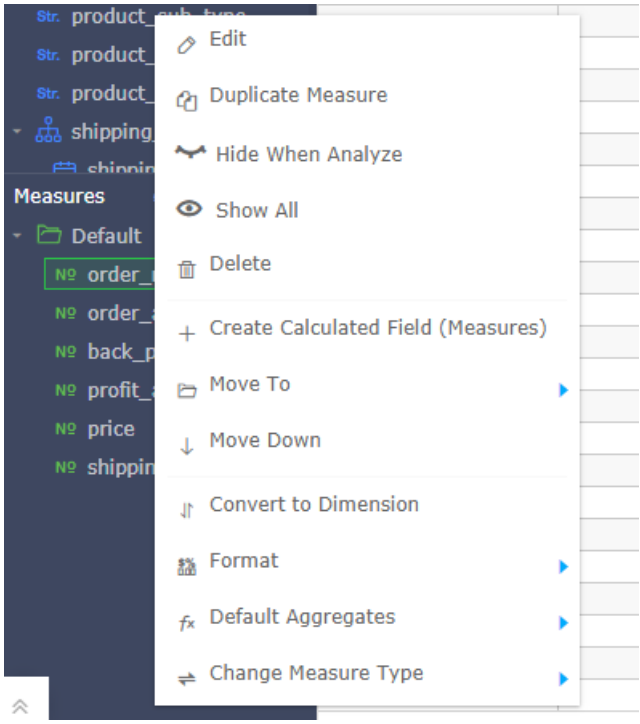
If the field data type of a dataset table is numeric, the field is classified as a measure by the system. You can edit the field in the Measures list.

Prerequisites

The Quick BI service is purchased.

Procedure

1. Log on to the Quick BI console.
2. Click the **Workspace** tab.
3. In the left-side navigation pane of the Workspace page, click **Datasets**.
4. In the Datasets list, click the target dataset name to go to the dataset edit page.
5. Select a field from the Measures list.
6. Right-click the field. A shortcut menu appears.



- Edit: You can edit the measure name and description.

- Duplicate Measure: You can duplicate the measure. The name of the duplicate field ends with **Duplicate**.
- Hide When Analyze: You can hide the measure as needed.
- Show All: You can display all measures.
- Delete: You can delete the measure.
- Create Calculated Field (Measures): You can create a measure and customize its calculation method.
- Move To: You can move the measure to an existing folder.
- Move Up or Move Down: You can select Move Up or Move Down to move the measure upwards or downwards, or drag it to the target position.
- Convert to Dimension: You can convert the measure to a dimension.
- Format: You can specify the numeric display format.
- Default Aggregates: You can specify an aggregate function. Aggregate functions include SUM, MAX, and MIN.
- Change Measure Type: You can change the type of the measure to String or Numeric.

5.3.3.4.3. Toolbar

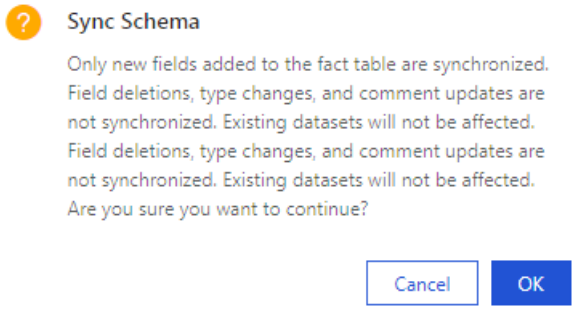
Quick BI provides a toolbar and a shortcut menu for you to edit a dataset and create a report on the dataset edit page.

Toolbar

- Lock: Multiple users can edit a dataset simultaneously, but only one user can save the changes at a time. If you want to save a dataset that is being edited by multiple users, you must lock the dataset, refresh the page to update the data, apply the changes to the dataset, and then save the dataset. If you lock a dataset and edit it without refreshing the page, the changes made by the previous user are overwritten.
- Sync Schema: synchronizes the dataset with the online physical table.

  If a field is deleted from the physical table or is modified, the system does not delete the relevant data from the dataset.

  Synchronize the schema

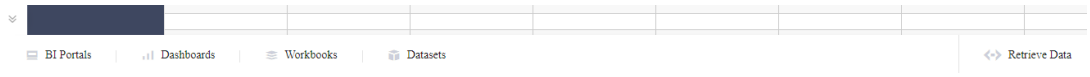


- Refresh Preview: refreshes the dataset and displays the data in the Preview mode. If you want to view the latest data in real time, save the dataset and then refresh the page.
- Set Filter: filters data in the dataset to avoid full table scan.
- Save As: saves the current dataset as a new dataset. This operation allows you to quickly duplicate a dataset or backup data.
- Save: saves the dataset.

  After you add new fields, delete fields, convert dimensions to measures, or convert measures to dimensions, you must save the dataset. After you save the dataset, you can refresh the page to view the updated dataset.

Shortcut menu

Shortcut menu

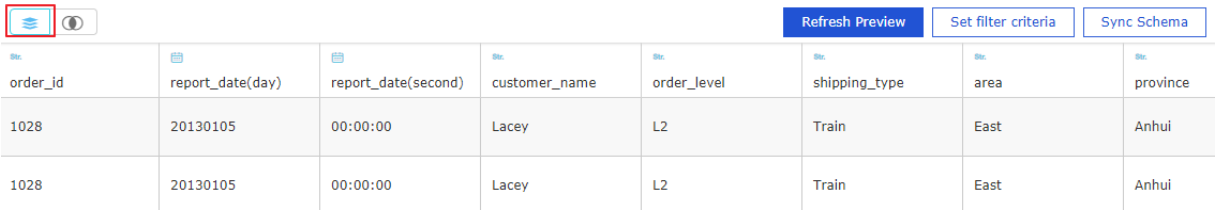


- Dashboards: You can click **Dashboards** to go to the **Create Dashboard** dialog box.
- Workbooks: You can click **Workbooks** to go to the workbook creation and edit page.
- Datasets: You can click **Datasets** to go to the dataset creation page.
- Data Portals: You can click **BI Portals** to go to the BI portal creation and edit page.
- Retrieve Data: You can click **Retrieve Data** to go the **Create Data Source** page.

5.3.3.4.4. Preview data

This topic describes how to preview data on the dataset edit page.

Click the **Preview** icon to preview the data.



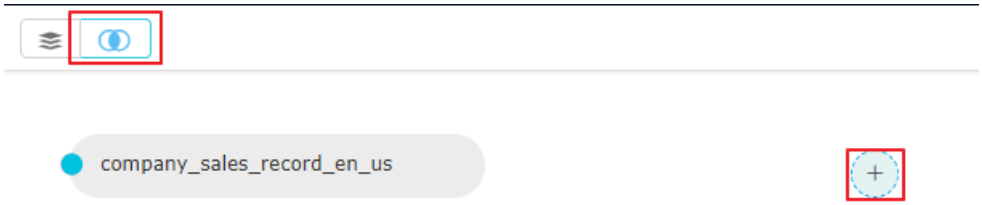
order_id	report_date(day)	report_date(second)	customer_name	order_level	shipping_type	area	province
1028	20130105	00:00:00	Lacey	L2	Train	East	Anhui
1028	20130105	00:00:00	Lacey	L2	Train	East	Anhui

5.3.3.4.5. Table join and examples

This topic describes how to join tables when you edit a dataset.

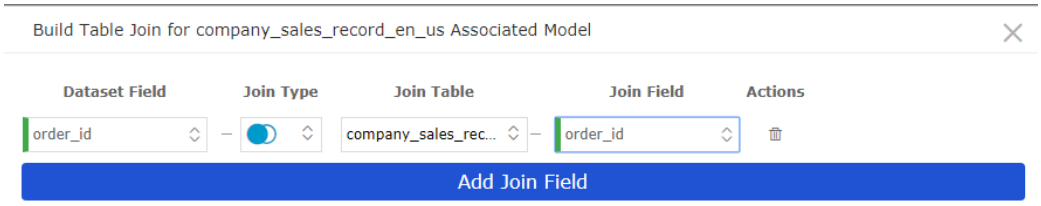
Procedure

1. Log on to the Quick BI console.
2. Click the **Workspace** tab.
3. In the left-side navigation pane of the Workspace page, click **Datasets**.
4. On the Datasets page, click the target dataset, for example, company_sales_record, to go to the dataset edit page.
5. Click the **Table Join** icon to switch the dataset to the Table Join mode.



6. Click the plus sign (+). The **Build Table Join for company_sales_record Associated Model** dialog box appears.
7. Select the field that is used to join tables, and a join type.

   Edit the table join model

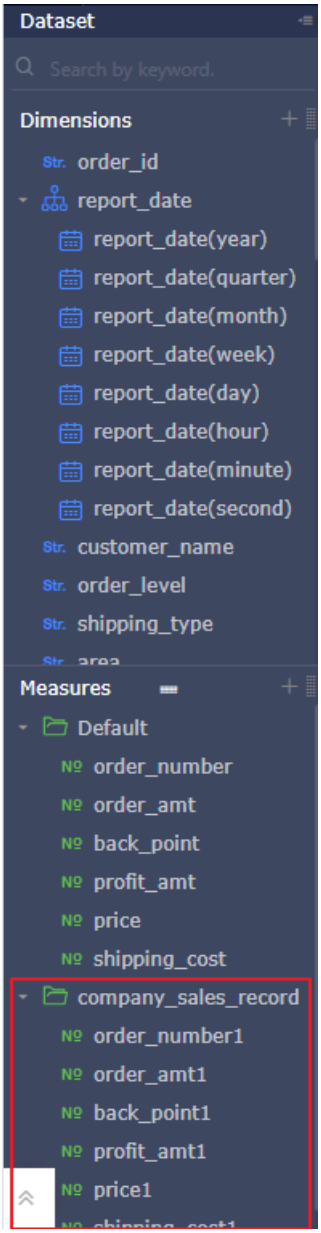
   

   Quick BI supports the following join types:

   - Inner Join: returns data records that match specific join fields in the two tables.
   - Left Outer Join: returns all records in the left table and data records that match specific join fields in the two tables.
   - All Join: returns all data records in the two tables.

   > **Note** MySQL data sources do not support the All Join type.

8. Click **Add Join Field** to add multiple join fields.
9. Click **OK** to save the model.
10. Click the **Preview** icon to preview the data.
11. In the Preview mode, click **Save** to save the dataset.
12. Click **Refresh Preview** to view the data after table join.



5.3.3.4.6. Calculated fields

5.3.3.4.6.1. Overview

Quick BI allows you to create new fields from existing fields in data sources by using SQL functions. The new fields are referred to as calculated fields.

If you want to create a calculated field, click the plus sign (+) next to Dimensions or Measures. In the Edit Calculated Field dialog box that appears, specify the field name and select a function. Take note of the following when you edit calculated fields:

- Fields selected created from the Dimensions list are calculated dimensions. Fields created from the Measures list are automatically classified as calculated measures.
- In the Expression edit box, you can select any functions or expressions supported by the current data source.

- You must enter the function name. You can specify the field name in the format of **[Field name]**. To insert a dimension or measure name in a edit box, enter an opening bracket ([) and then select the target field from the list, or double-click the target field in the left-side Dimensions or Measures list . Correct SQL statements are colored in the edit box.
- When you specify expressions, do not use full-width characters, such as quotation marks, commas, and parentheses. Only English punctuation marks are allowed in SQL statements. If an error occurs, check whether you have used full-width punctuation marks in the expression.
- After you create the calculated field, save the dataset before you refresh it.
- You cannot use calculated fields in the expression of another calculated field. If a field is deleted from the corresponding physical table, a calculated field whose expression uses the deleted field becomes invalid.

5.3.3.4.6.2. Rules for using calculated fields

This topic describes the rules for using calculated fields.

- Calculated fields not using aggregate functions can be used as dimensions, or as measures after you specify the aggregate method. Calculated fields using aggregate functions can only be used as measures, and cannot be converted to dimensions.
- You can set the data type for a calculated field. Currently, you can set the data type of dimension fields to Number, Text, or Date/Time, and set the data type of measure fields to Number or Text.
- Similar to dimensions and measures generated by the original fields in a data source, dimensions and measures generated by calculated fields can be used in rows, columns, and filters, and can be selected on the Data tab for charts and maps. You can also convert a calculated field from dimension to measure or from measure to dimension.

> **Note** If you use the SUM or AVG aggregate function in an expression of a calculated field whose data type is Text and values are text data, an error occurs due to a failure in data type conversion.

5.3.3.4.6.3. Types of calculated measures

A calculated field in the measure category is a calculated measure. Calculated measures are classified into common measures and aggregate measures based on the expression type.

The following table lists differences between common measures and aggregate measures.

Common measure	Aggregate measure
Expressions exclude aggregate functions.	Expressions include aggregate functions.
You can change the aggregation method.	You cannot change the aggregation method.
You can convert common measures to dimensions.	You cannot convert aggregate measures to dimensions.
No aggregate functions are supported.	Supported aggregate functions: SUM, AVG, MIN, MAX, COUNT, and COUNT DISTINCT.

You can use the COUNT or COUNT DISTINCT function that has dimensions as its parameters to form a deduplicated aggregate measure.

For example, to calculate the average purchase price per user, you can use the following expression: sum(purchase price)/countd(user ID). To calculate the proportion of order costs to order prices, you can use sum(order cost)/sum(order price) but not avg(order cost/order price).

> **Note** Common measures cannot be used with aggregate measures. For example, sum(order cost)/order price is incorrect.

5.3.3.4.6.4. Expressions of calculated fields

This topic describes functions and arithmetic operations of calculated fields.

Aggregation methods

- To calculate the total order price: sum([order_amt])
- To calculate the average order price: avg([order_amt])
- To calculate the maximum order price: max([order_amt])
- To calculate the minimum order price: min([order_amt])
- To count the number of customers: count([customer_name])
- To count the number of unique customers: count(distinct [customer_name])

Basic operations

order_cost = ([order_amt] - [profit_amt])/100

Substring

Substring([customer_name],1,1)

Group values of a measure by using the CASE WHEN statement

- Group orders based on the order price

  CASE WHEN [order_amt] < 500 THEN 'small order' WHEN [order_amt] >= 500 AND [order_amt] < 2000 Then 'medium order' WHEN [order_amt] >= 2000 AND [order_amt] < 5000 THEN 'big order' ELSE 'large order' END

- Group dimension members by using the CASE WHEN statement. In this example, provinces are classified into a specific physical region.

  CASE WHEN [province] in ('Heilongjiang', 'Liaoning', 'Jilin') THEN 'Northeast' ELSE [province] END

- Calculate a measure by using a complex expression: order price per customer

  sum([order_amt])/count(distinct[customer_name])

- Add a UNIX timestamp

  from_unixtime([order_id] + 1234567890)

- Locate different days in a month

  day([order date])

  Returns a number in the range of 1 to 31.

- Locate different hours in a day

  hour([report_date])

  Returns a number in the range of 0 to 23.

- Calculate the advertisement conversion rate

  CASE WHEN sum([Views]) > 0 THEN sum([Conversion times])/sum([Views]) ELSE 0 END

  The following example is an incorrect expression: sum(CASE WHEN [Views] > 0 THEN [Conversion times]/[Views] ELSE 0 END). For metrics that indicate rates, you must perform the sum operation before the division operation.

5.3.3.4.6.5. Add a calculated field

This topic describes how to add a calculated field.

Prerequisites

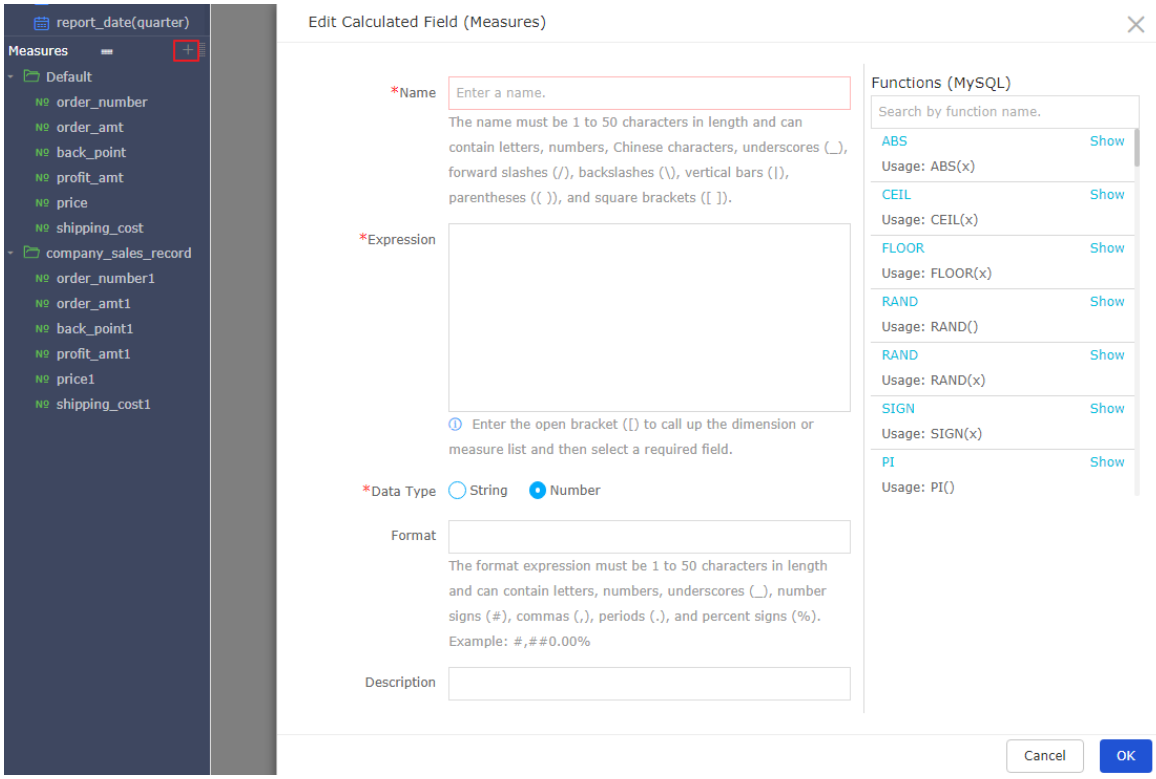
For information about the usage and expressions of calculated fields, see Rules for using calculated fields and Expressions of calculated fields.

Context

The following example uses the company_sales_record dataset to calculate the average profit of orders.

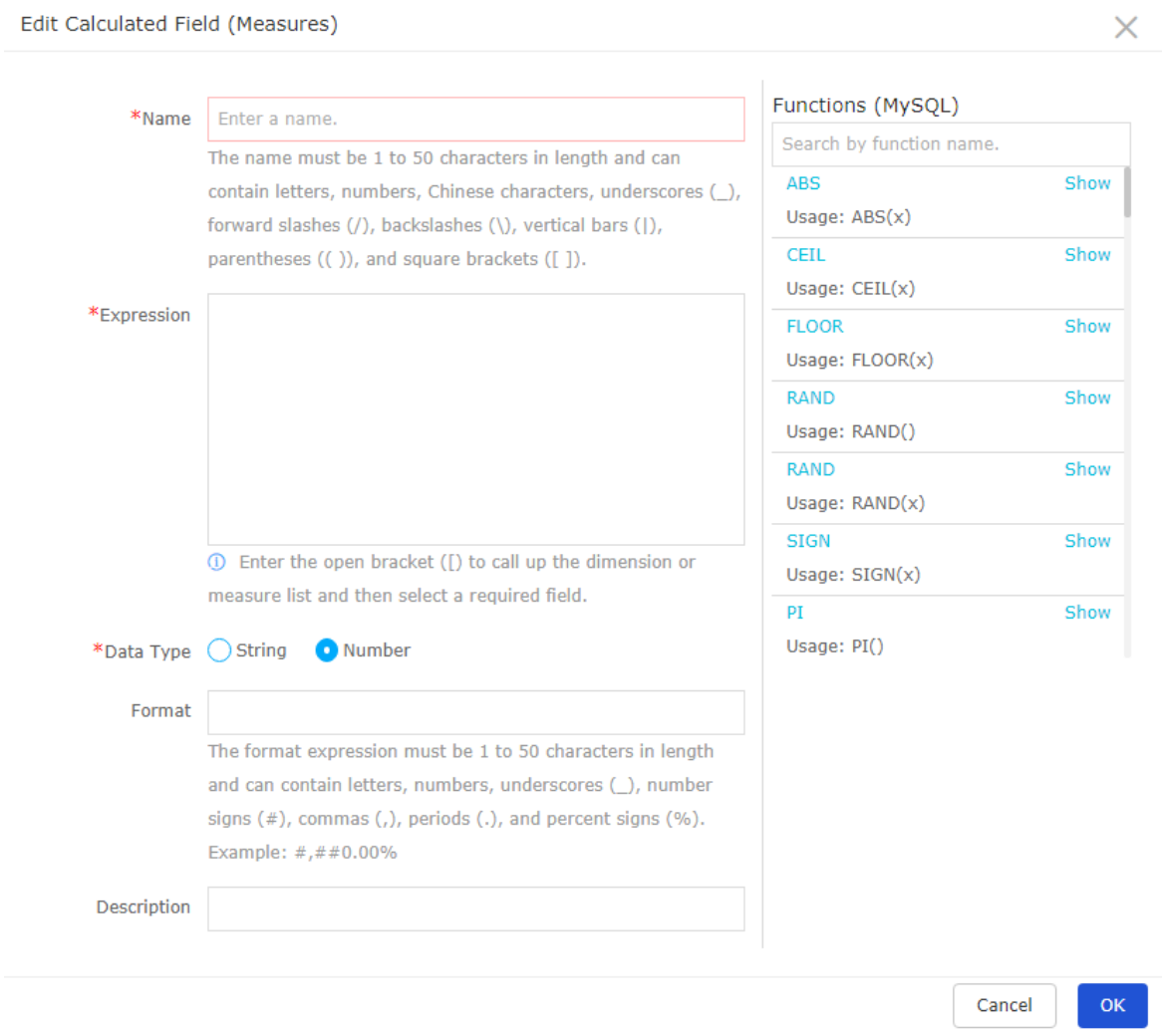
Procedure

1. Log on to the Quick BI console.
2. Click the **Workspace** tab.
3. In the left-side navigation pane of the Workspace page, click **Datasets**.
4. On the Datasets page, click the company_sales_record dataset.
5. In the Measures list, click the plus sign (+). The **Edit Calculated Field (Measures)** dialog box appears.



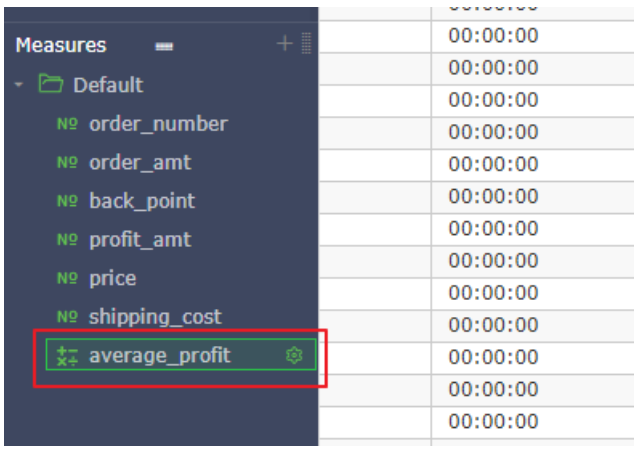
6. Enter the measure name and expression.

   If you want to calculate the average profit of orders, enter an expression to divide the total profit of the orders by the order quantity.



Note You must use an English IME to enter the expression.

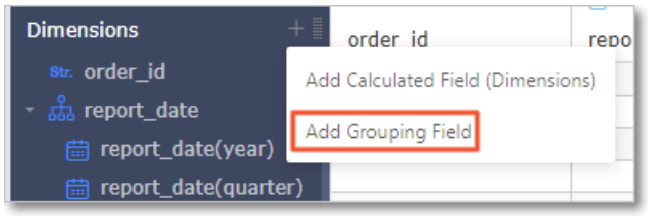
7. Select a data type. For example, if the average profit is a numeric value, you need to select **Number** for Data Type.
8. Click **OK** to add the field.
9. Click **Save** in the upper-right corner to save the dataset.
10. Click **Refresh Preview** to view the new calculated field.



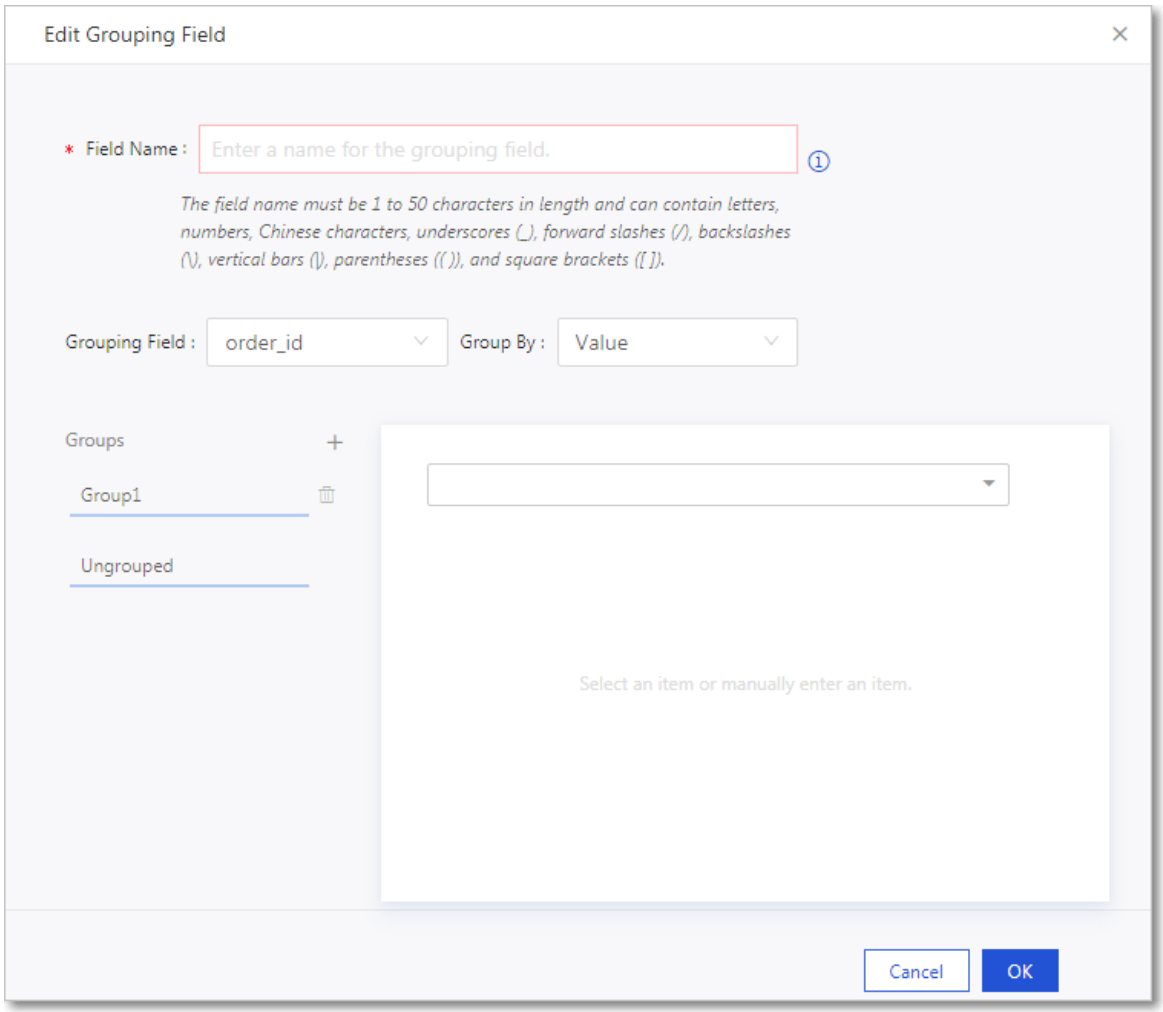
5.3.3.4.7. Add a grouping field

On the dataset edit page, you can use the **Add Grouping Field** feature to group data and store group information.

1. Log on to the Quick BI console.
2. Click the **Workspace** tab.
3. In the left-side navigation pane of the Workspace page, click **Datasets**.
4. On the Datasets page, find the dataset to which you want to add a grouping field, and click the Edit icon in the Actions column. On the dataset edit page, choose **+ > Add Grouping Field** next to Dimensions.



5. In the **Edit Grouping Field** dialog box that appears, enter the required information and click **OK**.



6. Click **Save** and then click **Refresh Preview**. The dimension list shows the new grouping field.

5.3.3.5. Rename a dataset

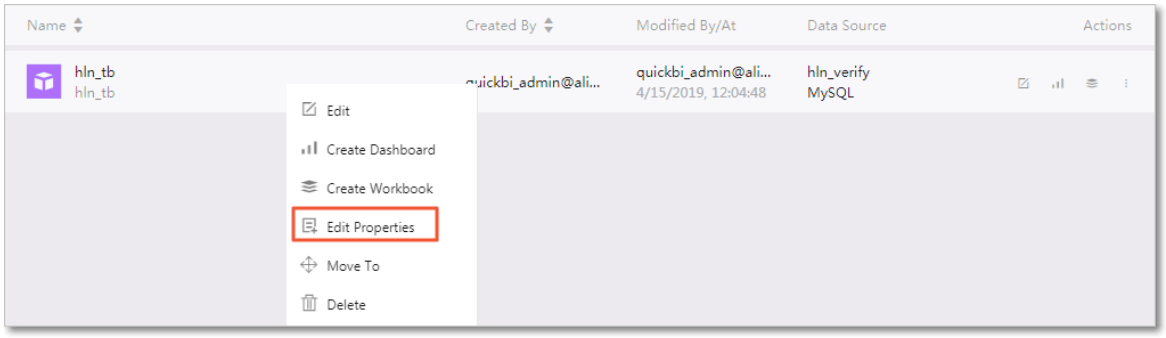
This topic describes how to rename a dataset.

Prerequisites

The Quick BI service is purchased.

Procedure

1. Log on to the Quick BI console.
2. Click the **Workspace** tab.
3. In the left-side navigation pane of the Workspace page, click **Datasets**.
4. On the **Datasets** page, select the dataset that you want to rename. Right-click the dataset or click the **More** icon in the Actions column.
5. Select **Edit Properties**. In the Edit Properties pane that appears, enter a new name for the dataset.



5.3.3.6. Search for a dataset

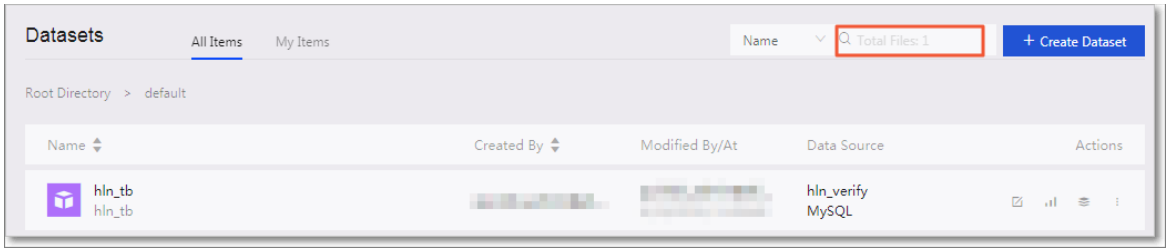
This topic describes how to search for a specific dataset.

Prerequisites

The Quick BI service is purchased.

Procedure

1. Log on to the Quick BI console.
2. Click the **Workspace** tab.
3. In the left-side navigation pane of the Workspace page, click **Datasets**.
4. On the **Datasets** page, find the search box.
5. Enter a keyword and click the **Search** icon to search for the target dataset.



5.3.3.7. Transfer a dataset

This topic describes how to transfer a dataset to another user.

Prerequisites

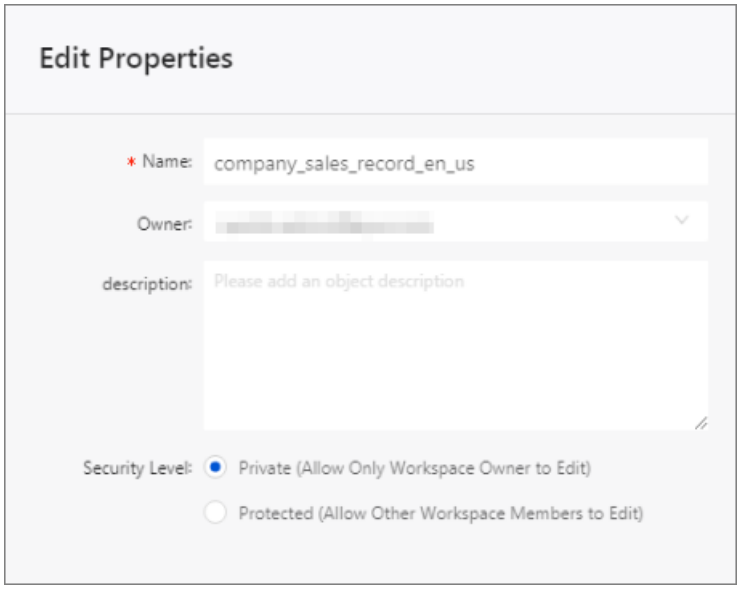
The Quick BI service is purchased.

Context

You can transfer datasets to other Apsara Stack accounts who are members of the same workspace.

Procedure

1. Log on to the Quick BI console.
2. Click the **Workspace** tab.
3. In the left-side navigation pane of the Workspace page, click **Datasets**.
4. On the **Datasets** page, right-click the dataset you want to transfer or click the **More** icon in the Actions column.
5. Select **Edit Properties**.
6. In the **Edit Properties** pane that appears, enter the target account and click **Save**.



5.3.3.8. Copy a dataset from one workspace to another

This function allows you to copy a dataset from one workspace to another.

Prerequisites

The Quick BI service is purchased.

Context

Only group workspaces support this function. Only the administrator of the source and destination workspaces can copy datasets.

Procedure

1. Log on to the Quick BI console.
2. Click the **Workspace** tab.
3. In the left-side navigation pane of the Workspace tab, click **Datasets**.
4. On the **Datasets** page, right-click the dataset that you want to copy and select **Copy**.
5. On the **Copy Dataset** dialog box that appears, set the destination workspace, storage path, and the name of the dataset in the destination workspace.

   > **Note** If the destination workspace does not contain the data source of the dataset, the data source is automatically copied to the destination workspace after the dataset is copied.

6. Click **OK**.

5.3.3.9. Create a dataset folder

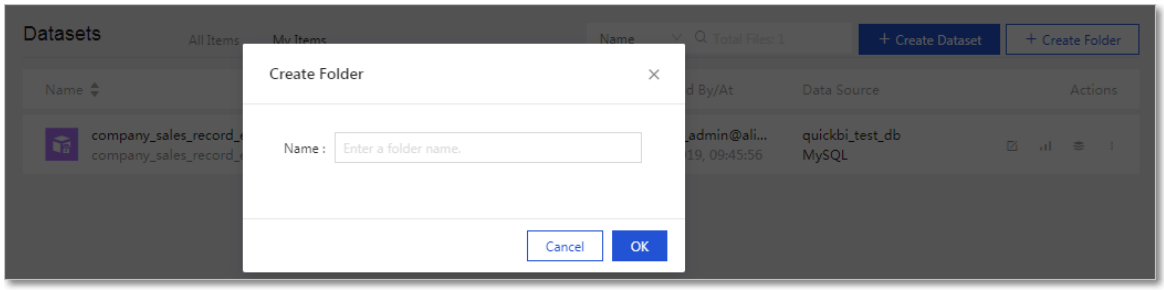
This topic describes how to create a dataset folder on the **Datasets** page.

Prerequisites

The Quick BI service is purchased.

Procedure

1. Log on to the Quick BI console.
2. Click the **Workspace** tab.
3. In the left-side navigation pane of the Workspace page, click **Datasets**.
4. In the upper-right corner of the **Datasets** page, click **Create Folder**.
5. In the **Create Folder** dialog box that appears, specify a name for the folder and click **OK**.



5.3.3.10. Rename a dataset folder

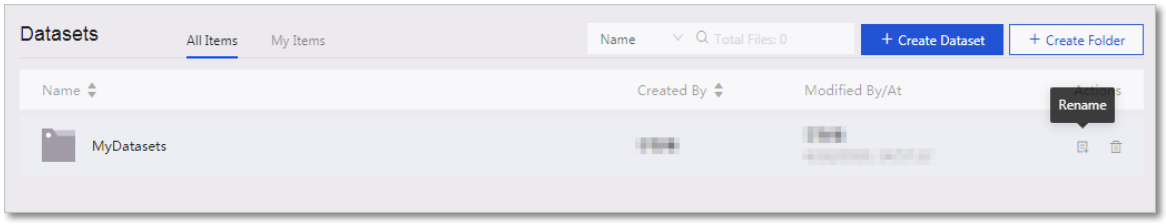
This topic describes how to rename a dataset folder.

Prerequisites

The Quick BI service is purchased.

Procedure

1. Log on to the Quick BI console.
2. Click the **Workspace** tab.
3. In the left-side navigation pane of the Workspace page, click **Datasets**.
4. On the **Datasets** page, find the folder you want to rename.
5. Right-click the folder and select **Rename**, or click the **Rename** icon in the Actions column.



6. Enter a new name and click **OK**.

5.3.3.11. Delete a dataset

This topic describes how to delete a dataset and the common issues that may occur during this process.

Prerequisites

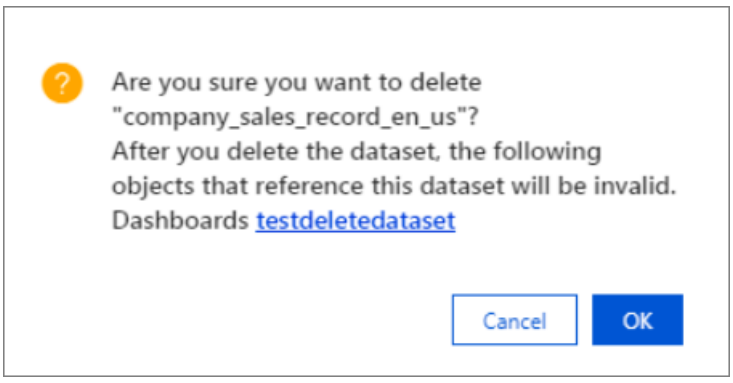
The Quick BI service is purchased.

Context

If workbooks are created based on the dataset, a notification prompts when you attempt to delete the dataset, as shown in Notification.

After you delete a dataset, an error occurs when you access the dashboard created based on that dataset, as shown in Error message.

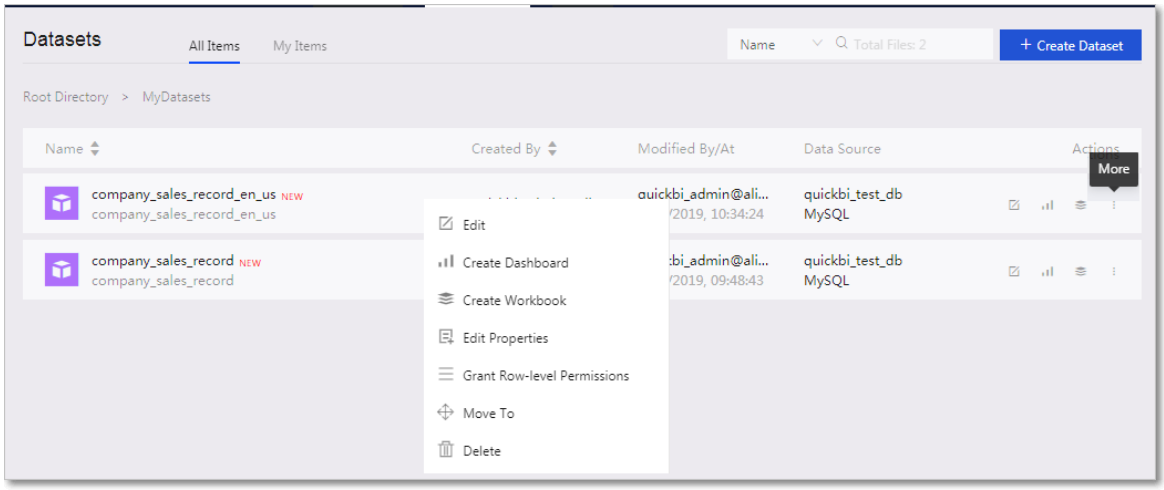
Notification



Error message

Procedure

1. Log on to the Quick BI console.
2. Click the **Workspace** tab.
3. In the left-side navigation pane of the Workspace page, click **Datasets**.
4. On the **Datasets** page, find the dataset you want to delete.
5. Right-click the dataset and select Delete, or click the **More** icon and select **Delete** to delete the dataset.



5.3.3.12. Set row-level permissions

For more information about configuring row-level permissions, see Row-level permission management.

5.4. Dashboards

5.4.1. Dashboard overview

5.4.1.1. Dashboard features

This topic describes the features of a Quick BI dashboard.

- Supports the Filter Bar, Text Area, IFrame, Tab, and Image widgets. You can drag and drop widgets to create pages for various products.
- Provides a wide range of chart components. You can easily create various reports by setting chart elements. A chart can be displayed in either standard or full-screen mode.
- Uses a more flexible tile layout. A dashboard visualizes data. It allows you to filter and query data, use multiple data display modes, and highlight the key fields of data.
- Enables you to drag, drop, and click fields in a dashboard to display data. You can follow the instructions on the pages to analyze data for better user experience.

5.4.1.2. Chart types and scenarios

Different types of data need to be displayed in charts of different types. Currently, Quick BI supports various data charts, such as line charts, vertical bar charts, bubble maps, and funnel charts.

For information about how to create charts, see Create a dashboard.

The following table describes the analysis types and scenarios for each chart type.

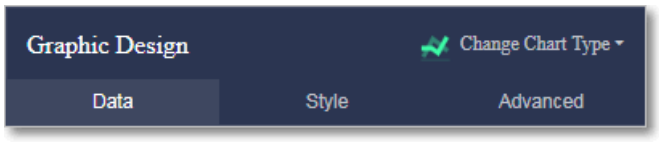
Chart types and scenarios

Analysis type	Description	Scenario	Applicable chart
Comparison	Compares values or compares measures by category	Compares the sales or income between different countries or regions.	Vertical bar chart, radar chart, funnel chart, cross table, polar diagram, tornado-leaned funnel chart, and word cloud
Percentage	Displays the proportion of a part to the total, or the proportion of a certain value to the whole.	Displays the sales of the salesperson that has the greatest percentage of total sales.	Pie chart, funnel chart, gauge, and treemap
Relationship	Displays the relationship between values or measures.	Displays the relationship between two measures. This helps you understand the influence the first measure has on the second measure.	Scatter chart, treemap, kanban, hierarchy chart, and flow analysis chart
Trend	Displays data trends, especially trends based on time, such as year, month, or day, or the progress of a data metric or other possible patterns.	Displays trends in sales or revenue for a product over a period of time.	Line chart
Geographic map	Displays the size and distribution of data metrics of a country or region on a map. The datasets must contain geographic data.	Displays the income information about different regions of a country.	Bubble map and colored map

5.4.1.3. Data elements of a chart

This topic describes the data elements of a chart.

Each chart has three tabs: **Data**, **Style**, and **Advanced**.



- On the **Data** tab, you can specify the data you want to display in the chart.
- On the **Style** tab, you can set the chart layout and items you want to display in the chart.
- On the **Advanced** tab, you can configure the filter interaction feature to dynamically compare and display data.

Each chart has unique core data elements. For example, in a geo map, a latitude field is required. Otherwise, data cannot be displayed.

The following table lists the core data elements of each type of chart.

Data elements of chart types

Chart type	Required data element	Data element description
Line chart	Category axis and value axis	You must specify at least one dimension for the category axis and at least one measure for the value axis.
Stacked line chart	Category axis and value axis	You must specify at least one dimension for the category axis and at least one measure for the value axis.
Area chart	Category axis and value axis	You must specify at least one dimension for the category axis and at least one measure for the value axis.
Stacked area chart	Category axis and value axis	You must specify at least one dimension for the category axis and at least one measure for the value axis.
100% stacked area chart	Category axis and value axis	You must specify at least one dimension for the category axis and at least one measure for the value axis.
Vertical bar chart	Category axis and value axis	You must specify at least one dimension for the category axis and at least one measure for the value axis.
Stacked vertical bar chart	Category axis and value axis	You must specify at least one dimension for the category axis and at least one measure for the value axis.

Chart type	Required data element	Data element description
100% stacked vertical bar chart	Category axis and value axis	You must specify at least one dimension for the category axis and at least one measure for the value axis.
Circular bar	Category axis and value axis	You must specify at least one dimension for the category axis and at least one measure for the value axis.
Horizontal bar chart	Category axis and value axis	You must specify at least one dimension for the category axis and at least one measure for the value axis.
Stacked horizontal bar chart	Category axis and value axis	You must specify at least one dimension for the category axis and at least one measure for the value axis.
100% stacked horizontal bar chart	Category axis and value axis	You must specify at least one dimension for the category axis and at least one measure for the value axis.
Combination chart	Category axis and value axis	You must specify at least one dimension for the category axis and at least one measure for the value axis.
Pie chart	Label and central angle	You can specify only one dimension for labels and only one measure for the central angle.
Bubble map	Geo location and bubble size	You can specify only one dimension for geo locations. The dimension type must be Geo. You can specify at least one and at most five measures for the bubble size.
Colored map	Geo location and colorscale	You can specify only one dimension for geo locations. The dimension type must be Geo. You can specify at least one and at most five measures for the colorscale.

Chart type	Required data element	Data element description
Geo map	Geo location and colorscale	You can specify only one dimension for geo locations. The dimension type must be Geo. You can specify at least one and at most five measures for the colorscale.
Geo bubble map	Geo location and colorscale	You can specify only one dimension for geo locations. The dimension type must be Geo. You can specify at least one and at most five measures for the colorscale.
Cross table	Rows and columns	You can specify an unlimited number of dimensions for the rows and an unlimited number of measures for the columns.
Pivot chart	Rows and values	You can specify an unlimited number of dimensions for the rows and an unlimited number of measures for the columns.
Gauge	Pointer angle	You can specify only one measure for the pointer angle.
Progress bar	Pointer	You must specify at least one and at most five measures for the pointer.
Radar chart	Label and length	You must specify one or two dimensions for labels and at least one measure for the length.
Scatter chart	Color legend, x-axis, and y-axis	You can specify only one dimension for the color legend. The number of the dimension values is up to 1,000. You can specify at least one and at most three measures for the x-axis and only one measure for the y-axis.
Bubble chart	x-axis, y-axis, and bubble size	You can specify at least one dimension for the x-axis. The number of dimension values can be up to 1,000. You can specify only one measure for the y-axis and only one measure for the bubble size.

Chart type	Required data element	Data element description
Funnel chart	Tier label and tier area	You can specify only one dimension for the tier labels and only one measure for the tier areas.
Kanban	Label and metric	You can specify only one dimension for labels and at least one and at most 10 measures for the metrics.
Treemap	Rectangle label and rectangle size	You can specify only one dimension for the rectangle labels and only one measure for the rectangle sizes.
Polar diagram	Arc radius and label	You can specify only one dimension for labels and only one measure for the arc radius.
Word cloud	Word size and word	You can specify only one dimension for the word sizes and only one measure for the words.
Tornado-leaned funnel chart	Metrics for measures and dimensions	You must specify one dimension and one measure for data comparison.
Hierarchy chart	Node label and node metric	You must specify at least two dimensions for the node label and at least one measure for the node metric.
Flow analysis chart	Previous page, current page, next page, previous page PV, previous page UV, current page PV, current page UV, next page PV, next page UV, conversion rate, and bounce rate	You must specify one dimension and one measure for each data element.

5.4.2. Access a dashboard

This topic describes how to access a dashboard.

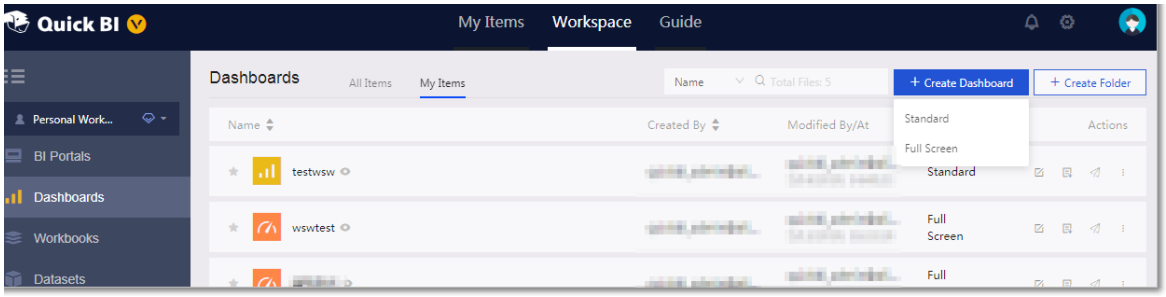
Prerequisites

The Quick BI service is purchased.

Procedure

1. Log on to the Quick BI console.
2. Click the **Workspace** tab.

3. In the left-side navigation pane of the Workspace page, click **Dashboards**.
4. Choose **Create Dashboard > Standard** to go to the dashboard.



5.4.3. Areas of a dashboard

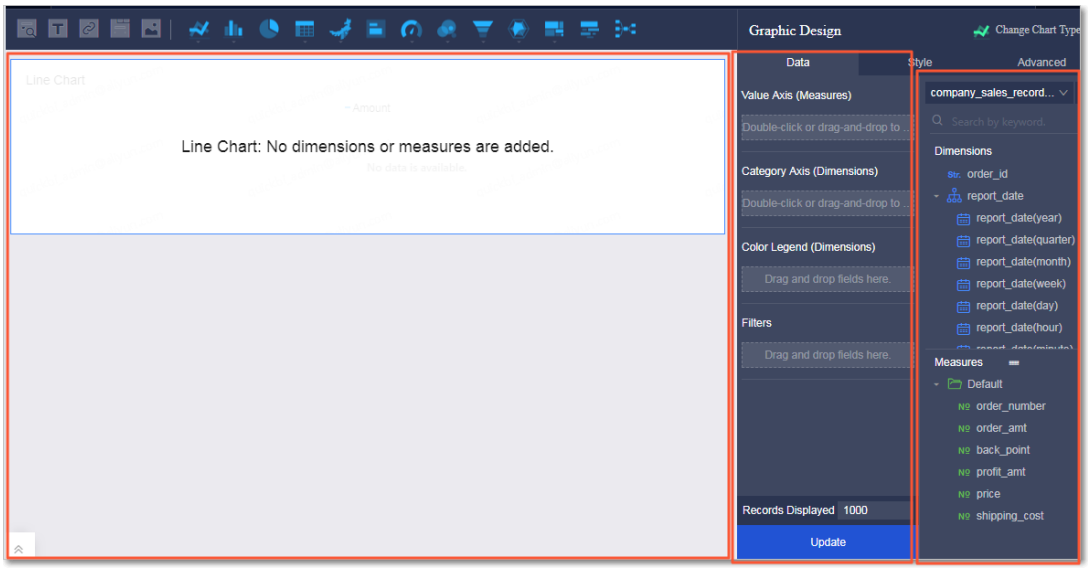
5.4.3.1. Overview

This topic describes the functional areas of a dashboard.

The dashboard edit page contains three areas, as shown in Dashboard.

- Dataset selection area
- Dashboard configuration area
- Dashboard display area

Dashboard



- Dataset selection area: In this area, you can switch the current dataset to another. The fields of each dataset are displayed in the respective Dimensions and Measures lists based on the data types preset in the system. You can select dimensions and measures based on the data elements in the chart.
- In the dashboard configuration area, you can select a chart type, and edit the title, layout, and legend position of a chart. On the Advanced tab, you can associate the current chart with other charts and display analysis results from multiple perspectives. You can also filter data by using filters, or insert a Filter Bar widget to query key data in a chart.
- Dashboard display area: In this area, you can drag charts to adjust their positions and

change chart types. For example, you can change a bar chart to a bubble map. The system displays information about missing or error elements. In the dashboard display area, you can save, preview, or create a dashboard. The dashboard provides instructions to help you learn how to create a dashboard.

5.4.3.2. Dataset selection area

5.4.3.2.1. Switch datasets

This topic describes how to switch datasets in a dashboard.

Prerequisites

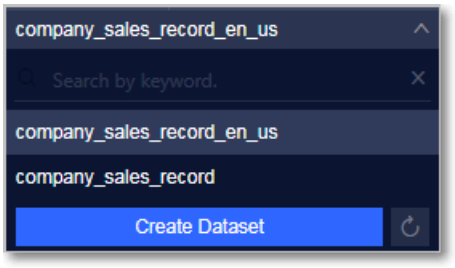
The Quick BI service is purchased.

Context

If you cannot find the required dataset in the drop-down list, go back to the dataset management page and ensure that you created the dataset. For information about how to create a dataset, see Create a dataset.

Procedure

1. Go to the target dashboard.
2. On the Data tab, click the **Switch Datasets** icon.
3. Select the target dataset from the drop-down list that appears.



5.4.3.2.2. Search for a dimension or measure

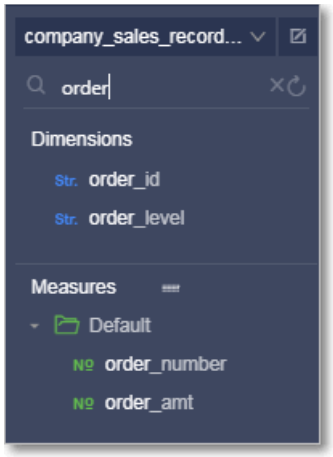
This topic describes how to search for a dimension or measure.

Prerequisites

The Quick BI service is purchased.

Procedure

1. Go to the target dashboard.
2. Enter a keyword of a field, such as **order**, in the search box.
3. Click the **Search** icon.



For information about how to edit dimensions and measures, see Edit a dimension and Edit a measure.

5.4.3.3. Dashboard graphic design area

5.4.3.3.1. Select fields

This topic describes how to select fields for a dataset.

Prerequisites

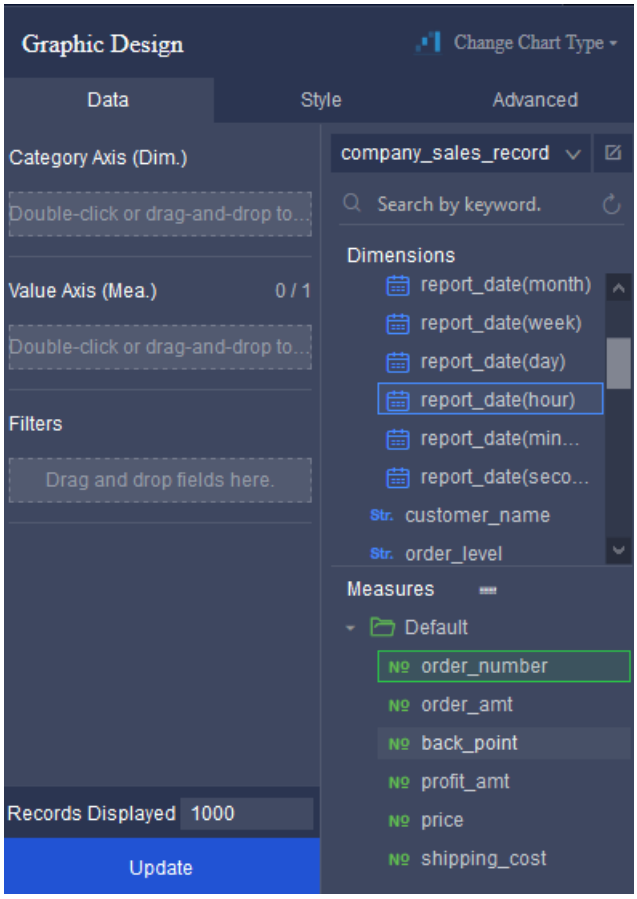
- The Quick BI service is purchased.
- A dataset is selected in the dataset selection area and is edited as needed. For information about how to edit a dataset, see Edit a dataset.

Context

Procedure

1. Go to the target dashboard.
2. Select a chart from the toolbar on the top of the dashboard.
3. Click the chart icon. The chart is created in the display area of the dashboard. If you want to change the chart type, click **Change Chart Type** in the Graphic Design area, and select the desired chart type.
4. On the **Data** tab, select the required fields, as shown in Select fields. Double-click a field to add it to the Dimensions or Measures list, or drag the field to the target list.

Select fields



- If you want to delete a field, click the Delete icon next to the field.
- If you want to sort the values of a field, click the ascending or descending icon next to the field.

5. Click **Update**. The chart is updated.

5.4.3.3.2. Color legend

This topic describes how to use the color legend.

Prerequisites

- The Quick BI service is purchased.
- A dataset is selected in the dataset selection area and is edited as needed. For information about how to edit a dataset, see Edit a dataset.

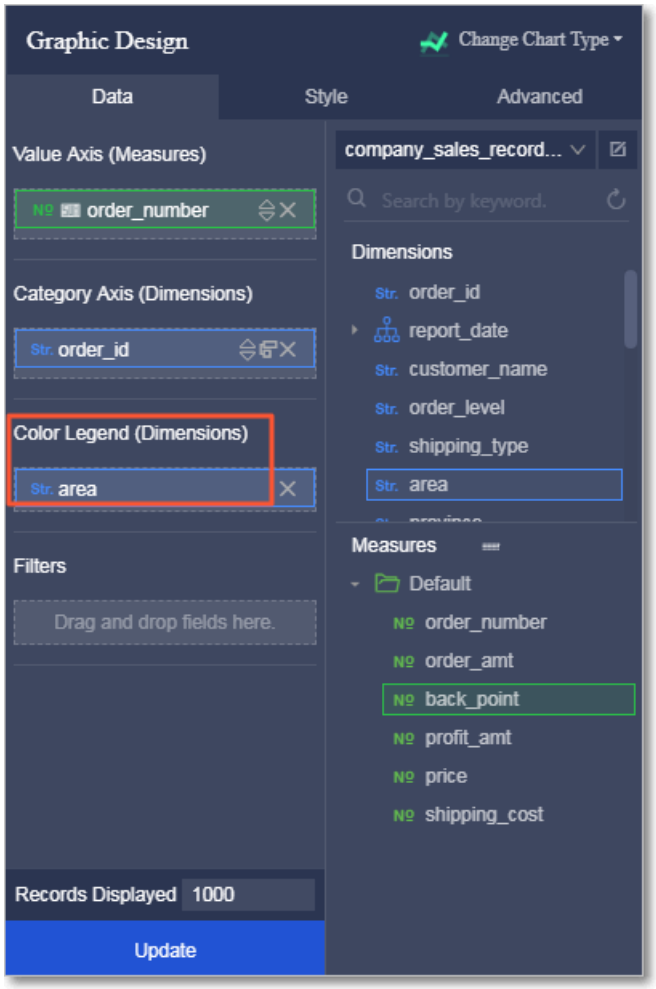
Context

The color legend feature displays the values of the selected field in different colors in a chart.

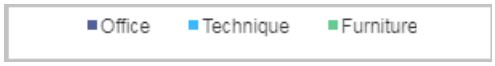
Only dimensions can be added to the Color Legend field.

Procedure

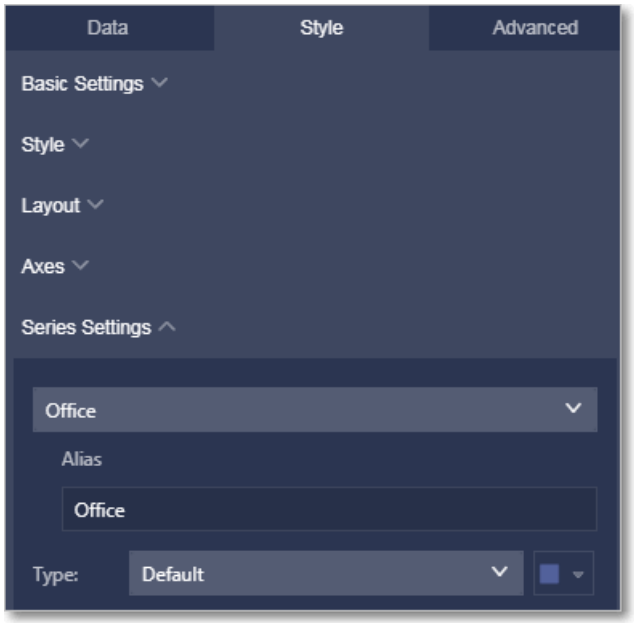
1. Go to the target dashboard.
2. Drag a dimension, such as product_type, to the **Color Legend** field.



3. Click **Update**. The values of the field are displayed in different colors in the chart.



4. Change legend colors in the **Series Settings** section on the **Style** tab.



5.4.3.3.3. Sort field data

This topic describes how to sort data on the **Data** tab.

Prerequisites

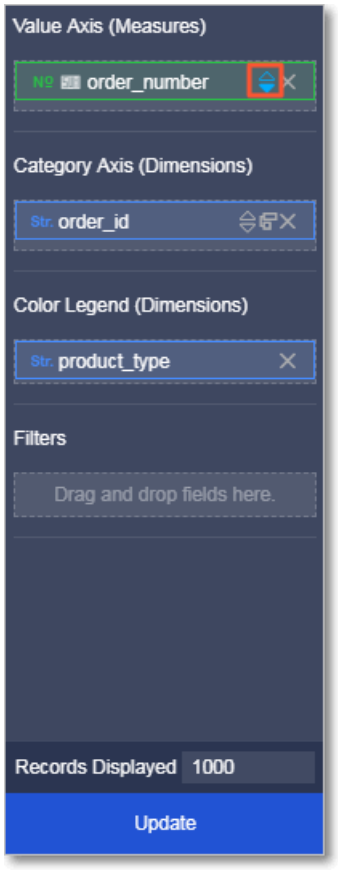
- The Quick BI service is purchased.
- A dataset is selected in the dataset selection area and is edited as needed. For information about how to edit a dataset, see Edit a dataset.

Procedure

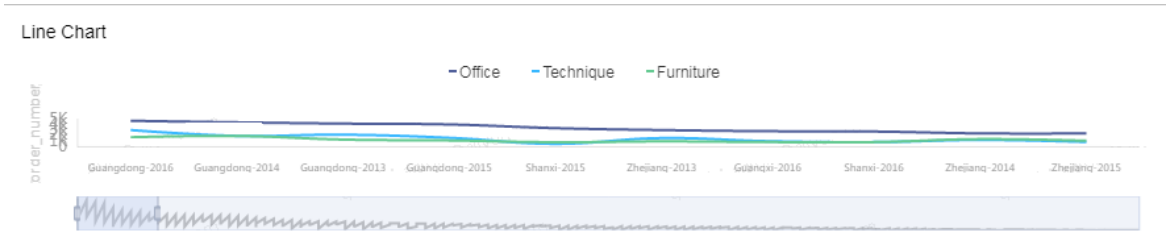
1. Go to the target dashboard.
2. Select a field, such as order_number.
3. Click the triangle icon next to the field, as shown in Set the sorting order.

   The upward arrow indicates ascending order, and the downward arrow indicates descending order.

   Set the sorting order



4. After you specify the sorting order, click **Update**.



5.4.3.3.4. Filter field data

This topic describes how to filter field data by using the set filter feature.

Prerequisites

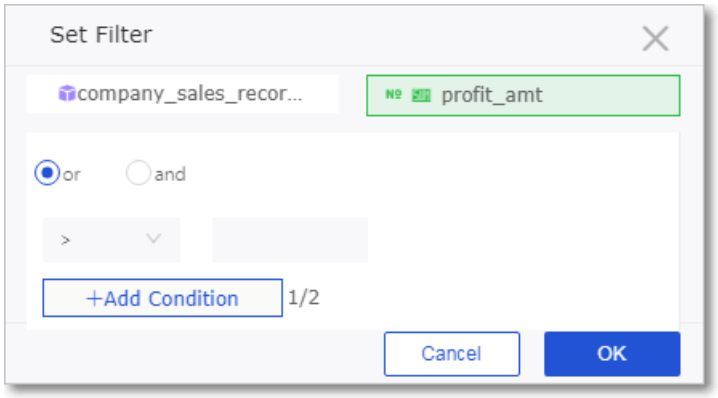
- The Quick BI service is purchased.
- A dataset is selected in the dataset selection area and is edited as needed. For information about how to edit a dataset, see Edit a dataset.

Context

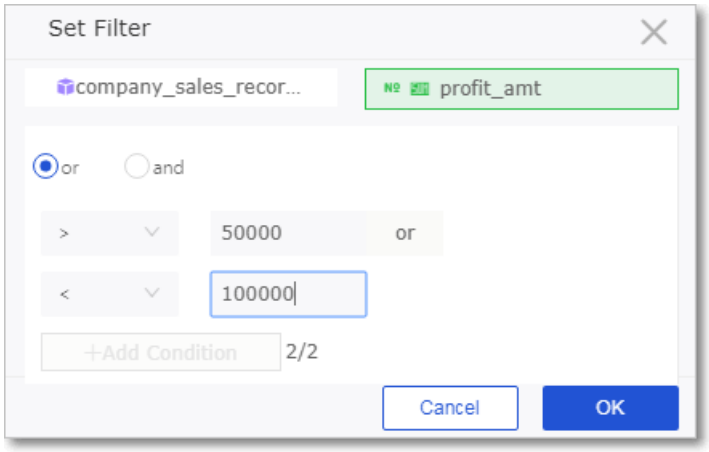
This topic takes the profit_amt field as an example to show how to filter data by using the set filter feature.

Procedure

1. Go to the target dashboard.
2. Drag profit_amt to the Filters field.
3. Click the **Filter** icon. The **Set Filter** dialog box appears.



4. Select a filter condition, such as greater than, less than, or equal to.



5. After you set the parameters, click **OK**.
6. Click **Update**. The chart is updated.

5.4.3.3.5. Filter interaction

You can use the filter interaction feature after you create multiple charts on a dashboard. This topic describes the filter interaction feature.

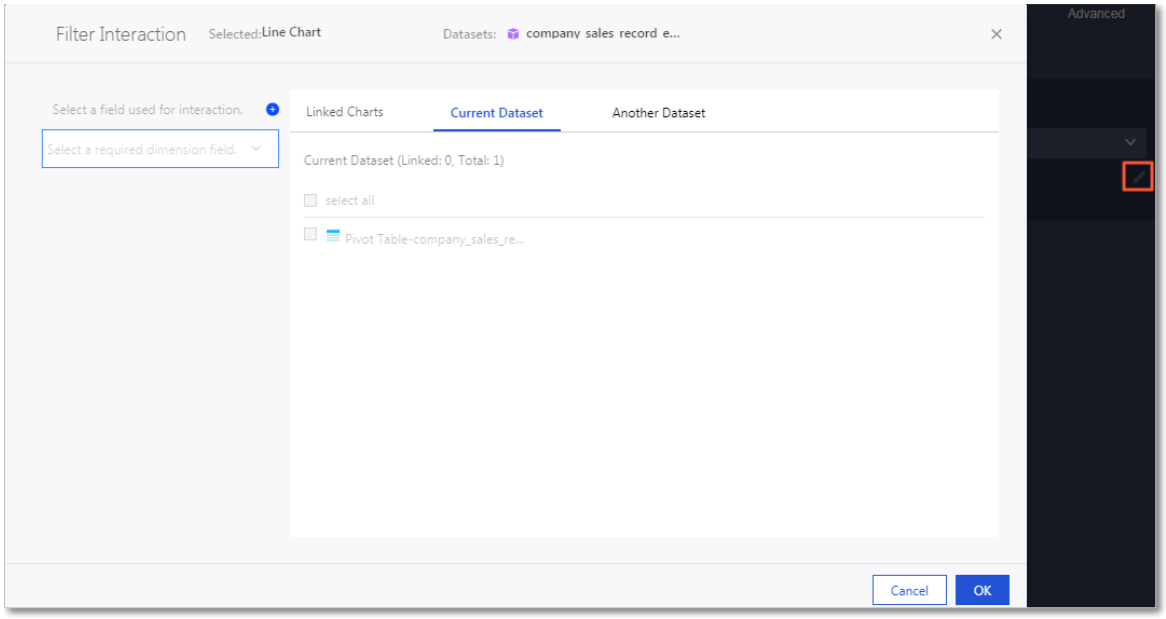
Prerequisites

- The Quick BI service is purchased.
- At least two charts are available in the display area of a dashboard.

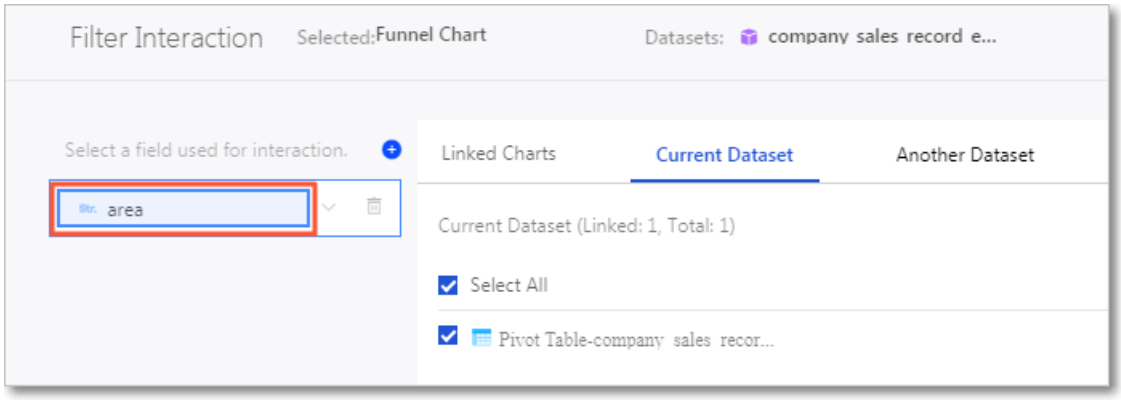
Procedure

1. Go to the target dashboard.
2. Select a chart, such as a funnel chart.
3. In the Graphic Design area, click the **Advanced** tab.
4. On the **Advanced** tab, click the **Pencil** icon next to Filter Interaction. The **Filter Interaction** dialog box appears.

   In the **Filter Interaction** dialog box, all available charts are displayed.

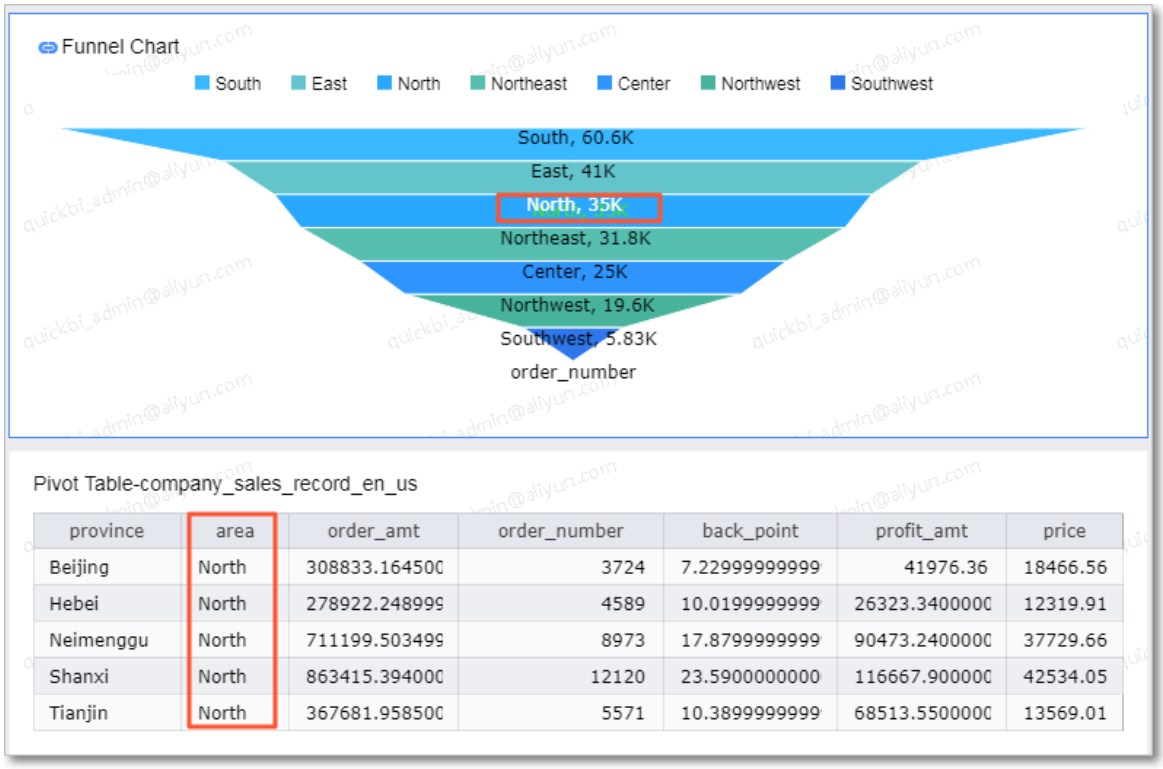


5. Select the same fields as the filter fields from the available charts to associate these charts, and click **OK**.



6. In the upper-right corner of the dashboard, click **Preview** to preview the current dashboard.

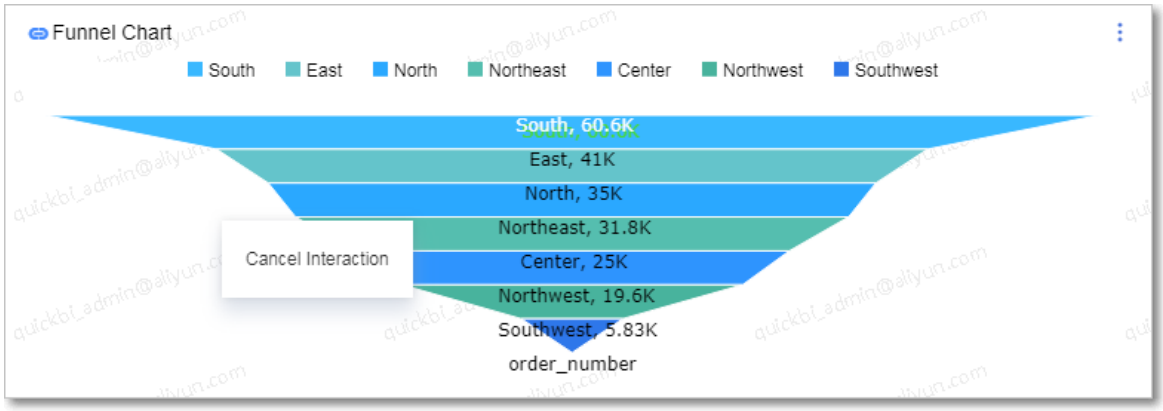
7. Click **North** in the funnel chart. The associated cross table displays data of the North China region.



Pivot Table-company_sales_record_en_us

province	area	order_amt	order_number	back_point	profit_amt	price
Beijing	North	308833.164500	3724	7.22999999999	41976.36	18466.56
Hebei	North	278922.248999	4589	10.0199999999	26323.3400000	12319.91
Neimenggu	North	711199.503499	8973	17.8799999999	90473.2400000	37729.66
Shanxi	North	863415.394000	12120	23.5900000000	116667.900000	42534.05
Tianjin	North	367681.958500	5571	10.3899999999	68513.5500000	13569.01

8. Move your pointer to any blank area in the funnel chart, and click **Cancel Interaction** to disable the filter interaction feature.



5.4.3.3.6. Metric analysis

This topic describes four methods of analysis: auxiliary line, trendline, prediction, and anomaly detection.

Prerequisites

- The Quick BI service is purchased.
- A dataset is selected in the dataset selection area and is edited as required.
- Go to the target dashboard.

Background

- Metric analysis allows you to analyze data from multiple perspectives. You can use this feature to

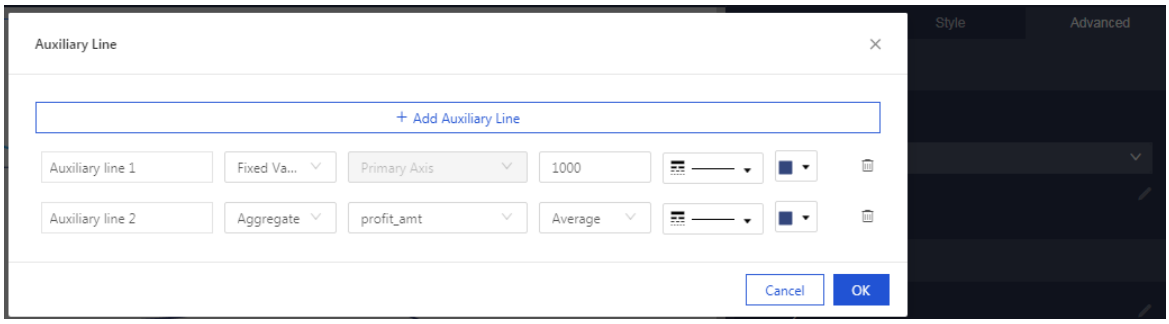
learn about data trends and anomalies.

- Metric analysis supports four methods of analysis: auxiliary line, trendline, prediction, and anomaly detection.

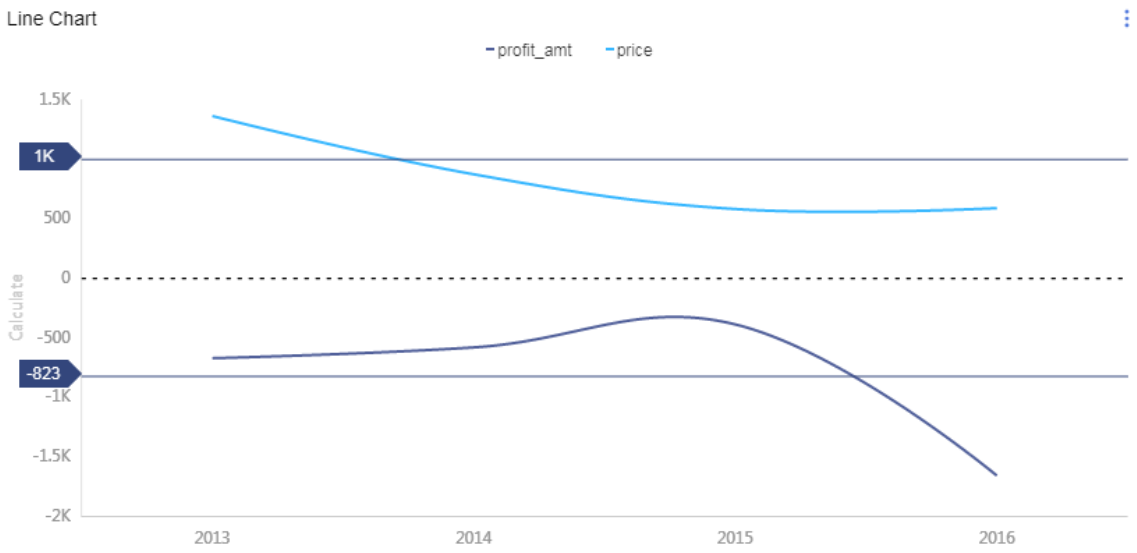
Auxiliary line

You can add an auxiliary line to view the difference between the value of a measure and the value shown by the auxiliary line. The value shown by an auxiliary line is either a fixed value or an aggregate value. Aggregate values includes average, maximum, minimum, and median values.

1. On the **Advanced** tab of the **Graphic Design** page, click next to **Auxiliary line** in the **Metric Analysis** section.
2. In the **Auxiliary Line** dialog box, click Add Auxiliary Line. Select a value type for the auxiliary line you want to create.



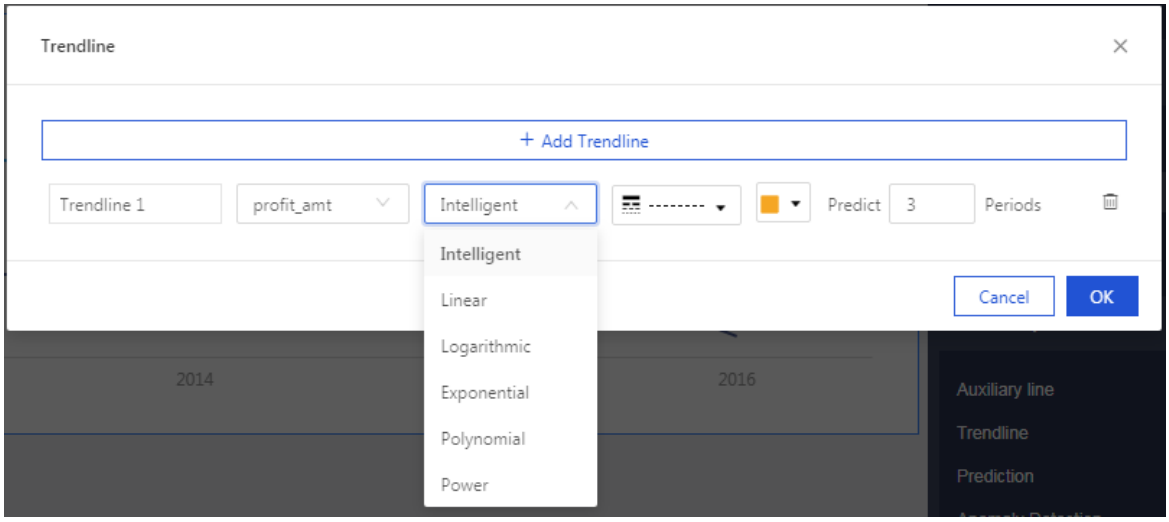
3. Click **OK**. The following figure shows a sample trendline.



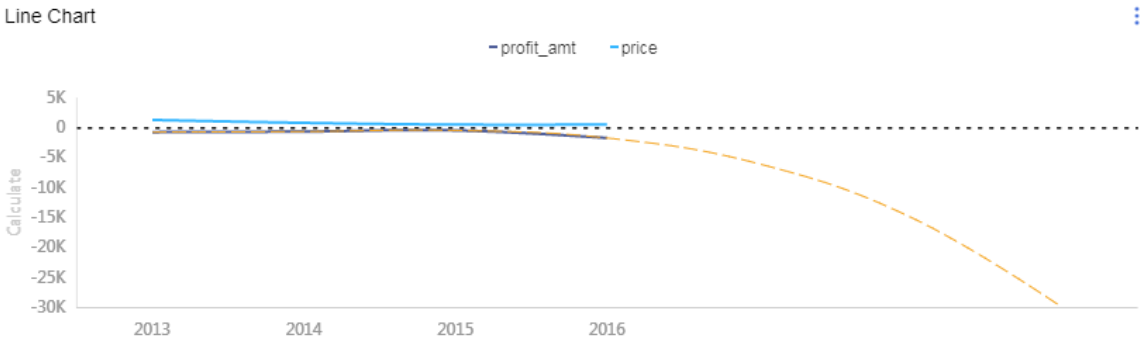
Trendline

A trendline displays data trends. Types of trendlines include Intelligent, Linear, Logarithmic, Exponential, Polynomial, and Power.

1. On the **Advanced** tab of the **Graphic Design** page, click next to **Trendline** in the **Metric Analysis** section.
2. In the **Trendline** dialog box, click Add Trendline. Select a measure, a trendline type, and the number of subsequent periods for which to predict trends.



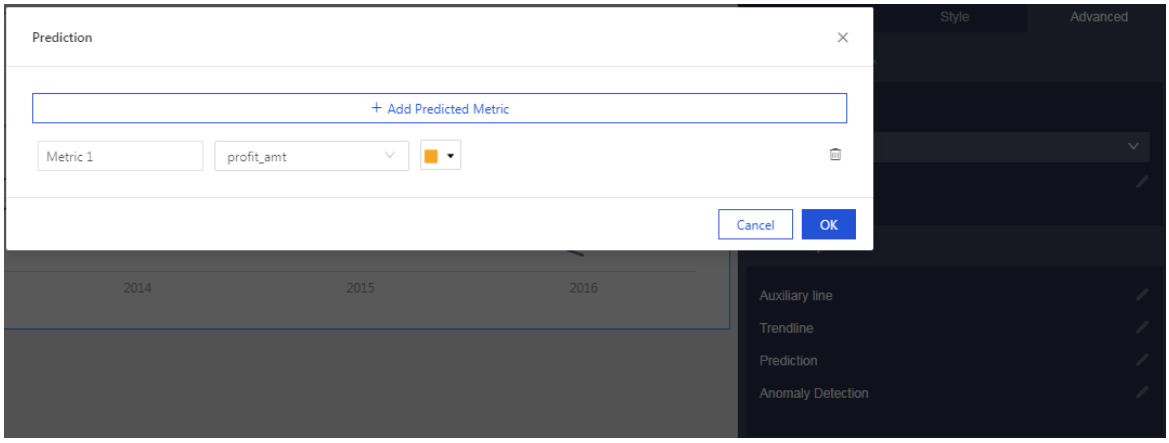
3. Click **OK**. The following figure shows a sample trendline.



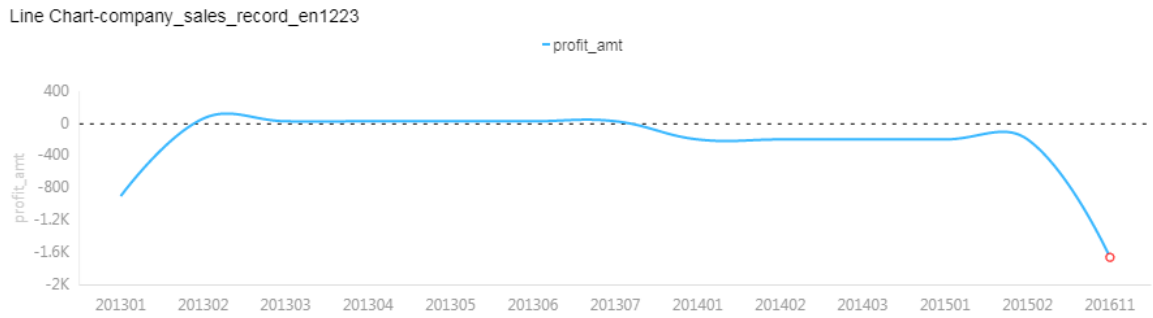
Prediction

You can add a predicted metric to view the trend of current data and predict future trends.

1. On the **Advanced** tab of the **Graphic Design** page, click next to **Prediction** in the **Metric Analysis** section.
2. In the **Prediction** dialog box, click Add Predicted Metric. Select a measure and a color for the line.



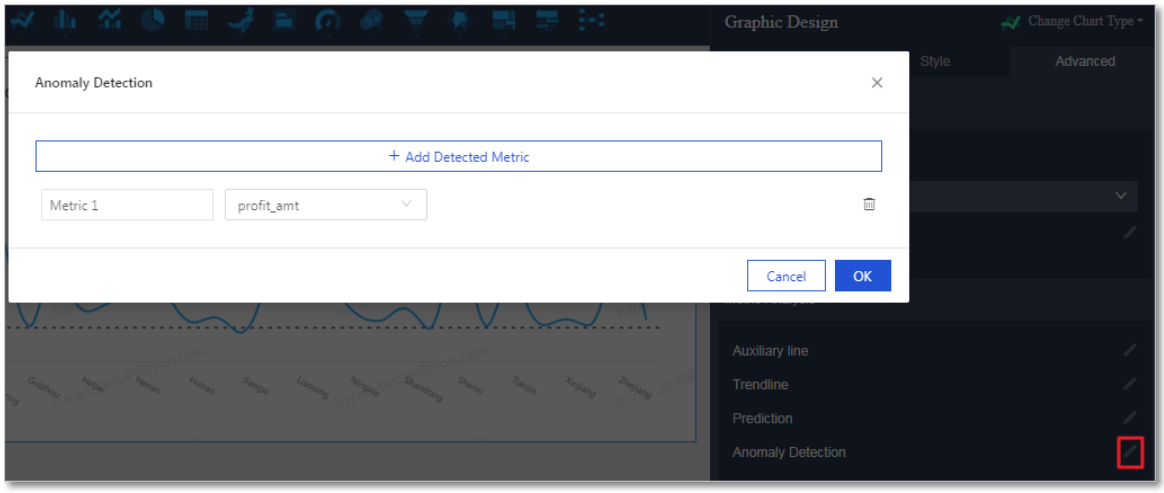
3. Click **OK**. The following figure shows sample prediction results.



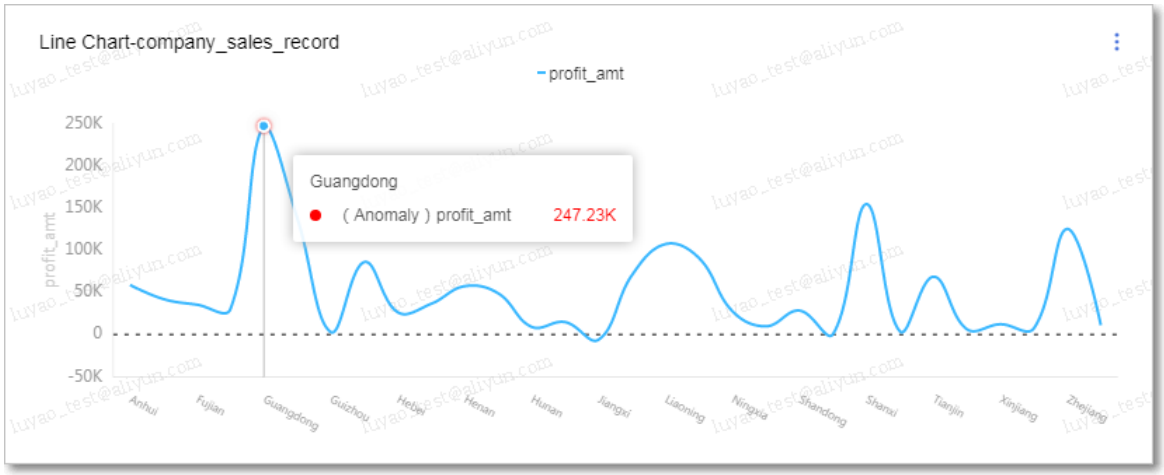
Anomaly Detection

You can add an anomaly detection metric to detect data anomalies.

1. On the **Advanced** tab of the **Graphic Design** page, click next to **Anomaly Detection** in the **Metric Analysis** section.
2. In the **Anomaly Detection** dialog box, click Add Detected Metric. Select a measure.



3. Click **OK**. The following figure shows sample anomaly detection results.



> **Note** In a line chart, anomalies are represented as red dots. In a bar chart, anomalies are represented as red vertical bars.

5.4.3.4. Dashboard display area

5.4.3.4.1. Overview

This topic describes the features of the dashboard display area.

In the display area of a dashboard, you can perform the following operations on one or more charts:

- Adjust chart positions
- View chart data
- Change chart types
- Add to favorites
- Delete a chart

5.4.3.4.2. Toolbar

This topic describes the features of the toolbar.

The toolbar of a dashboard allows you to save, preview, and edit the dashboard, as shown in Dashboard toolbar.

Dashboard toolbar

5.4.3.4.3. Adjust chart positions

Multiple charts may be displayed on the same dashboard. In this case, you can drag the charts to adjust their positions.

Prerequisites

The Quick BI service is purchased.

Procedure

1. Go to the target dashboard.
2. Select a chart or widget.
3. Drag the chart or widget to the desired position.

> **Note** You can drag a chart or widget to anywhere within the display area of the dashboard.

5.4.3.4.4. View chart data

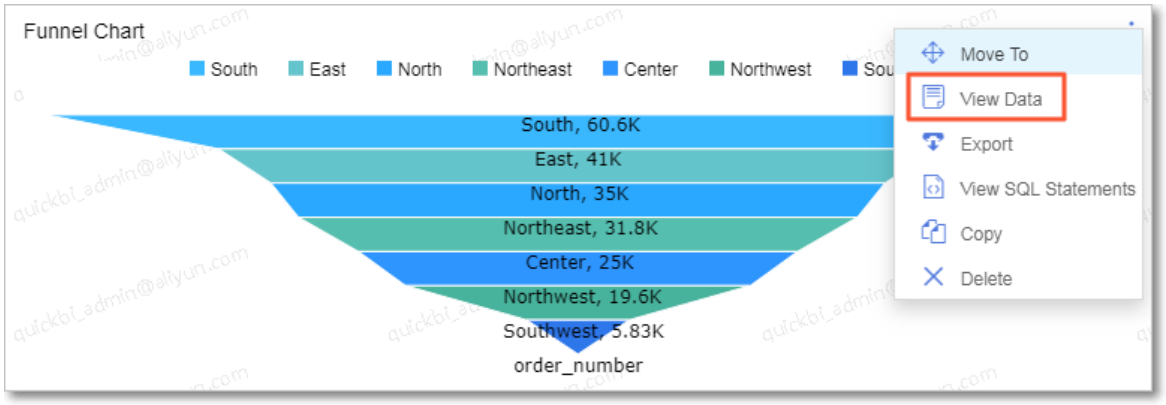
This topic describes how to view chart data.

Prerequisites

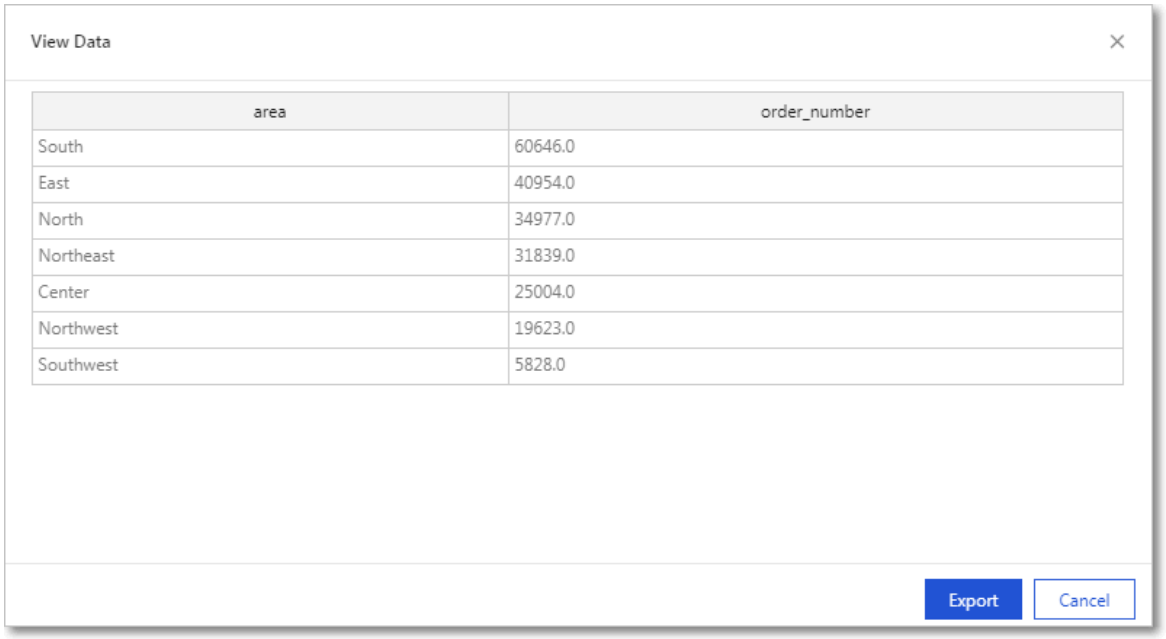
The Quick BI service is purchased.

Procedure

1. Go to the target dashboard.
2. Select a chart, for example, a funnel chart.
3. Click the More icon in the upper-right corner of the chart.
4. Select **View Data** to view data items in the chart.



5. Select **Export** to download data to a local PC.



5.4.3.4.5. Change chart types

You can select different chart types from the toolbar on the top of the dashboard. This topic describes how to change chart types.

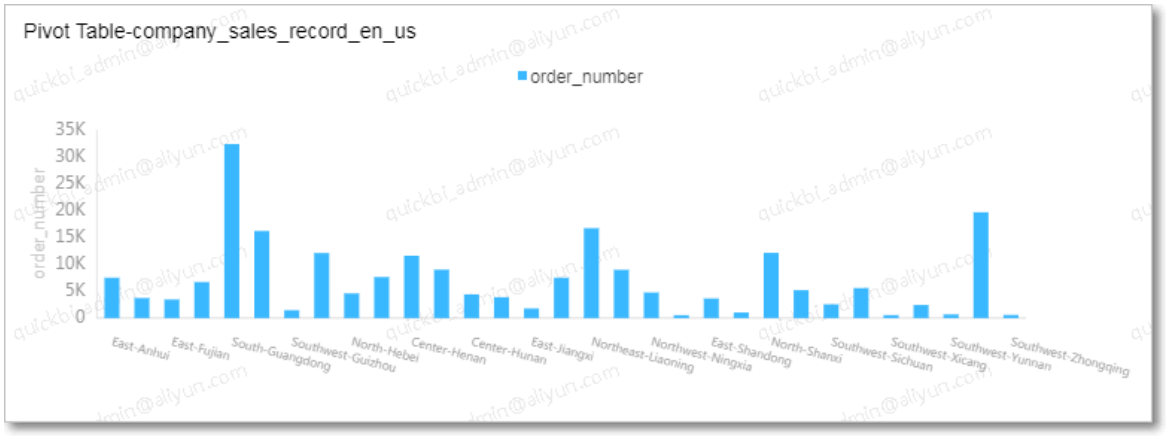
Prerequisites

The Quick BI service is purchased.

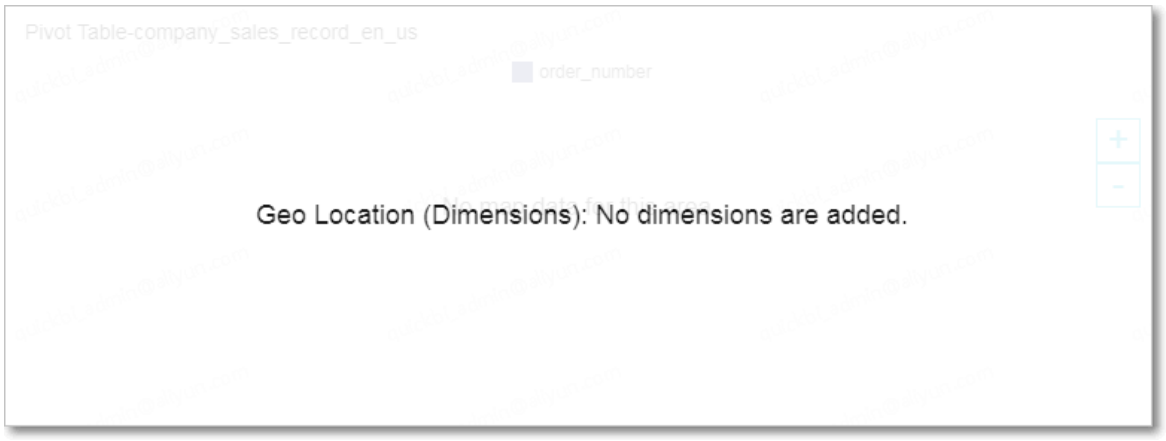
Procedure

1. Go to the target dashboard.
2. Select a chart, such as a cross table.
3. In the Graphic Design area, click **Change Chart Type** and select the required type, such as a vertical bar chart.
4. Click the **Vertical Bar Chart** icon to change the chart type.

   The system then converts the cross table to a vertical bar chart.



If the switch between chart types fails, the elements of the selected chart type do not match those of the current chart type. You need to modify the problematic data fields based on the requirements of the selected chart type.



You can follow the instructions to adjust the dimensions and measures to change the chart type.

5.4.3.4.6. Add to Favorites

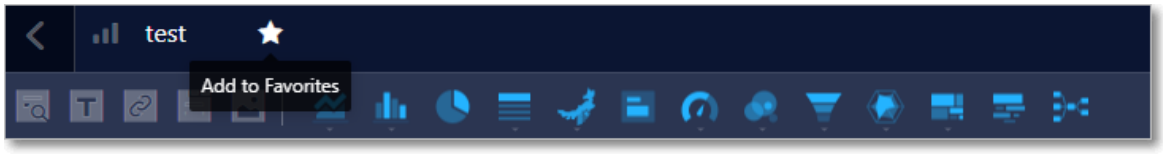
This topic describes how to add a dashboard to the Favorites tab.

Prerequisites

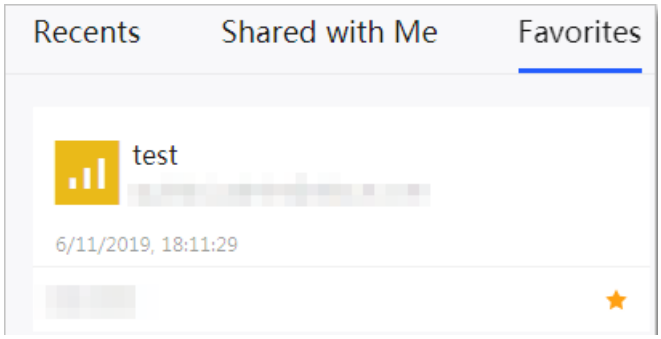
The Quick BI service is purchased.

Procedure

1. Go to the target dashboard.
2. On the top of the dashboard, click the **Add to Favorites** icon.



3. On the Quick BI homepage, you can click the **Favorites** tab to view the dashboards that you have added.



5.4.3.4.7. Delete a chart

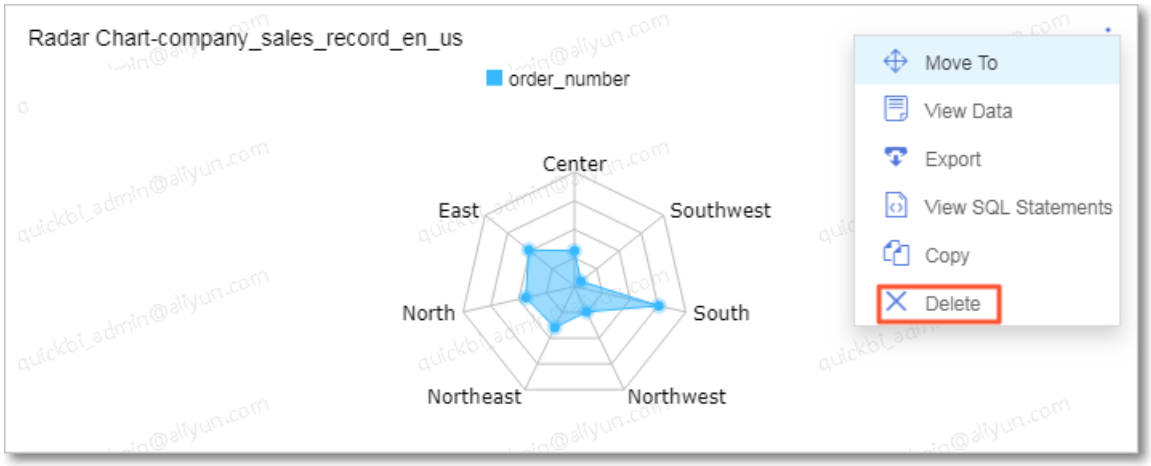
This topic describes how to delete a chart.

Prerequisites

The Quick BI service is purchased.

Procedure

1. Go to the target dashboard.
2. Select a chart, such as a radar chart.
3. Click the **More** icon in the upper-right corner of the chart.
4. Select **Delete**.



5.4.3.4.8. Widgets

5.4.3.4.8.1. Overview

This topic describes the widgets of a dashboard.

The display area of a dashboard provides the following widgets:

- Filter Bar
- Text Area
- IFrame
- Tab
- Image

5.4.3.4.8.2. Filter bar

5.4.3.4.8.3. Expanded filter bar

5.4.3.4.8.4. Text Area

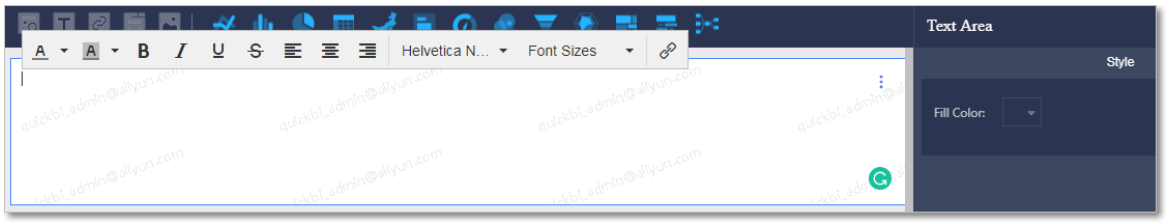
The Text Area widget allows you to enter text into a text area, for example, a title for a chart.

Prerequisites

The Quick BI service is purchased.

Procedure

1. Go to the target dashboard.
2. Click the **Text Area** icon.
3. Enter text in the text box.



5.4.3.4.8.5. IFrame

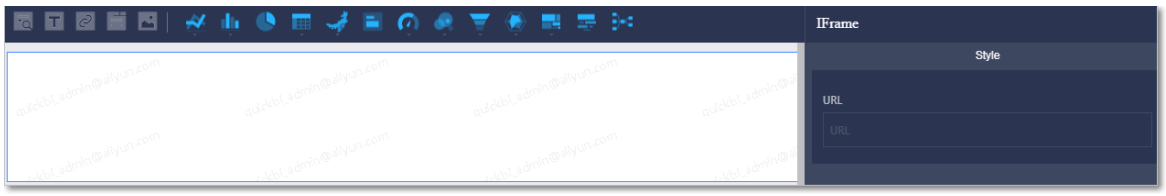
You can use the IFrame widget to insert web pages to query Internet data or browse web pages or websites related to the data on the current dashboard in real time.

Prerequisites

The Quick BI service is purchased.

Procedure

1. Go to the target dashboard.
2. Click the **IFrame** icon.
3. In the URL input box, enter the address of the web page you want to visit.



Note The web page address must start with https.

If you want to delete the current IFrame widget, click the **More** icon in the upper-right corner of the **IFrame** widget and select **Delete**.

5.4.3.4.8.6. Tab

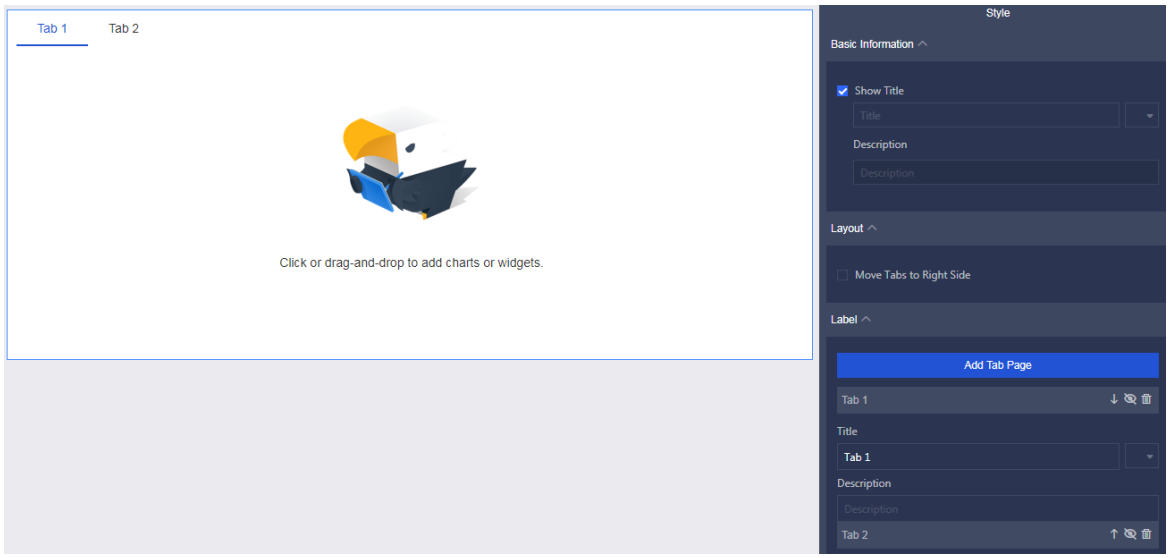
The tab widget enables you to display charts as tabs on a dashboard.

Prerequisites

The Quick BI service is purchased.

Procedure

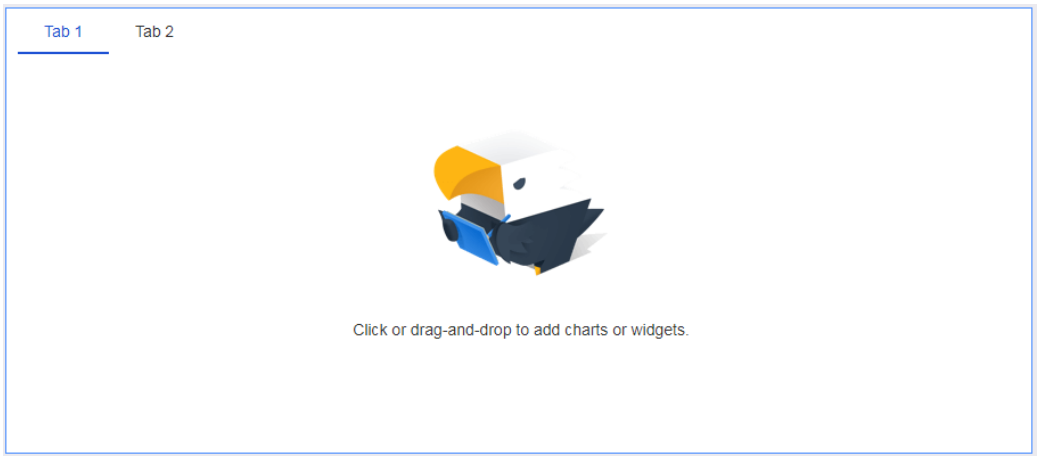
1. Go to the target dashboard.
2. Click the Tab icon.
3. Click the **Style** tab. Click **Add Tab Page** in the **Label** field.



4. Select a tab where you want to add charts, as shown in Tabs.

   Click **Tab 1**. The tab name **Tab 1** becomes blue.

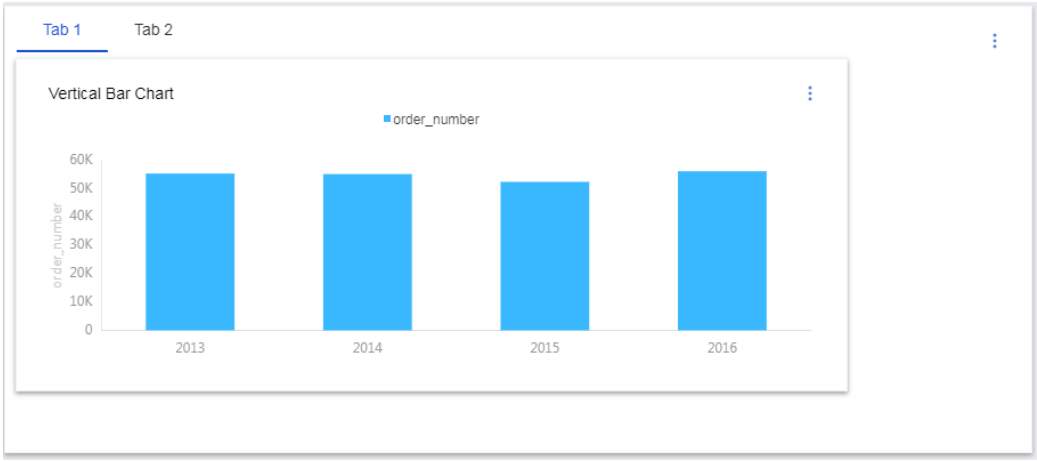
   Tabs



5. Click a chart icon to add a chart to Tab 1.

Add and configure a chart. Sample tab shows the tabs.

Sample tab



If you want to delete the current tab widget, click the **More** icon in the upper-right corner of the tab, and click **Delete**.

5.4.3.4.8.7. Image

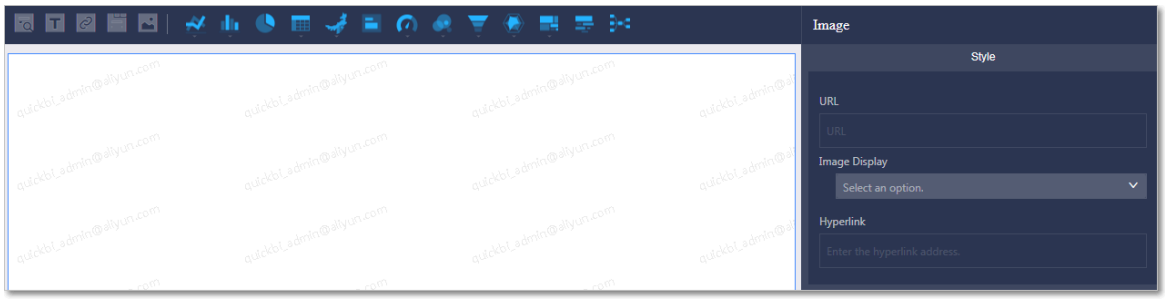
The Image widget allows you to insert images into a dashboard. You can adjust the image position and display effects as needed.

Prerequisites

The Quick BI service is purchased.

Procedure

1. Go to the target dashboard.
2. Click the **Image** icon.
3. In the Style field, enter the URL and hyperlink of the image, and specify **Image Display**.



5.4.4. Create a chart on the dashboard

5.4.4.1. Create a line chart

A line chart shows the correlation and changes between multiple groups of data over time. You can analyze the sales volume of a group of products or multiple groups of products over an amount of time to obtain a forecast of sales trends.

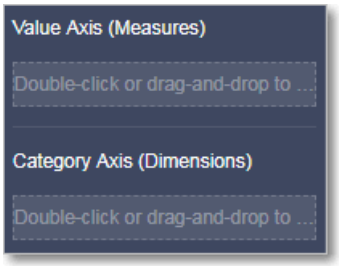
Prerequisites

- The Quick BI service is purchased.
- A dataset is created.

Context

A line chart consists of a category axis and value axis. The category axis is horizontal and determined by dimensions, such as date, province, and product type. The value axis is vertical and determined by measures, such as order amount and performance metrics.

The system automatically matches dimensions to the category axis, and measures to the value axis. Follow the instructions to add fields.



You must specify at least one dimension to determine the category axis and at least one measure to determine the value axis. You can also specify one dimension to determine the legend.

> **Note** The color legend is applicable only when the value axis has one measure.

The following example uses the company_sales_record dataset to describe how to use a line chart to demonstrate the order quantity of each type of products in each province every year.

Procedure

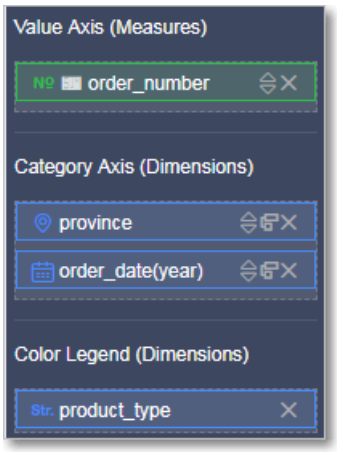
1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** tab, click **Datasets** to go to the Datasets page.
3. Find the company_sales_record dataset, click the **Create Dashboard** icon in the Actions column, select **Standard** in the dialog box that appears, and click **OK**.
4. On the dashboard edit page, click the **Line Chart** icon.
5. On the **Data** tab, select required dimensions and measures.

   In the Dimensions list, find and add the **order_date(year)** and **province** dimensions to the Category Axis (Dimensions) field. In the Measures list, find and add the **order_number** measure to the Value Axis (Measures) field, as shown in Specify fields for the line chart.

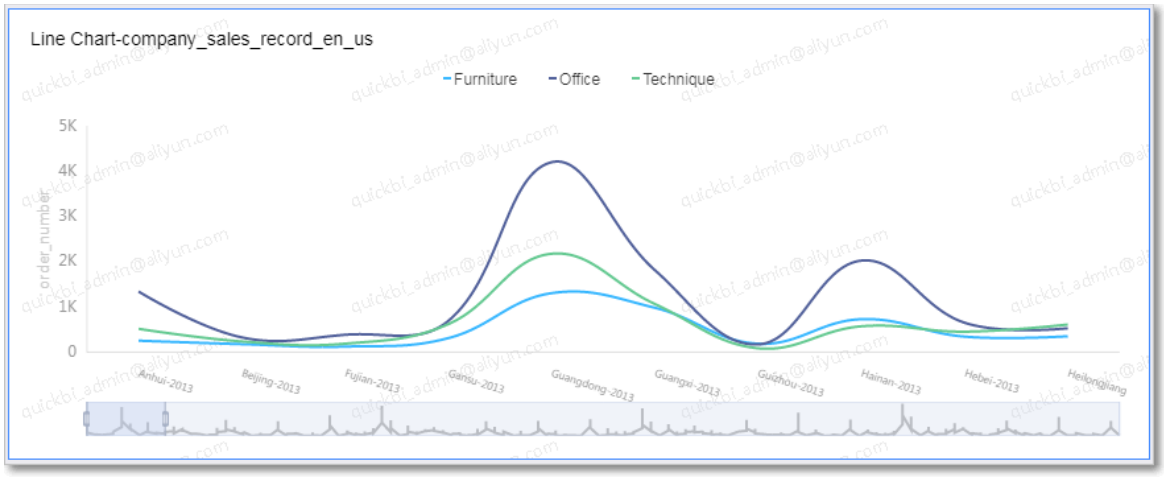
   > **Note** Ensure that you have converted the dimension type of province from String to Geo.

   For information about how to convert a dimension type, see Edit a dimension.

   Specify fields for the line chart

6. Find and add the **product_type** dimension to the **Color Legend (Dimensions)** field.
7. Click **Update**. The chart is updated.
8. Click the **Style** tab, and change the title, layout, and legend position.



9. Click **Save** in the upper-right corner on the dashboard edit page to save the dashboard.

   If you want to delete the chart, click the **More** icon in the upper-right corner of the chart and select **Delete**.

5.4.4.2. Create an area chart

An area chart shows data change trends at equal intervals with different sizes of area. In addition, you can use an area chart to analyze the interactions between multiple groups of data that changes over time. For example, analyze the sales volume of a group of products or multiple groups of products that change over time to forecast future sales volume.

An area chart consists of a category axis and value axis. The category axis is horizontal and determined by dimensions, such as date, province, and product type. The value axis is vertical and determined by measures, such as order quantity and performance metrics.

The system automatically matches dimensions with the category axis and measures with the value axis. You only need to follow the instructions to add fields.

Notes

You must specify at least one dimension to determine the category axis, and at least one measure to determine the value axis. If you need to use the color legend, specify only one dimension for the color legend.

> **Note** The legend is applicable only when the value axis has one measure.

The following example uses the company_sales_record dataset to describe how to use an area chart to demonstrate the order quantity of each product type in different provinces.

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** tab, click **Datasets** to go to the Datasets page.
3. Find the company_sales_record dataset, click the **Create Dashboard** icon in the Actions column, select **Standard** in the dialog box that appears, and click OK.
4. On the dashboard edit page, click the **Area Chart** icon. An area chart is created in the display area of the dashboard.
5. Select required dimensions and measures.

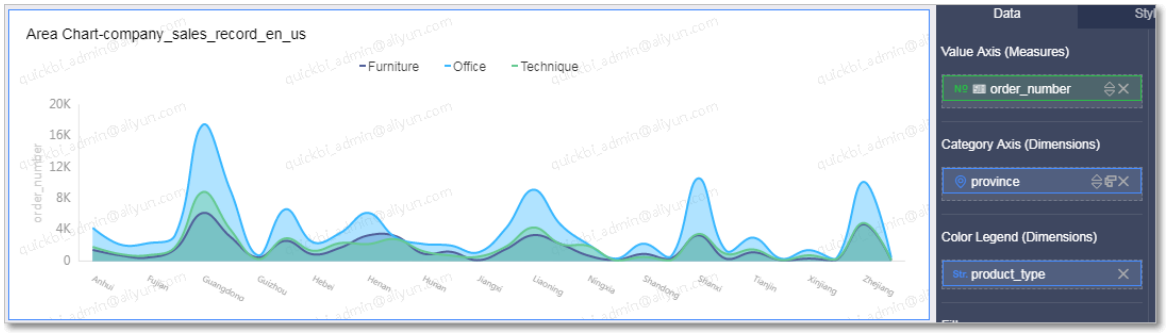
In the Dimensions list, find and add the **province** dimension to the Category Axis (Dimensions) field. In the Measures list, find and add the **order_number** measure to the Value Axis (Measures) field.

> **Note** Ensure that you have converted the dimension type of province from String to Geo.

6. Drag the **product_type** dimension to the Color Legend (Dimensions) field. Click **Update**.

> **Note** The legend is applicable only when the value axis has one measure.

7. Click the **Style** tab, and change the title, layout, legend position, and axis style of the chart, as shown in the following figure.



> **Note** You can switch to another area chart type, such as stacked area chart, 100% stacked area chart, or stacked line chart.

8. Click **Save** in the upper-right corner to save the dashboard.

If you want to delete the chart, click the **More** icon in the upper-right corner of the chart and select **Delete**.

5.4.4.3. Create a vertical bar chart

A vertical bar chart demonstrates data changes over a period of time or comparisons among discrete categories. For example, you can use a vertical bar chart to show the traffic flow over different periods of time at a crossing.

Prerequisites

- The Quick BI service is purchased.
- A dataset is created.

Context

Similar to a line chart, a vertical bar chart consists of a category axis and value axis. You can use a vertical bar chart to show data changes over a specific period of time or differences among multiple objects.

This topic uses the following scenarios to describe how to use the filter and the Dual Y-Axis function in a vertical bar chart.

- Scenario 1: Compare the shipping costs for different products in provinces in the East China region.
- Scenario 2: Compare the order quantities and average profits of different products in different

provinces.

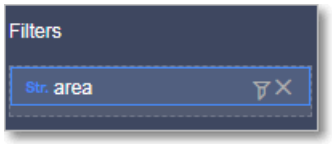
You must specify at least one dimension, such as **province** and **product_type**, for the category axis. You must specify at least one measure, such as **order_number** and **profit_amt**, for the value axis. You can specify only one dimension for the color legend.

> **Note** The legend is applicable only when the value axis has one measure.

Procedure

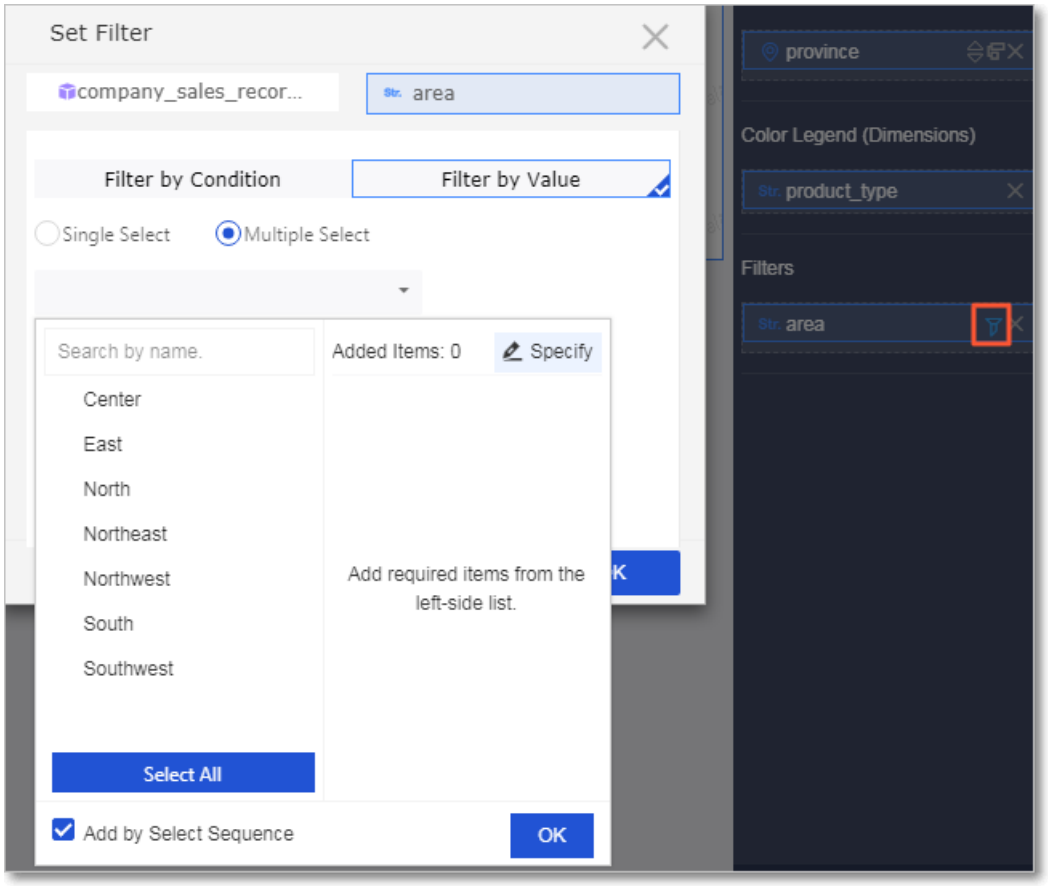
1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** tab, click **Datasets** to go to the Datasets page.
3. Find the company_sales_record dataset, click the **Create Dashboard** icon in the Actions column, select **Standard** in the dialog box that appears, and click OK.
4. On the dashboard edit page, click the **Vertical Bar Chart** icon. Scenario 1: The following example uses the company_sales_record dataset to describe how to use a vertical bar chart to compare the shipping costs for different products in provinces in the East China region.
   i. In the Dimensions list, find and add the area dimension to the Filters field, as shown in Filter. You can use the filter to filter data of **East China**.

      Filter

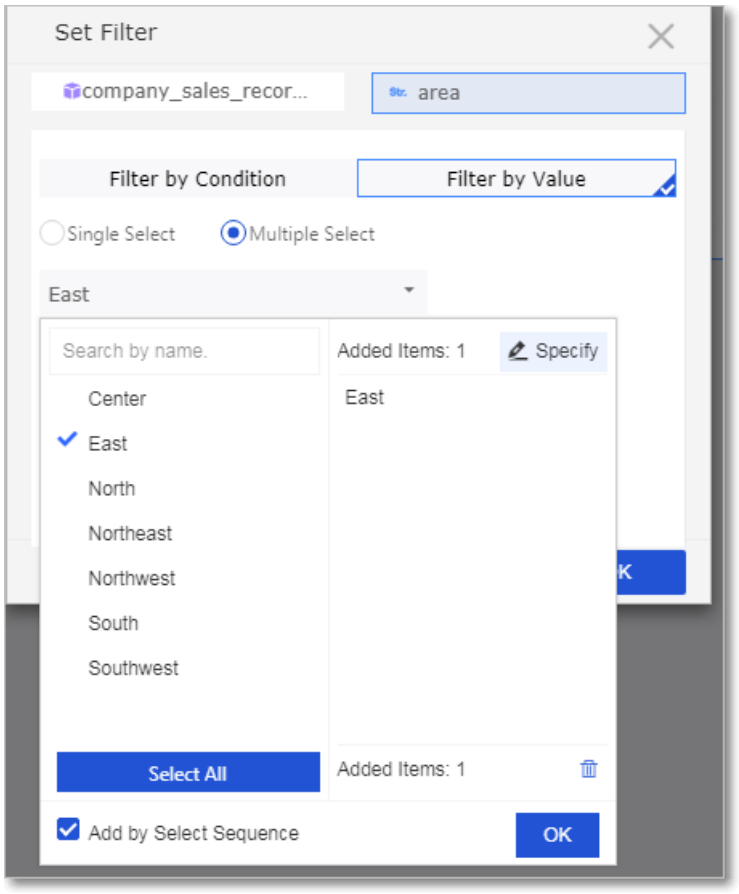
      

   ii. Click the **Filter** icon to set filter conditions.

iii. Select Filter by Value and **Multiple Select**. The system automatically lists all available options.



iv. Select **East** and click **OK**.



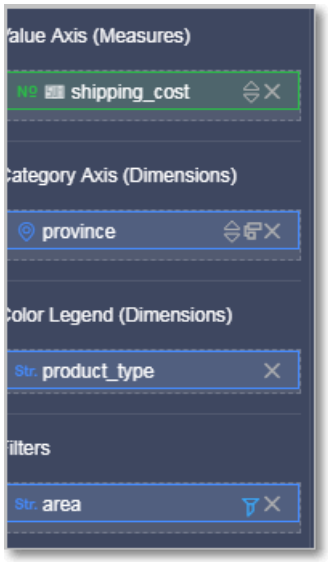
v. In the Dimensions list, find and add the **province** and **product_type** dimensions to the Category Axis (Dimensions) field.

vi. In the Measures list, find and add the **shipping_cost** measure to the Value Axis (Measures) field.

> **Note** Ensure that you have converted the dimension type of province from String to Geo.

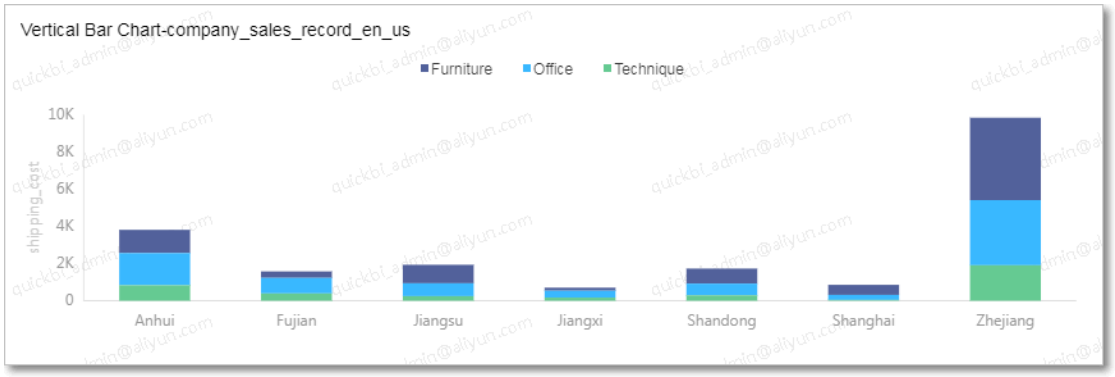
For information about how to convert a dimension type, see Edit a dimension.

vii. Drag **product_type** from the Category Axis (Dimensions) field to the **Color Legend (Dimensions)** field.



viii. Click **Update**. The chart is updated.

ix. Click the **Style** tab, and select **Stacked** under Chart Type.

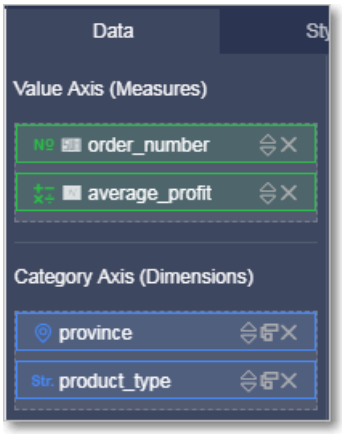


Scenario 2: The following example uses the company_sales_record dataset to describe how to use a vertical bar chart to compare the order quantities and average profits of different products in different provinces.

> **Note**
>
> Data modeling may be required in this scenario. For information about data modeling, see Add a calculated field.

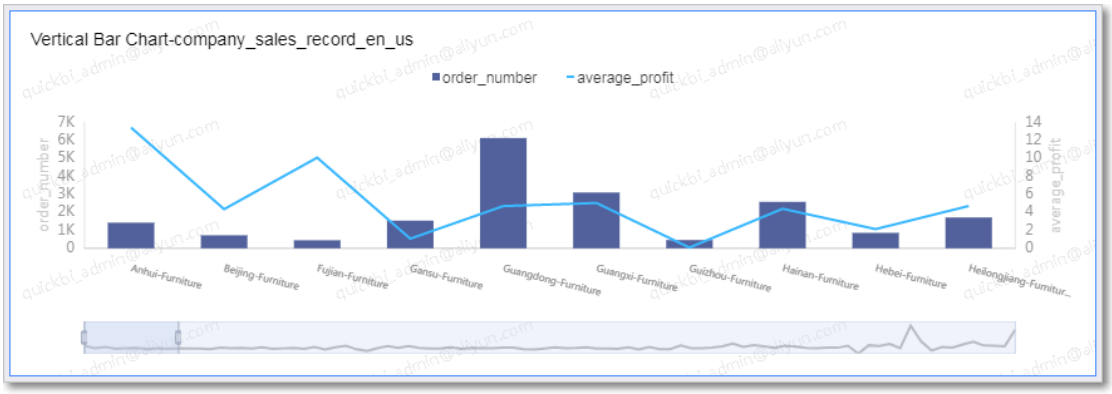
i. On the **Data** tab, select required dimensions and measures.

In the Dimensions list, find and add the **province** and **product_type** dimensions to the Category Axis (Dimensions) field. In the Measures list, find and add the **order_number** and **average_profit** measures to the Value Axis (Measures) field.



ii. Click **Update**. The chart is updated.

iii. Click the **Style** tab, and select **Dual Y-Axis** under Chart Type.



iv. Click **Save** in the upper-right corner to save the dashboard.

5.4.4.4. Create a horizontal bar chart

Similar to a vertical bar chart, a horizontal bar chart displays the differences between data of different categories.

Notes

You must specify at least one dimension, such as province or product type, to determine the category axis. You must specify at least one measure, such as order number or profit, to determine the value axis. You can specify only one dimension to determine the legend.

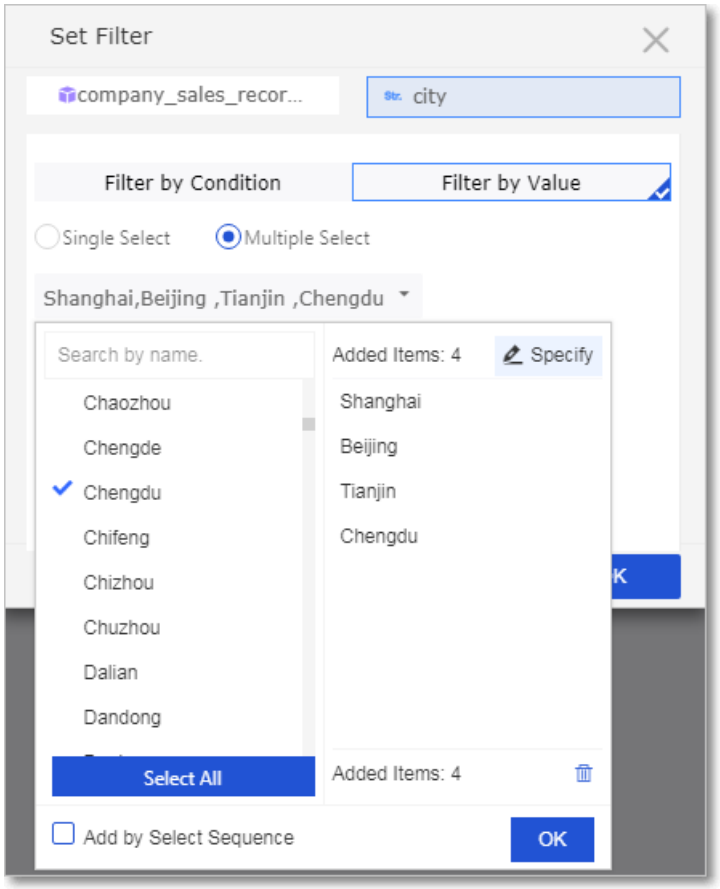
> **Note** The legend is applicable only when the value axis has one measure.

The following example uses the company_sales_record dataset to describe how to use a horizontal bar chart to compare the shipping costs of different products in different municipalities.

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** tab, click **Datasets** to go to the Datasets

page.

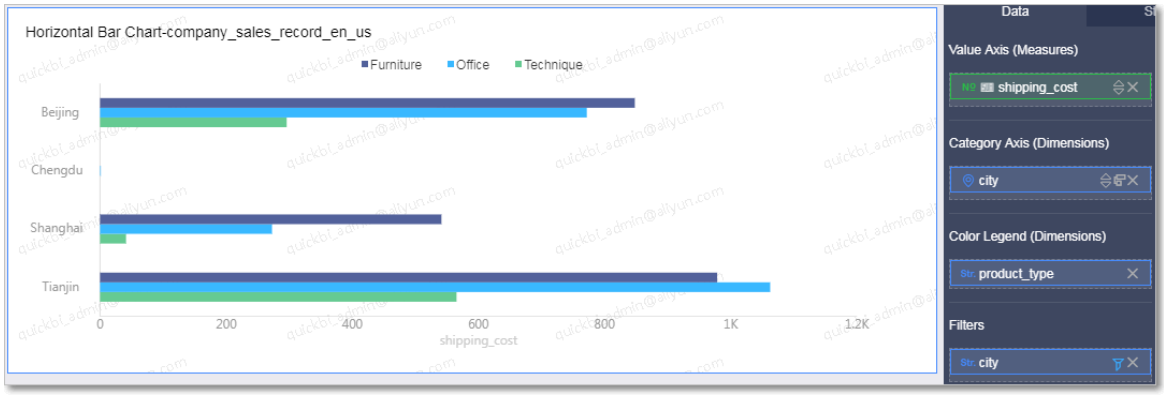
3. Find the company_sales_record dataset, click the **Create Dashboard** icon in the Actions column, select **Standard** in the dialog box that appears, and click OK.
4. On the dashboard edit page, click the **Horizontal Bar Chart** icon. A horizontal bar chart is created in the display area of the dashboard.
5. In the Dimensions list, find and add the **city** dimension to the Filters field and select four municipalities, as shown in the following figure.



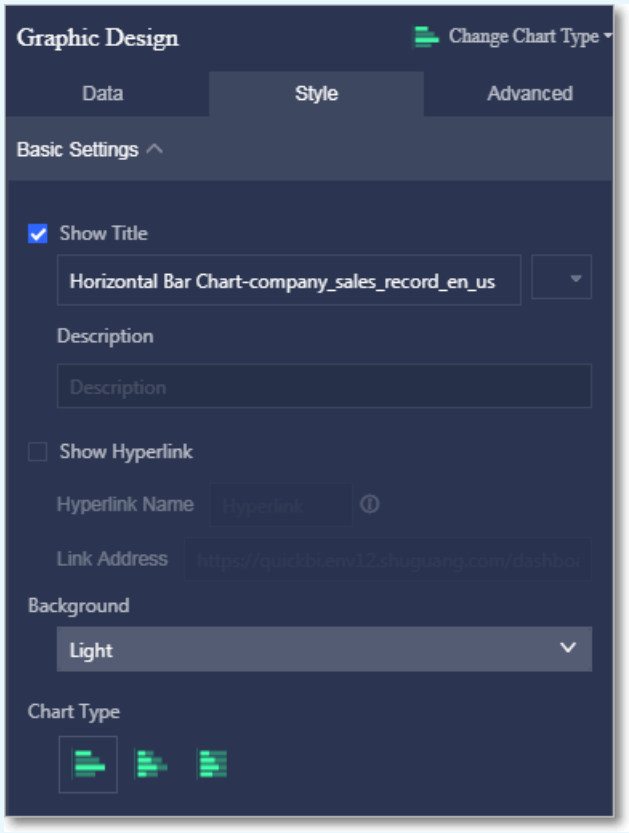
6. In the Dimensions list, find and add the **city** dimension to the Category Axis (Dimensions) field. In the Measures list, find and add the **shipping_cost** measure to the Value Axis (Measures) field. In the Dimensions list, find and add the **product_type** dimension to the Color Legend (Dimensions) field.

> Note
> - Ensure that you have converted the dimension type of city from String to Geo.
> - The legend is applicable only when the value axis has one measure.

7. Click **Update**. The chart is updated, as shown in the following figure.



Note You can also switch the current chart to another bar chart type, such as a stacked horizontal bar chart or 100% stacked horizontal bar chart, as shown in the following figure.



8. Click **Save** in the upper-right corner to save the dashboard.

If you want to delete the chart, click the **More** icon in the upper-right corner of the chart and select **Delete**.

5.4.4.5. Create a progress bar

Similar to a gauge, a progress bar displays the progress of a specific metric.

A progress bar has a pointer. The pointer is determined by measures, such as order quantity.

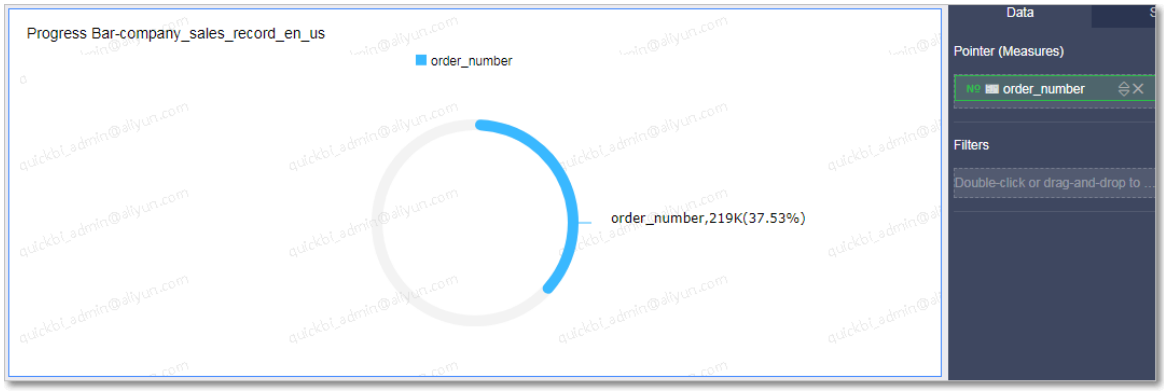
Notes

- You can specify up to five measures to determine the pointer.
- To use a progress bar, you must set the maximum and minimum values in the **Series Settings** field on the **Style** tab.

The following example uses the company_sales_record dataset to describe how to use a progress bar to show order completion.

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** tab, click **Datasets** to go to the Datasets page.
3. Find the company_sales_record dataset, click the **Create Dashboard** icon in the Actions column, select **Standard** in the dialog box that appears, and click OK.
4. On the dashboard edit page, click the Progress Bar icon. A progress bar is created in the display area of the dashboard.
5. On the **Data** tab, select required measures.

   In the Measures list, find and add the **order_number** measure to the Pointer (Measures) field. On the **Style** tab, change the title and legend of the chart, set an alias for a measure, and set the maximum and minimum values.
6. Click **Update**. The chart is updated, as shown in the following figure.



7. Click **Save** in the upper-right corner to save the dashboard.

If you want to delete the chart, click the **More** icon in the upper-right corner of the chart and select **Delete**.

5.4.4.6. Create a combination chart

A combination chart can be used to compare data across multiple categories and magnitudes.

Prerequisites

- The Quick BI service is purchased.
- A dataset is created.

Context

Combination charts provide a dual y-axis to compare multiple chart types, including line chart, vertical bar chart, and area chart, and stack modes, including stacked and 100% stacked. For example, you can use a combination chart to display the change trends of different projects.

A combination chart consists of a category axis, primary value axis, and secondary value axis.

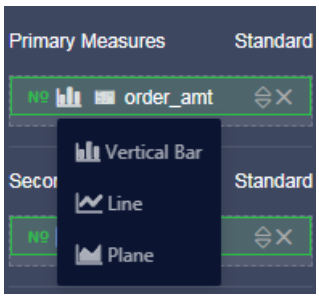
> **Notice** You can specify at least one dimension for the category axis, such as the order_date(year). You can specify at least one measure each for the primary and secondary value axes, such as order price or profit. You can specify only one dimension for the color legend. The legend is applicable only when one measure is specified for the primary or secondary value axis.

Procedure

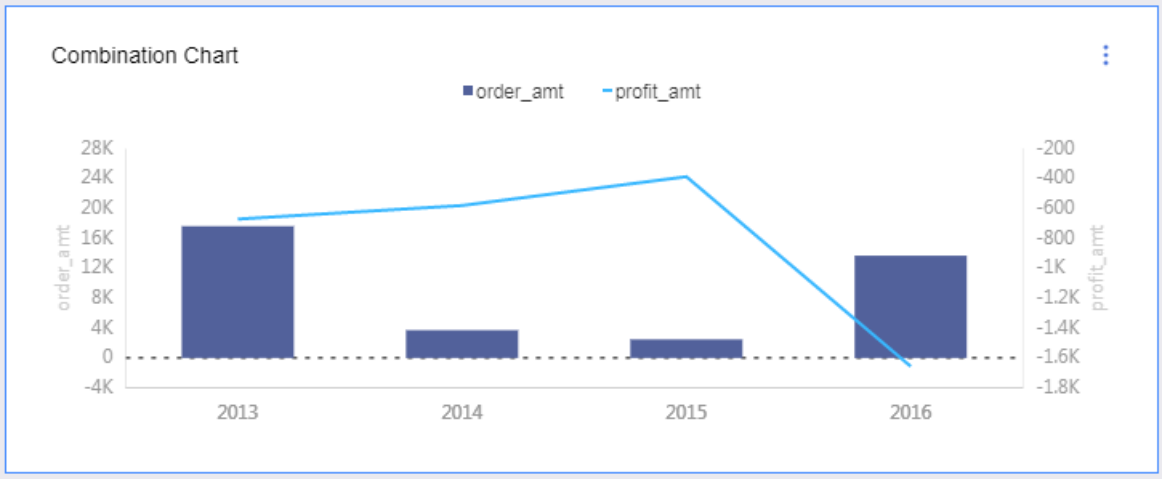
1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** tab, click **Datasets** to go to the Datasets page.
3. Find the *company_sales_record* dataset, click the icon in the Actions column, select **Standard** in the dialog box that appears, and click OK.
4. On the dashboard edit page, click the icon.
5. On the **Data** tab, select required dimensions and measures.

   In the Dimensions list, find and add the **order_date (year)** dimension to the Category Axis (Dimensions) field. In the Measures list, find and add **order_amt** to the Primary Measures field and **profit_amt** to the Secondary Measures field.

   - Click the icon to specify vertical bar chart, line chart, or area chart for the primary or secondary value axis.

   - Click the icon to select the stack mode.
6. Click **Update**. The chart is updated.



7. Click **Save**. The **Save Dashboard** dialog box appears. Specify Name and Save To.
8. Click **OK** to save the dashboard.

   If you want to delete the chart, perform the following steps:

   i. Click ⋮ in the upper-right corner of the chart.

   ii. Select **Delete**.

5.4.4.7. Create a pie chart

A pie chart shows data of different objects. Each object has a unique color or pattern. A pie chart can be used to show the ratio of multiple values in proportion to their total amount. For example, you can use a pie chart to show the ratio of the income tax to total personal income, or the ratio of the sales volume of a car brand in comparison to total sales volume.

Prerequisites

- The Quick BI service is purchased.
- A dataset is created.

Context

A pie chart consists of multiple slices. Slice labels are determined by a dimension, such as area or product type. The central angle of each slice is determined by a measure, such as order quantity, order price, or profit.

You can specify only one dimension to determine slice labels. You can specify only one measure to determine the central angle.

The following example uses the company_sales_record dataset to describe how to use a pie chart to compare the shipping costs in different regions.

Procedure

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** tab, click **Datasets** to go to the Datasets page.
3. Find the company_sales_record dataset, click the **Create Dashboard** icon in the Actions column,

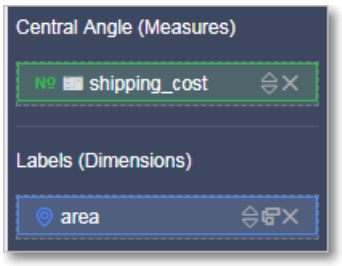
select **Standard** in the dialog box that appears, and click OK.

4. On the dashboard edit page, click the **Pie Chart** icon.
5. On the **Data** tab, select required dimension and measure.

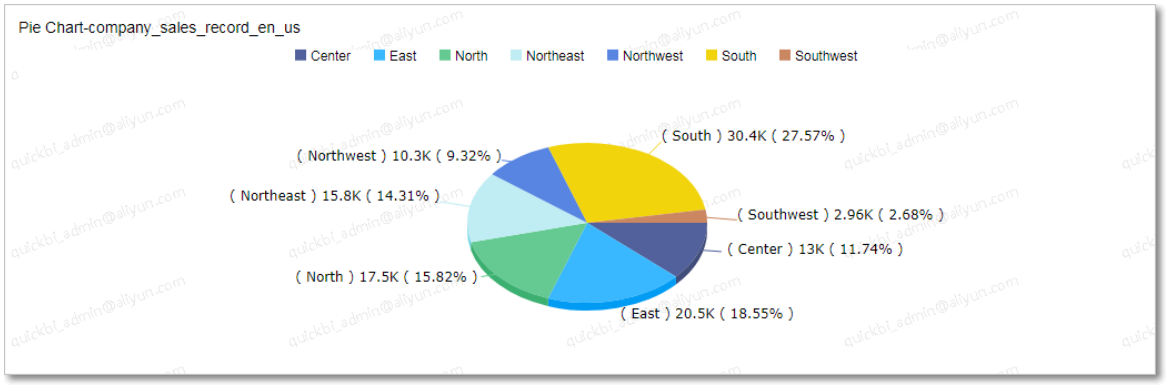
   In the Dimensions list, find and add the area dimension to the Labels (Dimensions) field. In the Measures list, find and add the shipping_cost measure to the Central Angle (Measures) field, as shown in Specify fields for the pie chart.

   > **Note** Ensure that you have converted the dimension type of area from String to Geo. For information about how to convert a dimension type, see Edit a dimension.

   Specify fields for the pie chart

6. Click **Update**. The chart is updated.
7. Click the **Style** tab. In the **Display Mode** field, select **3D**. In the **Label Style** field, select **Name, Percentage**.

8. Click **Save** in the upper-right corner and enter a name for the dashboard in the Save Dashboard dialog box that appears.
9. Click **OK** to save the dashboard.

   If you want to delete the chart, click the **More** icon in the upper-right corner of the chart and select **Delete**.

5.4.4.8. Create a bubble map

A bubble map uses a map profile as its background and shows data distribution with bubbles of different sizes. It displays data metrics and distribution in a country or region. For example, you can use a bubble map to display the volume of tourist arrivals at different destinations, or the average income in different regions.

Prerequisites

- The Quick BI service is purchased.
- A dataset is created.

Context

A bubble map consists of geographic locations and the bubble size. Geographic locations are determined by a dimension, such as province. The bubble size is determined by one or more measures, such as shipping cost and order quantity.

You can specify only one dimension to determine geographic locations, such as area, province, or city. The dimension type must be Geo. You must specify at least one measure to determine the bubble size. You can specify up to five measures.

The following example uses the company_sales_record dataset to describe how to use a bubble map to compare the order quantities and average profits in different provinces.

Data modeling may be required for this scenario.

For information about data modeling, see Add a calculated field.

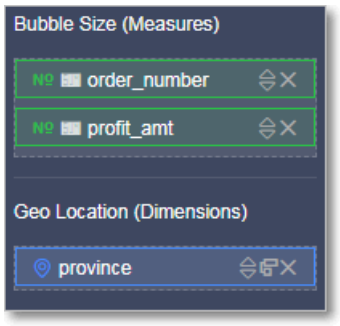
Procedure

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** tab, click **Datasets** to go to the Datasets page.
3. Find the company_sales_record dataset, click the **Create Dashboard** icon in the Actions column, select **Standard** in the dialog box that appears, and click OK.
4. On the dashboard edit page, click the **Bubble Map** icon.
5. On the **Data** tab, select required dimension and measures.

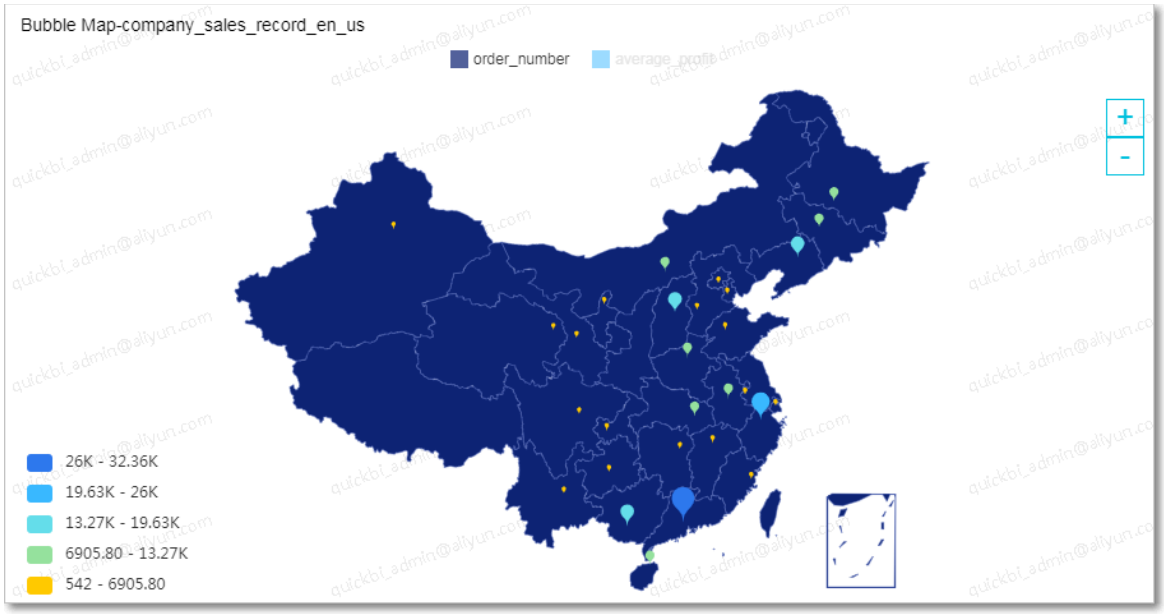
   In the Dimensions list, find and add the province dimension to the Geo Location (Dimensions) field. In the Measures list, find and add the order_number and average_profit measures to the Bubble Size (Measures) field, as shown in Specify fields for the bubble map:

   > **Note** Ensure that you have converted the dimension type of province from String to Geo. For information about how to convert a dimension type, see Edit a dimension.

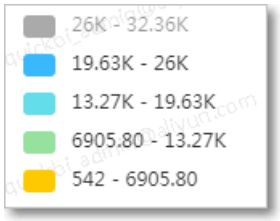
   Specify fields for the bubble map

6. Click **Update**. The chart is updated.
7. Click the **Style** tab, and edit the title and legend position of the chart.



- You can switch between order_number and average_profit to show required data.
- Click a legend to hide its data.



- Click the plus (+) or minus (-) sign to zoom in or zoom out on the map.

8. Click **Save** in the upper-right corner and enter a name for the dashboard in the Save Dashboard dialog box that appears.
9. Click **OK** to save the dashboard.

   If you want to delete the chart, click the **More** icon in the upper-right corner of the chart and select **Delete**.

5.4.4.9. Create a colored map

Similar to a bubble map, a colored map displays data as a single color at different saturation levels. This visualization is useful to show distribution of data across areas on a map.

Prerequisites

- The Quick BI service is purchased.
- A dataset is created.

Context

A colored map consists of geographic locations and a colorscale. Geographic locations are determined by a dimension, such as province. The colorscale is determined by one or more measures, such as order price and profit.

You can specify only one dimension to determine geographic locations. The type of the dimension must be Geo. You must specify at least one measure to determine the colorscale. You can specify up to five measures.

The following example uses the company_sales_record dataset to describe how to use a colored map to compare the shipping costs, order price, and profits in different regions.

Procedure

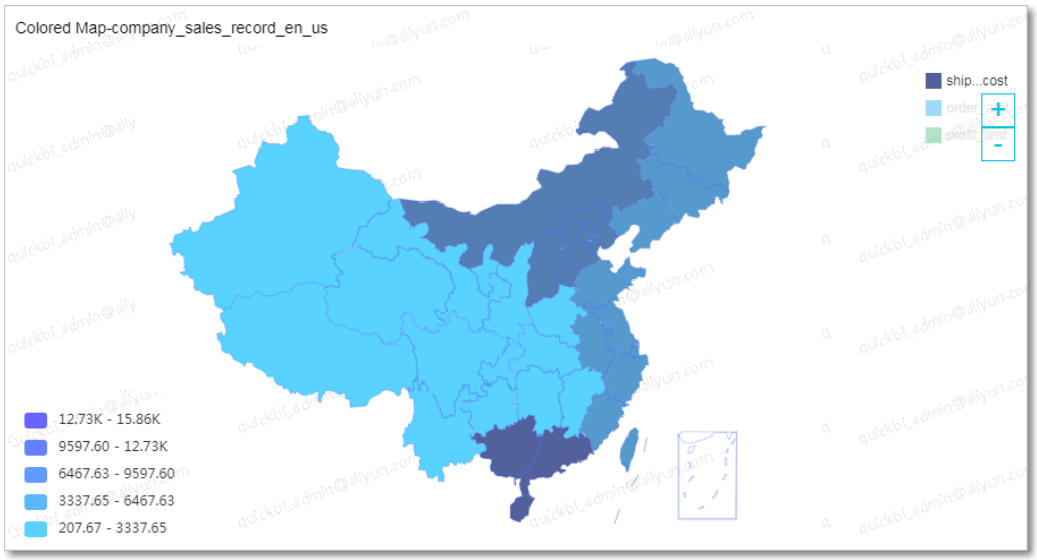
1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** tab, click **Datasets** to go to the Datasets page.
3. Find the company_sales_record dataset, click the **Create Dashboard** icon in the Actions column, select **Standard** in the dialog box that appears, and click OK.
4. On the dashboard edit page, click the **Colored Map** icon.
5. On the **Data** tab, select required dimension and measures.

   In the Dimensions list, find and add the area dimension to the Geo Location (Dimensions) field. In the Measures list, find and add the order_amt, profit_amt, and shipping_cost measures to the Colorscale (Measures) field .

   > **Note** Ensure that you have converted the dimension type of area from String to Geo. For information about how to convert a dimension type, see Edit a dimension.

6. Click **Update**. The chart is updated.
7. Click the **Style** tab, click the **Right** icon under the **Show legend** field in the **Layout** section, as shown in The colored map.

   The colored map

   You can perform various operations on the map, such as change the title, adjust the position and size, and hide irrelevant data. For more information, see Create a bubble chart.

8. Click **Save** in the upper-right corner and enter a name for the dashboard in the Save Dashboard dialog box that appears.

9. Click **OK** to save the dashboard.

   If you want to delete the chart, click the **More** icon in the upper-right corner of the chart and select **Delete**.

5.4.4.10. Create a geo bubble map

A geo bubble map uses a map profile as its background and shows data distribution with bubbles of different sizes. It displays data metrics and distribution in a country, region, or city. Compared with bubble maps, geo bubble maps provide more accurate geographic locations.

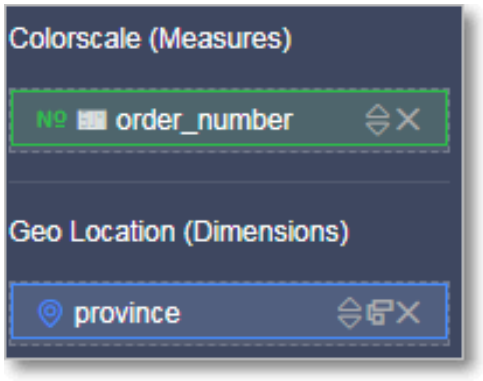
A geo bubble map consists of geographic locations displayed with different saturation levels. Geographic locations are determined by a dimension, such as province. Saturation levels are determined by a measure, such as order quantity. You must specify one dimension and one measure for a geo bubble map. The dimension type must be Geo.

The following example uses the company_sales_record dataset to describes how to use a geo bubble map to compare the order quantities of different provinces in the North China region.

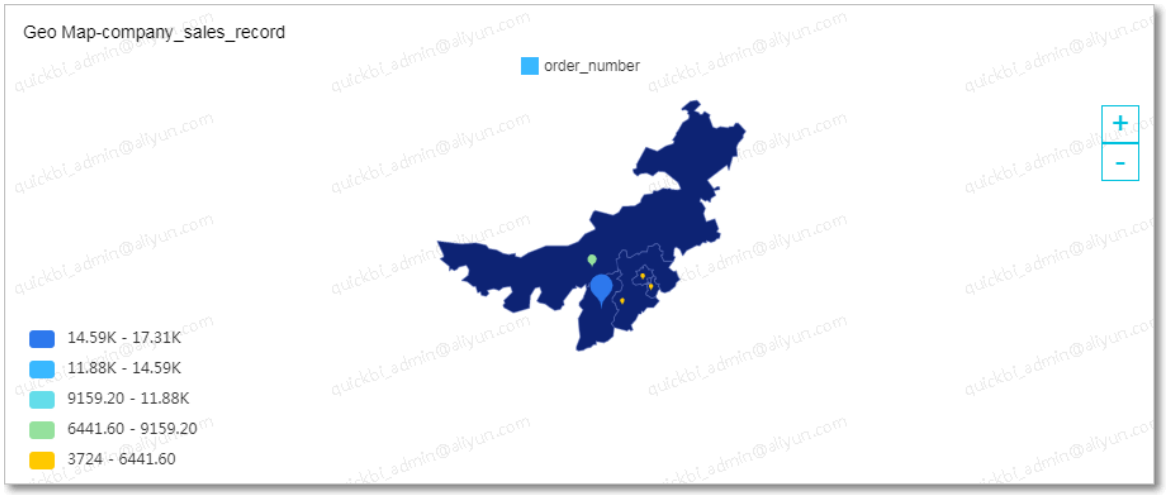
1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** tab, click **Datasets** to go to the Datasets page.
3. Find the company_sales_record dataset, click the **Create Dashboard** icon in the Actions column, select Standard in the dialog box that appears, and click OK.
4. Click the Geo Bubble Map icon. A geo bubble map is created in the display area of the dashboard.
5. On the **Data** tab, select the target measure and dimension.

   In the Dimensions list, find and add the **province** dimension to the Location (Dimension) field. In the Measures list, find and add the **order_number** measure to the Color Scale (Measures) field, as shown in the following figure.

   > **Note** Ensure that you have converted the dimension type of province from String to Geo.

6. Click **Update**. The chart is updated.
7. On the **Style** tab, change the value ranges and saturation levels, as shown in the following figure.



8. Click **Save** to save the dashboard.

If you want to delete the geo bubble map, click the **More** icon in the upper-right corner of the map and select **Delete**.

5.4.4.11. Create a geo map

A geo map displays data as a single color at different saturation levels. This visualization is useful to show distribution of data across areas on a map. Compared with colored maps, geo maps provide more accurate geographic locations.

A geo map consists of geographic locations displayed in one color with different saturation levels. Geographic locations are determined by a dimension, such as province. Saturation levels are determined by a measure, such as order quantity. You must specify one dimension and one measure for a geo map. The dimension type must be Geo.

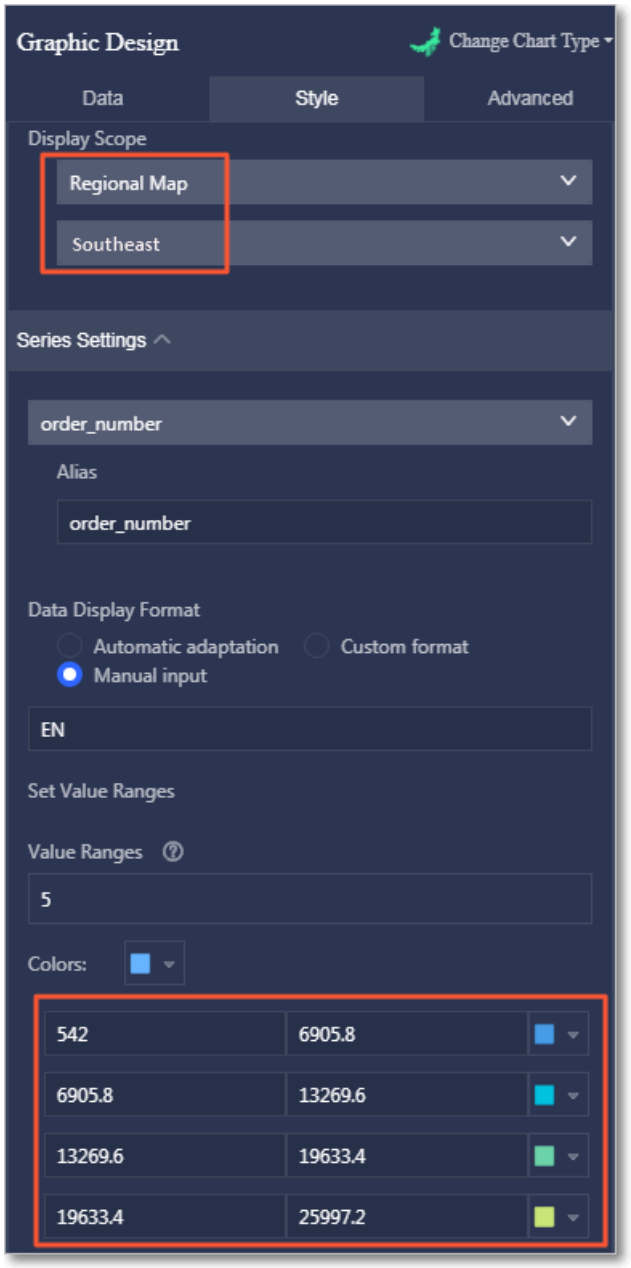
The following example uses the company_sales_record dataset to describe how to use a geo map to compare the order quantities of different provinces in the South China region.

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** tab, click **Datasets** to go to the Datasets page.
3. Find the company_sales_record dataset, click the **Create Dashboard** icon in the Actions column, select Standard in the dialog box that appears, and click OK.
4. On the dashboard edit page, click the Geo Map icon. A geo map is created in the display area of the dashboard.
5. On the **Data** tab, select the required measures and dimensions.

   In the Dimensions list, find and add the **province** dimension to the Geo Location (Dimensions) field. In the Measures list, find and add the **order_number** measure to the Colorscale (Measures) field, as shown in the following figure:

   > **Note** Ensure that you have converted the dimension type of province from String to Geo.

6. Click **Update**. The chart is updated.
7. On the **Style** tab, change the value ranges and saturation levels.



8. Click **Save** to save the dashboard.

If you want to delete the geo map, click the **More** icon in the upper-right corner of the map and select **Delete**.

5.4.4.12. Create a cross table

A cross table displays the summary of a field and classifies data items into different categories. Cells in a cross table support multiple aggregate functions, such as SUM, AVG, COUNT, MAX, and MIN.

Prerequisites

- The Quick BI service is purchased.
- A dataset is created.

Context

A cross table consists of rows and columns. Rows are determined by dimensions such as province and product type. Columns are determined by measures such as order quantity and profit.

There is no limit to the number of dimensions and measures that you can include in a cross table.

The following example uses the company_sales_record dataset to describe how to use a cross table to compare the packaging, shipping costs, order quantities, and average profits of different products in multiple provinces.

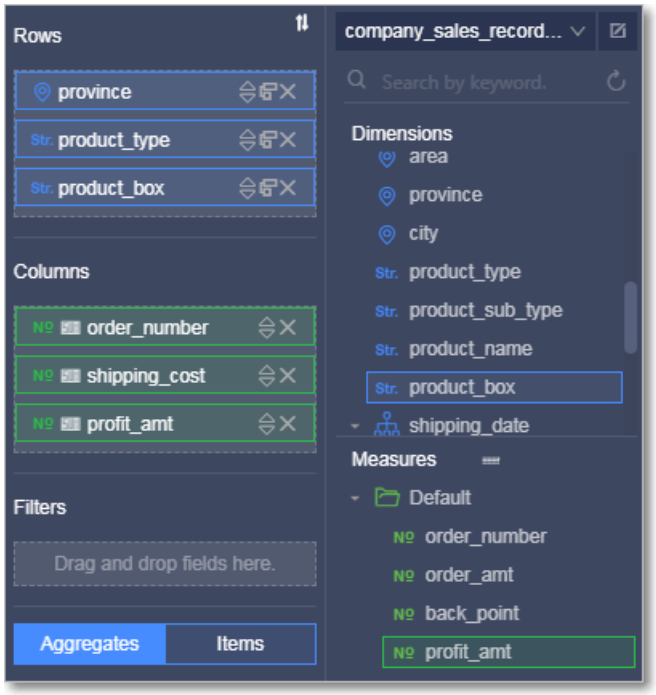
Procedure

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** tab, click **Datasets** to go to the Datasets page.
3. Find the company_sales_record dataset, click the **Create Dashboard** icon in the Actions column, select **Standard** in the dialog box that appears, and click OK.
4. On the dashboard edit page, click the **Cross Table** icon.
5. On the **Data** tab, select dimensions and measures.

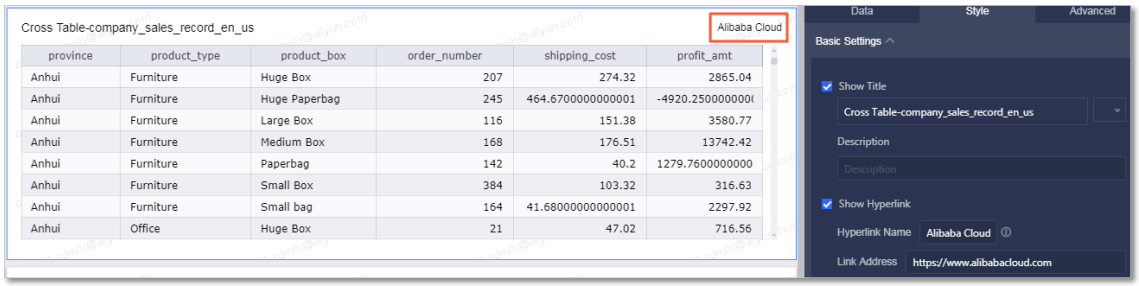
   In the Dimensions list, find and add the province, product_type, and product_box dimensions to the Rows field. In the Measures list, find and add the order_number, shipping_cost, and profit_amt measures to the Columns field, as shown in Specify fields for the cross table.

   > **Note** Ensure that you have converted the dimension type of province from String to Geo. For information about how to convert a dimension type, see Edit a dimension.

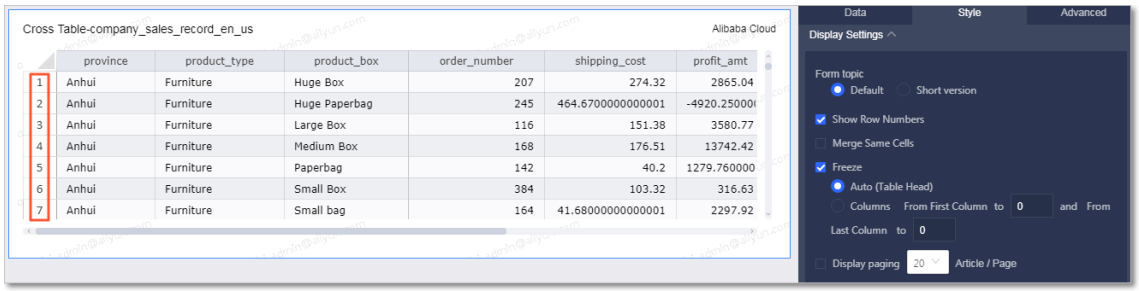
   Specify fields for the cross table



6. Click **Update**. The chart is updated.
7. Click the **Style** tab, and perform the following operations:
   - In the **Basic Settings** section, specify a title and hyperlink for the cross table, as shown in the following figure.



   - In the **Display Settings** section, specify whether to show row numbers, merge cells that belong to the same category, freeze all columns by selecting Auto (Table Head), or freeze specific columns. After you set the parameters, update the table, as shown in the following figure.



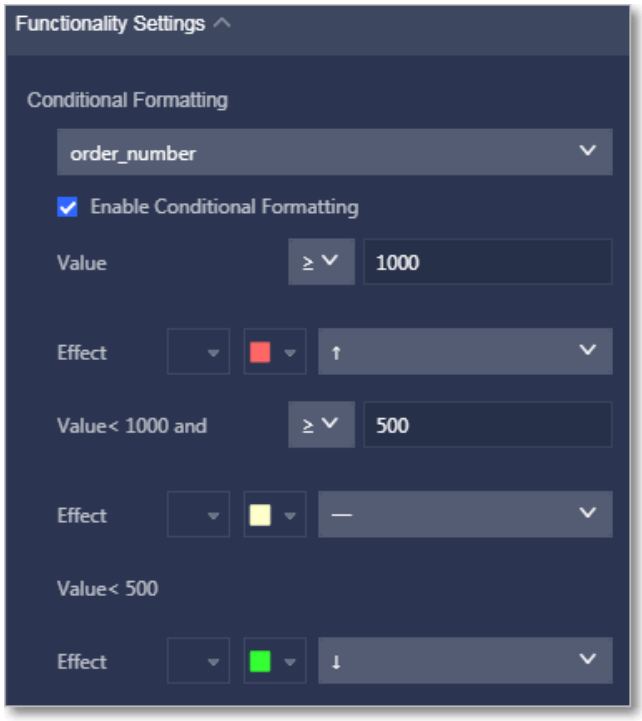
   - In the **Functionality Settings** section, set conditional formatting and sort columns.

     Conditional formatting

- Select the target field, and select the **Enable Conditional Formatting** check box to enable conditional formatting. To disable conditional formatting, clear the check box, as shown in the following figure.

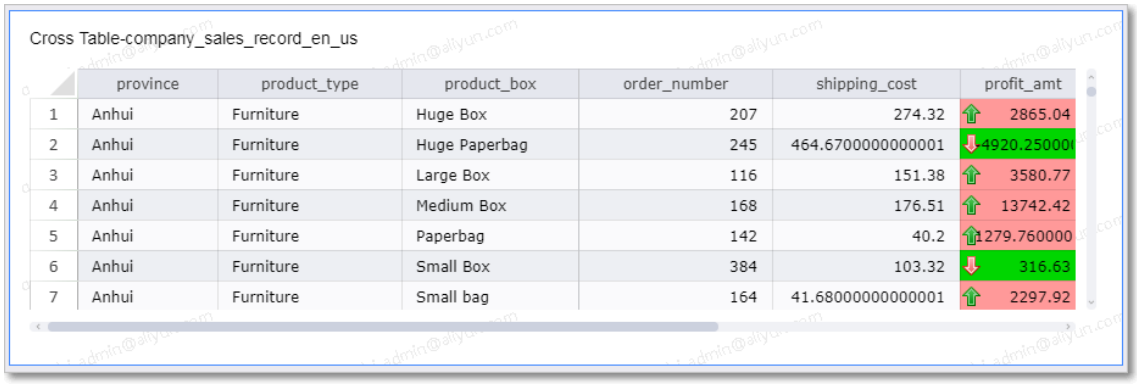
- Click the drop-down icon and select another field, as shown in the following figure.

- Specify a value for the Value parameter, click the Color icons next to the Effect parameter, and select colors to mark the values, as shown in the following figure.



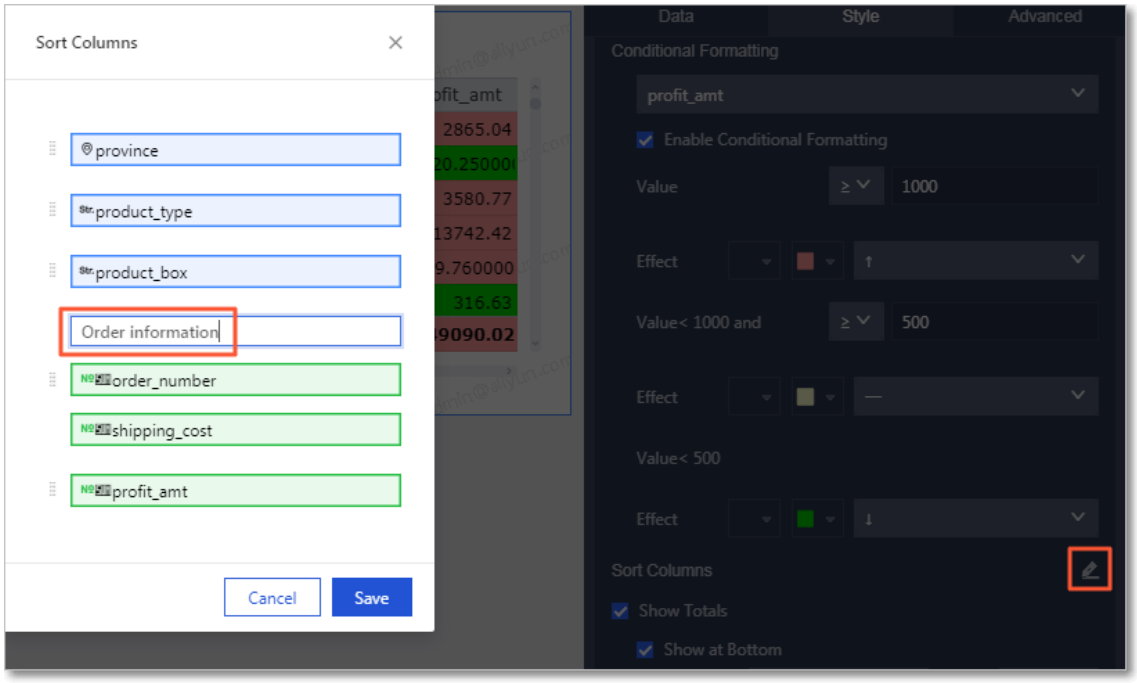
In this example, the **profit_amt** field is selected for conditional formatting. The rules are:

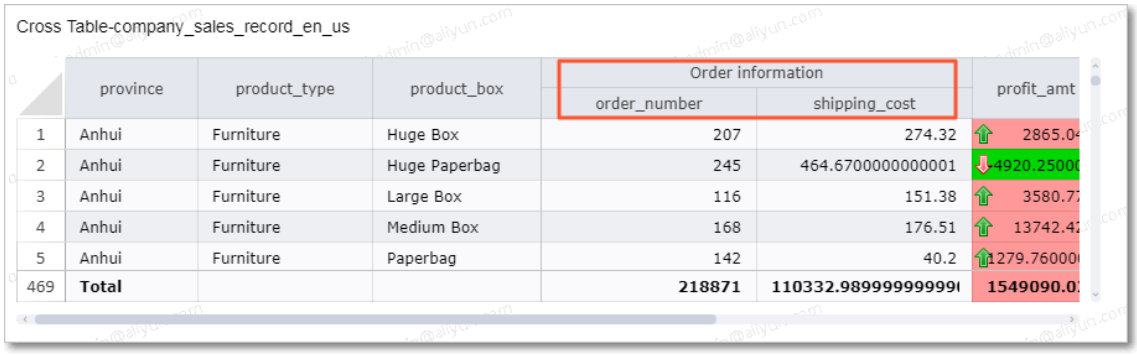
- Cells with values greater than 1000 are highlighted in red and are marked with a green upward arrow.
- Cells with values from 500 to 1000 are highlighted in gray and are marked with an orange hyphen.
- Cells with values smaller than 500 are highlighted in green and are marked with a red downward arrow.



Sort columns

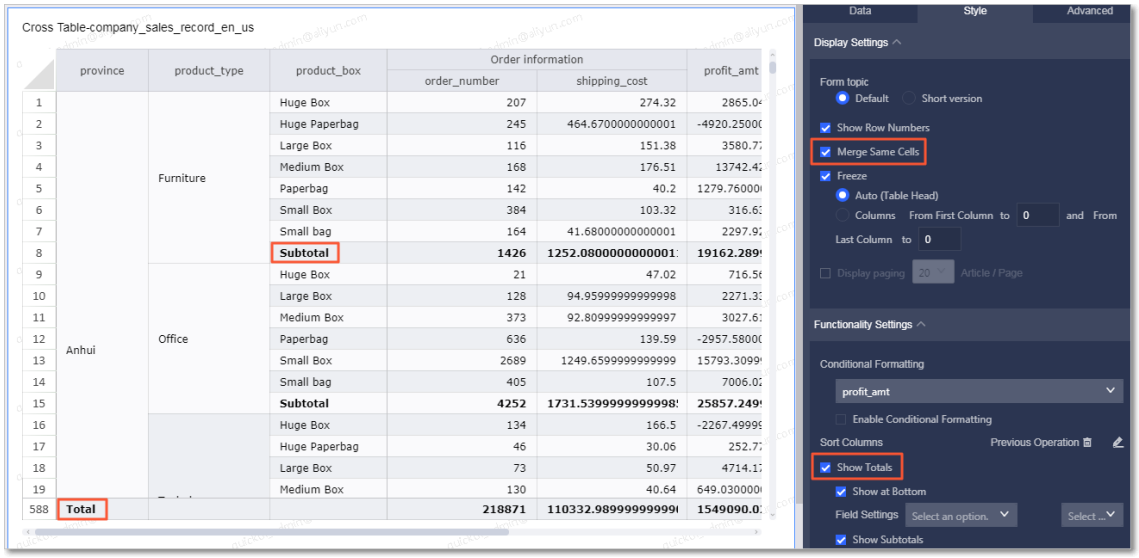
This function allows you to sort columns into different groups. You must name the groups. Otherwise, only the column order is changed.





- Select **Show Totals** to obtain the sum of specific or all data items. You can also select an aggregate function, as shown in the following figure.

> **Note** If you want to obtain the subtotal of grouped data items, you must select **Merge Same Cells** in the **Display Settings** section.



- In the **Series Settings** section, rename fields, set the alignment mode, and specify the number of records displayed on a single page.

8. Click **Save** in the upper-right corner and enter a name for the dashboard in the Save Dashboard dialog box that appears.
9. Click **OK** to save the dashboard.

   If you want to delete the chart, click the **More** icon in the upper-right corner of the chart and select **Delete**.

5.4.4.13. Create a pivot table

A pivot table displays aggregates of variables and allows you to analyze data in a tree structure. One variable defines the values in the header row while the other variable defines the values in the header column. Aggregate functions include SUM, AVG, COUNT, MAX, and MIN.

Similar to Cross tables, pivot tables consists of rows and columns. You can specify an unlimited number of dimensions, such as province and product type, to determine rows and an unlimited number of measures, such as order quantity and profit to determine columns.

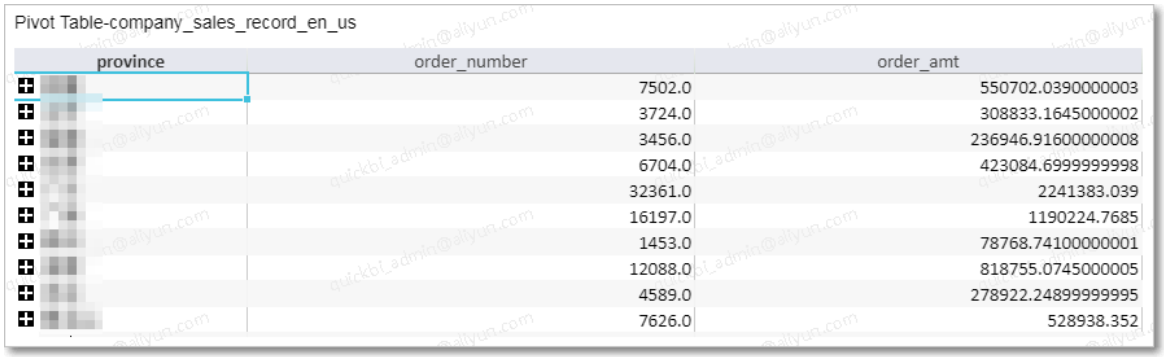
The following example uses the company_sales_record dataset to describe how to use a pivot table to show the packaging, order quantities, and order prices of different products.

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** tab, click **Datasets** to go to the Datasets page.
3. Find the company_sales_record dataset, click the **Create Dashboard** icon in the Actions column, select **Standard** in the dialog box that appears, and click OK.
4. On the dashboard edit page, click the **Pivot Table** icon. An pivot table is created in the display area of the dashboard.
5. On the **Data** tab, select the required dimensions and measures.

   In the Dimensions list, find and add the **province**, **product_type** and **product_box** dimensions to the Rows (Dimensions) field. In the Measures list, find and add the **order_number** and **order_amt** measures to the Values (Measures) field.

> **Note** Ensure that you have converted the dimension type of province from String to Geo.

6. Click **Update**. The chart is updated.



7. Click **Save** in the upper-right corner to save the dashboard.

   If you want to delete the pivot table, click the **More** icon in the upper-right corner of the chart and select **Delete**.

5.4.4.14. Create a gauge

Similar to a dashboard in a car, a gauge shows the range of a specific metric. You can view the progress of a current task or determine whether a metric exceeds its range in a gauge. For example, you can use a gauge to show the inventory status of a commodity, which helps you replenish the inventory in a timely manner.

Prerequisites

- The Quick BI service is purchased.
- A dataset is created.

Context

A gauge consists of the indicator angle and tooltip. The tooltip and indicator angle are determined by a measure, such as discount or profit.

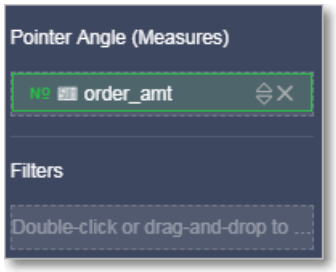
For each gauge, you can specify only one measure for the indicator angle and tooltip.

The following example uses the company_sales_record dataset to describe how to use a gauge to show the order price.

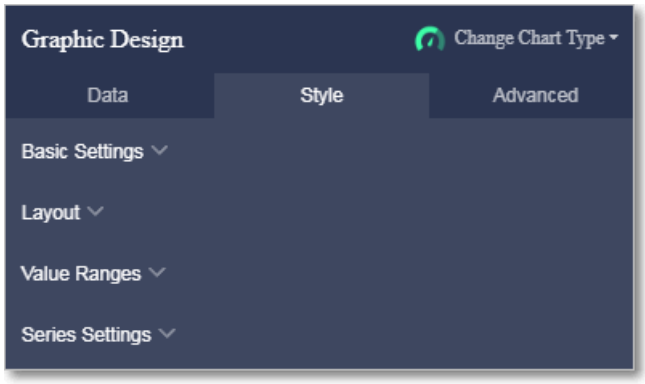
Procedure

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** tab, click **Datasets** to go to the Datasets page.
3. Find the company_sales_record dataset, click the **Create Dashboard** icon in the Actions column, select **Standard** in the dialog box that appears, and click OK.
4. On the dashboard edit page, click the **Gauge** icon.
5. On the **Data** tab, select the required measure.

In the Measures list, find and add the order_amt measure to the Indicator Angle (Measures) or Tooltip (Measures) field.



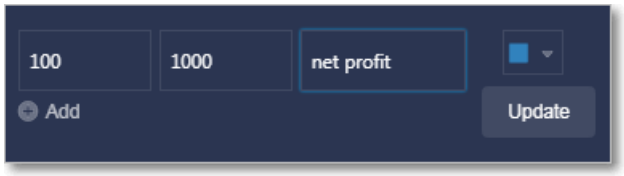
6. Click **Update**. The chart is updated.
7. Click the **Style** tab, and set the title, layout, and show or hide legend and tick marks.



8. Click **Add** in the Value Ranges section, and specify the start value and end value.

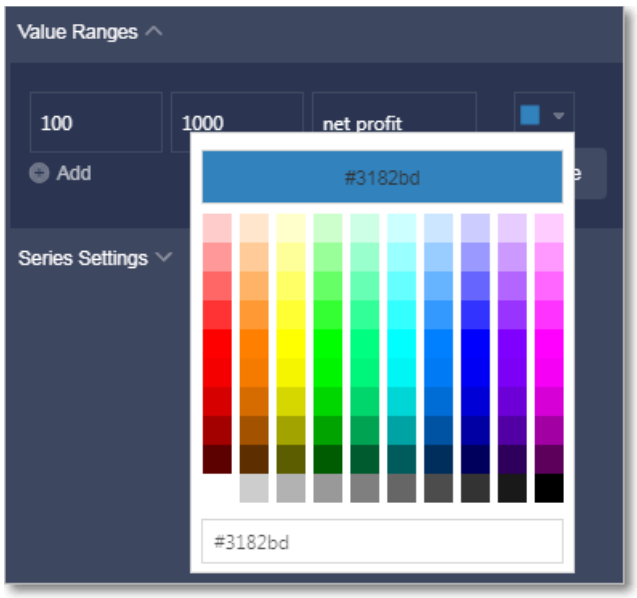
   For example, you can set the start value to 100, the end value to 1000, and the range title to Net Profit, as shown in Set a value range.

   Set a value range



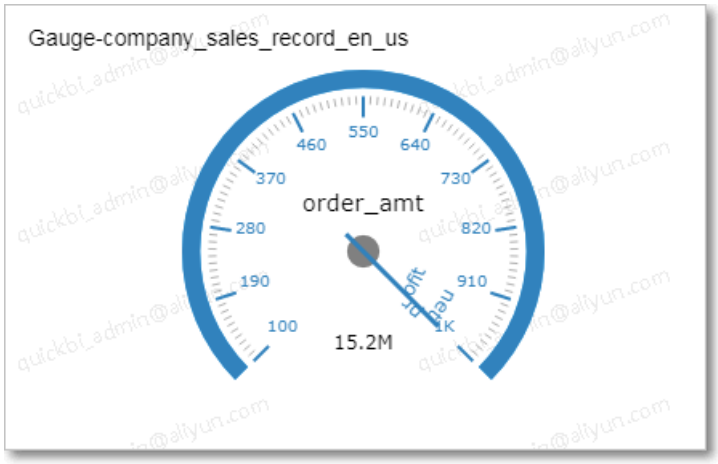
9. Click the Color icon and select a color for the value range, as shown in Change colors for value ranges.

   Change colors for value ranges



10. Click **Update**. The chart is updated, as shown in The gauge.

    The gauge



11. Click **Save** in the upper-right corner and enter a name for the dashboard in the Save Dashboard dialog box that appears.
12. Click **OK** to save the dashboard.

    If you want to delete the gauge, click the **More** icon in the upper-right corner of the chart and select **Delete**.

5.4.4.15. Create a radar chart

A radar chart compares values relative to a center point for data analysis. You can use a radar chart to compare trends of multiple indicators, such as sale volumes of all regions.

Prerequisites

- The Quick BI service is purchased.
- A dataset is created.

Context

A radar chart consists of labels and label lengths. Labels are determined by dimensions, such as product type. Label lengths are determined by measures, such as shipping cost.

You can specify up to two dimensions to determine the labels. It is recommended that the total number of unique dimension values be at least three and less than or equal to 12. You must specify at least one measure to determine the length of each label.

The following example uses the company_sales_record dataset to describe how to use a radar chart to compare the order quantities and order prices in different regions.

Procedure

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** tab, click **Datasets** to go to the Datasets page.
3. Find the company_sales_record dataset, click the **Create Dashboard** icon in the Actions column, select **Standard** in the dialog box that appears, and click OK.
4. On the dashboard edit page, click the **Radar Chart** icon.
5. On the **Data** tab, select required dimensions and measures.

   In the Dimensions list, find and add the area dimension to the Labels (Dimensions) field. In the Measures list, find and add the order_number and order_amt measures to the Length (Measures) field, as shown in Specify fields for the radar chart.

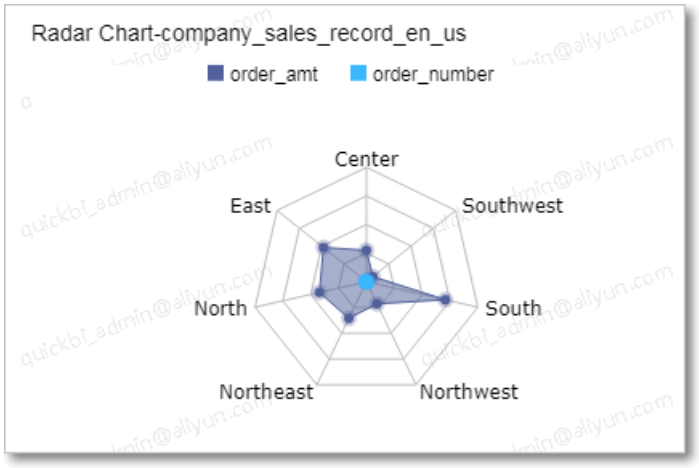
   > **Note** Ensure that you have converted the dimension type of area from String to Geo. For information about how to convert a dimension type, see Edit a dimension.

   Specify fields for the radar chart

6. Click **Update**. The chart is updated.
7. Click the **Style** tab, and change the title, layout, and legend position of the radar chart, as shown in The radar chart.

   The radar chart



8. Click **Save** in the upper-right corner and enter a name for the dashboard in the Save Dashboard dialog box that appears.
9. Click **OK** to save the dashboard.

   If you want to delete the radar chart, click the **More** icon in the upper-right corner of the chart and select **Delete**.

5.4.4.16. Create a scatter chart

A scatter chart displays data distribution and aggregation.

Prerequisites

- The Quick BI service is purchased.
- A dataset is created.

Context

A scatter chart consists of up to three separate x-axes and only one y-axis. You can specify one to three measures for the x-axes, one measure for the y-axis, and one dimension to determine the legend.

There can be a maximum of 1,000 values in the Dimensions list.

You can specify one to three measures for the x-axes.

You can specify only one measure for the y-axis.

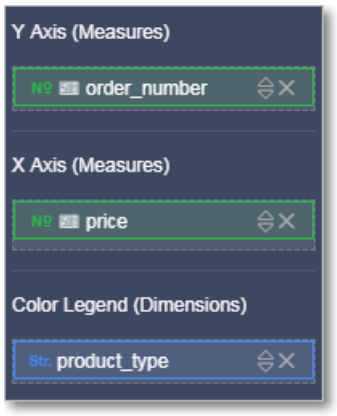
The following example uses the company_sales_record dataset to describe how to use a scatter chart to compare the prices and order quantities of different products.

Procedure

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** tab, click **Datasets** to go to the Datasets page.
3. Find the company_sales_record dataset, click the **Create Dashboard** icon in the Actions column, select **Standard** in the dialog box that appears, and click OK.
4. On the dashboard edit page, click the **Scatter Chart** icon.
5. On the **Data** tab, select required dimension and measures.

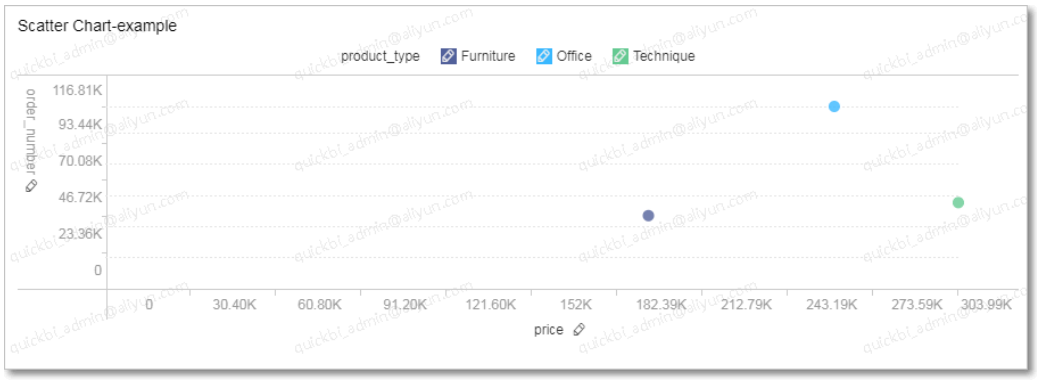
In the Dimensions list, find and add the product_type dimension to the Color Legend (Dimensions) field. In the Measures list, find and add the price measure to the X Axis (Measures) field, and the order_number measure to the Y Axis (Measures) field, as shown in Specify fields for the scatter chart.

Specify fields for the scatter chart



6. Click **Update**. The chart is updated.
7. Click the **Style** tab, and change the title, layout, and legend position of the scatter chart, as shown in The scatter chart.

The scatter chart



8. Click **Save** in the upper-right corner and enter a name for the dashboard in the Save Dashboard dialog box that appears.
9. Click **OK** to save the dashboard.

If you want to delete the scatter chart, click the **More** icon in the upper-right corner of the chart and select **Delete**.

5.4.4.17. Create a bubble chart

A bubble chart displays data distribution and aggregation by placing proportionally sized bubbles in corresponding locations.

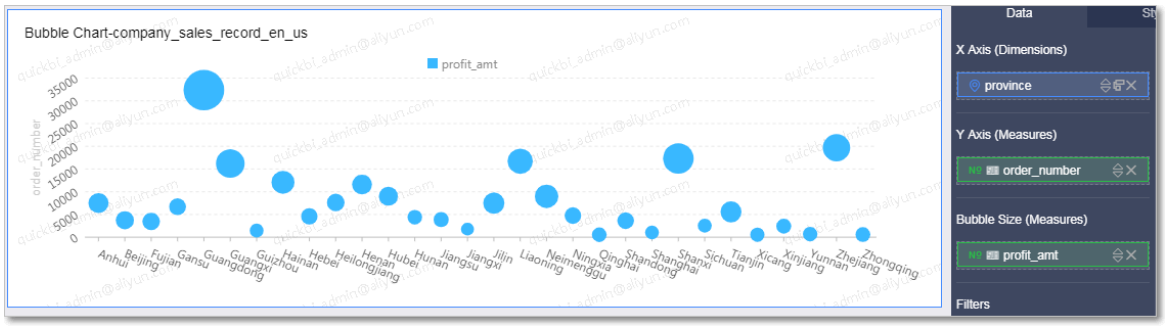
Notes

A bubble chart consists of an x-axis, a y-axis, and bubbles of different sizes. You can specify only one dimension for the x-axis, one measure for the y-axis, and one measure to determine the bubble size.

The following example uses the company_sales_record dataset to describe how to use a bubble chart to compare the order quantities and profits in different provinces.

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** tab, click **Datasets** to go to the Datasets page.
3. Find the company_sales_record dataset, click the **Create Dashboard** icon in the Actions column, select **Standard** in the dialog box that appears, and click OK.
4. On the dashboard edit page, click the Bubble Chart icon. A bubble chart is created in the display area of the dashboard.
5. On the **Data** tab, select the required dimension and measures.

   In the Dimensions list, find and add the **province** dimension to the X Axis (Dimensions) field. In the Measures list, find and add the **order_number** measure to the Y Axis (Measures) field, and the **profit_amt** measure to the Bubble Size (Measures) field. On the **Style** tab, change the title, layout, and legend position of the bubble chart.
6. Click **Update**. The chart is updated.



7. Click **Save** in the upper-right corner to save the dashboard.

If you want to delete the chart, click the **More** icon in the upper-right corner of the chart and select **Delete**.

5.4.4.18. Create a funnel chart

A funnel chart analyzes standard, long-running, and multi-flow business procedures. By comparing business data from different flows, funnel charts allow you to explore and analyze problems in depth. You can also use a funnel chart to display the conversion rate of each step. With a funnel chart, you can perform flow analysis on multi-flow business data. A funnel chart clearly displays the conversion rate, which represents the percentage of visitors who became paying customers of a website.

Prerequisites

- The Quick BI service is purchased.
- A dataset is created.

Context

A funnel chart consists of tier areas and tier labels. Tier labels are determined by a dimension, such as area. Tier areas are determined by a measure, such as order profit.

Only one dimension can be specified to determine tier labels and only one measure can be specified to determine tier areas.

The following example uses the company_sales_record dataset to describe how to use a funnel chart to compare the order profit in different regions.

Procedure

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** tab, click **Datasets** to go to the Datasets page.
3. Find the company_sales_record dataset, click the **Create Dashboard** icon in the Actions column, select **Standard** in the dialog box that appears, and click OK.
4. On the dashboard edit page, click the **Funnel Chart** icon.
5. On the **Data** tab, select the required dimension and measure.

   In the Dimensions list, find and add the area dimension to the Tier Labels (Dimensions) field. In the Measures list, find and add the order_amt measure to the Tier Area (Measures) field, as shown in Specify fields for the funnel chart.

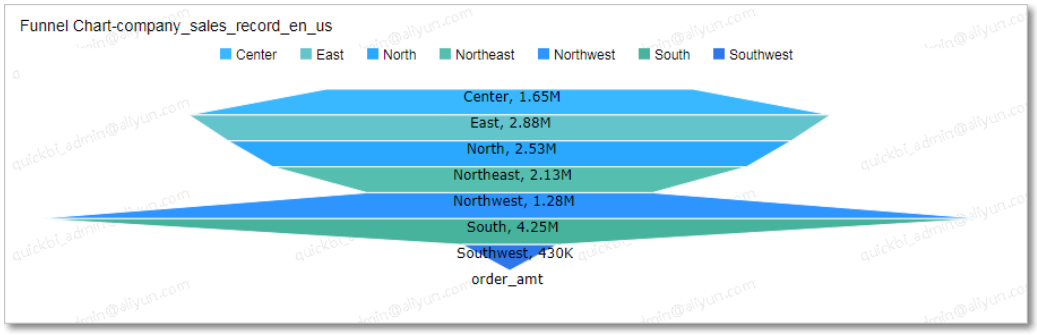
   > **Note** Ensure that you have converted the dimension type of area from String to Geo. For information about how to convert a dimension type, see Edit a dimension.

   Specify fields for the funnel chart

6. Click **Update**. The chart is updated.
7. Click the **Style** tab, and change the title and legend mode of the funnel chart, as shown in The funnel chart.

   The funnel chart

8. Click **Save** in the upper-right corner and enter a name for the dashboard in the Save Dashboard dialog box that appears.
9. Click **OK** to save the dashboard.

   If you want to delete the chart, click the **More** icon in the upper-right corner of the chart and

select **Delete**.

5.4.4.19. Create a kanban

A kanban displays data such as sales or operation status, to help you formulate solutions based on the data. Kanbans help you to discover and solve problems.

Prerequisites

- The Quick BI service is purchased.
- A dataset is created.

Context

A kanban consists of metrics and labels. Labels are determined by a data dimension, such as area. Metrics are determined by data measures, such as order quantity and order price.

For each kanban, only one dimension can be specified to determine the label. You must specify at least one measure to determine the metrics. You can specify up to 10 measures.

The following example uses the company_sales_record dataset to describe how to use a kanban to compare the order quantity, order price, shipping cost, and profit in different provinces.

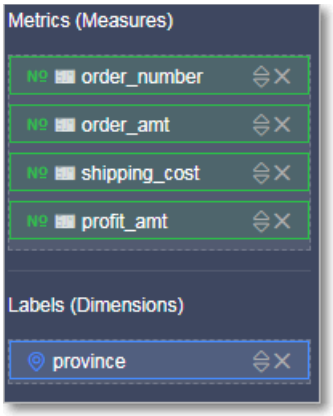
Procedure

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** tab, click **Datasets** to go to the Datasets page.
3. Find the company_sales_record dataset, click the **Create Dashboard** icon in the Actions column, select **Standard** in the dialog box that appears, and click OK.
4. On the dashboard edit page, click the **Kanban** icon.
5. On the **Data** tab, select the required dimension and measures.

   In the Dimensions list, find and add the province dimension to the Labels (Dimensions) field. In the Measures list, find and add the order_number, order_amt, shipping_cost, and profit_amt measures to the Metrics (Measures) field, as shown in Specify fields for the kanban.

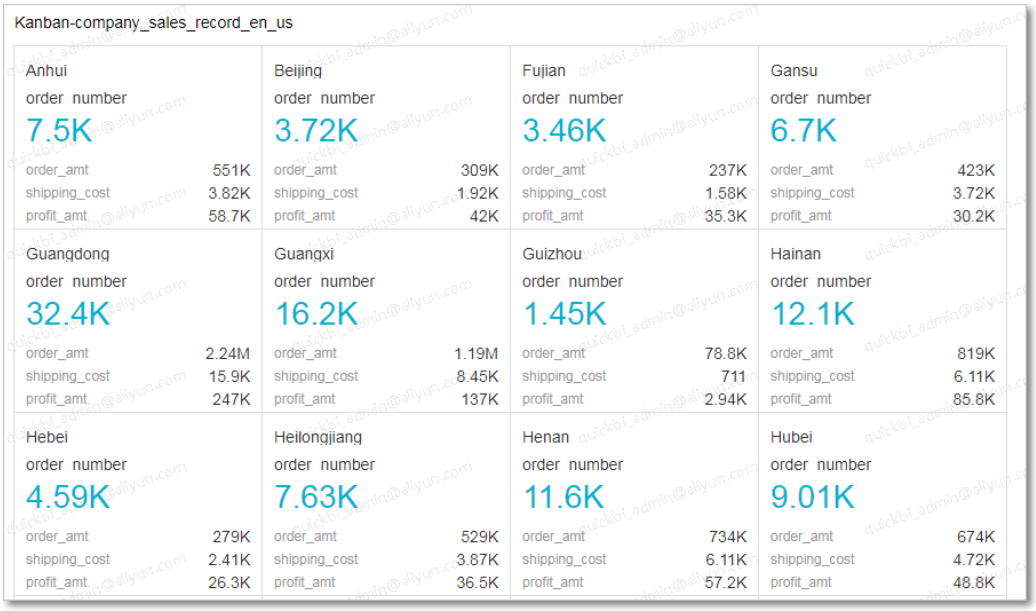
   > **Note** Ensure that you have converted the dimension type of province from String to Geo. For information about how to convert a dimension type, see Edit a dimension.

   Specify fields for the kanban



6. Click **Update**. The chart is updated.
7. Click the **Style** tab, and set the Columns Allowed field to 3, as shown in The kanban.

   The kanban



8. Click **Save** in the upper-right corner and enter a name for the dashboard in the Save Dashboard dialog box that appears.
9. Click **OK** to save the dashboard.

   If you want to delete the chart, click the **More** icon in the upper-right corner of the chart and select **Delete**.

5.4.4.20. Create a treemap

A treemap compares the proportions of objects metrics.

Prerequisites

- The Quick BI service is purchased.
- A dataset is created.

Context

It displays rectangle labels in different sizes based on the measure. Rectangle labels are determined by data dimensions, such as packaging. The size of each rectangle label is determined by a data measure, such as shipping cost.

Only one dimension can be specified for each treemap to determine rectangle labels. The dimension has a maximum of 12 values. Only one measure can be specified to determine the rectangle size.

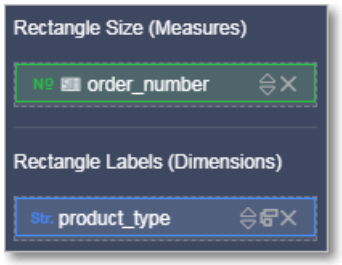
The following example uses the company_sales_record dataset to describe how to use a treemap to compare the order number of different products.

Procedure

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** tab, click **Datasets** to go to the Datasets page.
3. Find the company_sales_record dataset, click the **Create Dashboard** icon in the Actions column, select **Standard** in the dialog box that appears, and click OK.
4. On the dashboard edit page, click the **Treemap** icon.
5. On the **Data** tab, select the required dimension and measures.

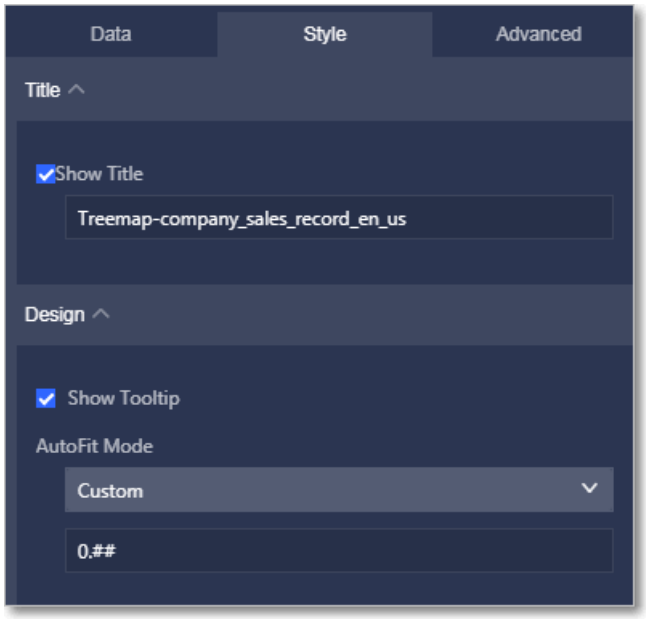
   In the Dimensions list, find and add the product_type dimension to the Rectangle Labels (Dimensions) field. In the Measures list, find and add the order_number measure to the Rectangle Size (Measures) field, as shown in Specify fields for the treemap.

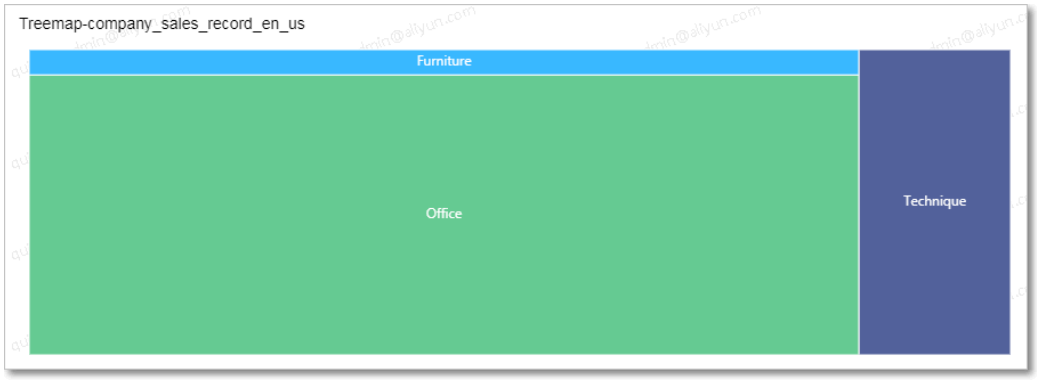
   Specify fields for the treemap

6. Click **Update**. The chart is updated.
7. Click the **Style** tab, and change the title and layout of the treemap, as shown in The treemap.

The treemap





8. Click **Save** in the upper-right corner and enter a name for the dashboard in the Save Dashboard dialog box that appears.
9. Click **OK** to save the dashboard.

   If you want to delete the chart, click the **More** icon in the upper-right corner of the chart and select **Delete**.

5.4.4.21. Create a polar diagram

A polar diagram displays data changes over time or compares metric values. It is ideal for comparing data of different objects, for example, to compare data across different regions.

Prerequisites

- The Quick BI service is purchased.
- A dataset is created.

Context

Similar to a pie chart, a polar diagram consists of multiple slices. Slice labels are determined by data dimensions, such as area and product type. The arc radius of each slice is determined by data measures, such as order quantity and order price.

You can specify only one dimension to determine slice labels and one measure to determine the arc radius for each polar diagram.

The following example uses the company_sales_record dataset to describe how to use a polar diagram to compare the order number in different regions. The number of regions must be greater than or equal to 3 and less than or equal to 12.

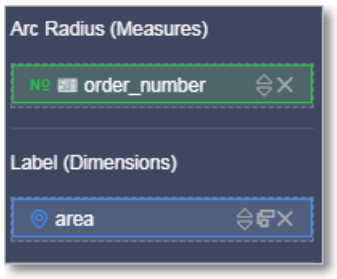
Procedure

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** tab, click **Datasets** to go to the Datasets page.
3. Find the company_sales_record dataset, click the **Create Dashboard** icon in the Actions column, select **Standard** in the dialog box that appears, and click OK.
4. On the dashboard edit page, click the **Polar Diagram** icon.
5. On the **Data** tab, select the required dimension and measure.

   In the Dimensions list, find and add the area dimension to the Label (Dimensions) field. In the Measures list, find and add the order_number measure to the Arc Radius (Measures) field, as shown in Specify fields for the polar diagram.

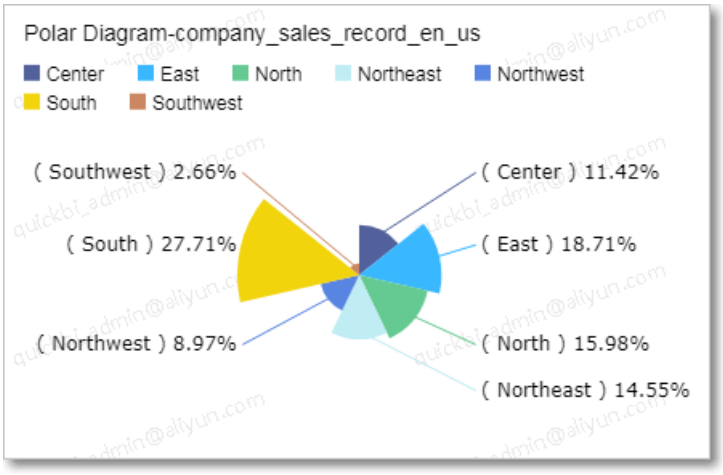
   > **Note** Ensure that you have converted the dimension type of area from String to Geo. For information about how to convert a dimension type, see Edit a dimension.

   Specify fields for the polar diagram

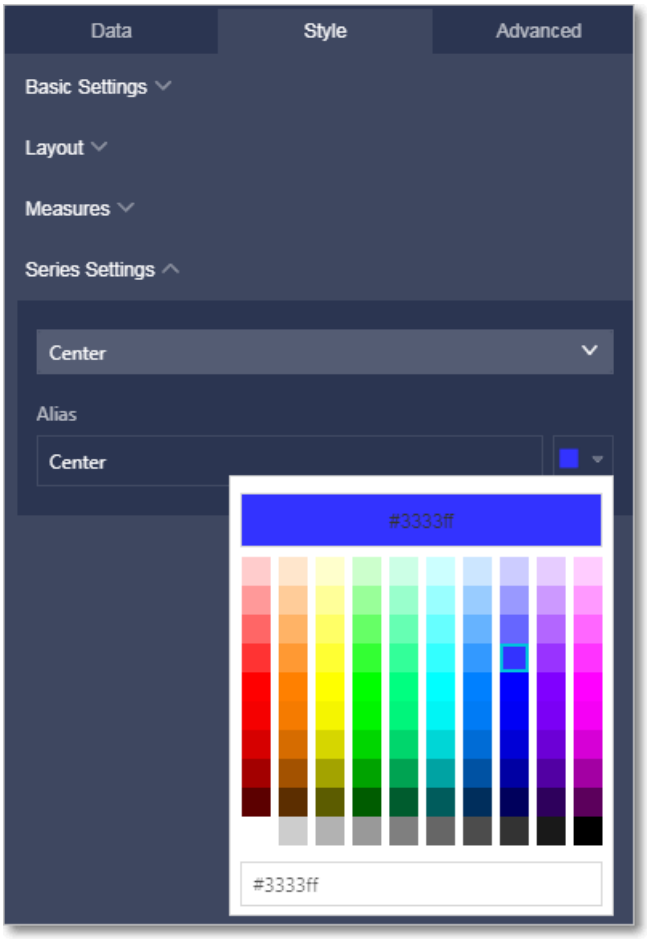
6. Click **Update**. The chart is updated.
7. Click the **Style** tab, and change the title and layout of the polar diagram, as shown in The polar diagram.

   The polar diagram



8. Click the **Style** tab, and change the legend colors in the **Series Settings** field.

   Change legend colors



9. Click **Save** in the upper-right corner and enter a name for the dashboard in the Save Dashboard dialog box that appears.
10. Click **OK** to save the dashboard.

    If you want to delete the chart, click the **More** icon in the upper-right corner of the chart and select **Delete**.

5.4.4.22. Create a word cloud

A word cloud displays the frequency of words in a dataset. It is ideal for creating user personas and user tags.

Prerequisites

- The Quick BI service is purchased.
- A dataset is created.

Context

A word cloud displays words in different sizes based on their frequency of use. Words are determined by data dimensions, such as customer name and product type. The size of each word is determined by a data measure, such as profit or unit price.

You can specify only one dimension and one measure for each word cloud.

The following example uses the company_sales_record dataset to describe how to use a word cloud to compare the order quantities in different provinces.

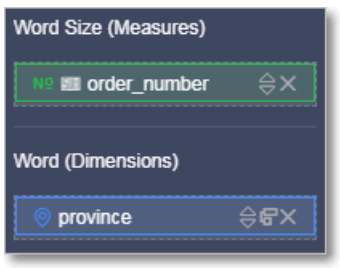
Procedure

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** tab, click **Datasets** to go to the Datasets page.
3. Find the company_sales_record dataset, click the **Create Dashboard** icon in the Actions column, select **Standard** in the dialog box that appears, and click OK.
4. On the dashboard edit page, click the **Word Cloud** icon.
5. On the **Data** tab, select the required dimension and measure.

   In the Dimensions list, find and add the province dimension to the Word (Dimensions) field. In the Measures list, find and add the order_number measure to the Word Size (Measures) field, as shown in Specify fields for the word cloud.

   > **Note** Ensure that you have converted the dimension type of province from String to Geo. For information about how to convert a dimension type, see Edit a dimension.

   Specify fields for the word cloud

6. Click **Update**. The chart is updated.
7. Click the **Style** tab, and change the title of the word cloud, as shown in The word cloud.

   The word cloud

8. Click **Save** in the upper-right corner and enter a name for the dashboard in the Save Dashboard dialog box that appears.
9. Click **OK** to save the dashboard.

   If you want to delete the chart, click the **More** icon in the upper-right corner of the chart and select **Delete**.

5.4.4.23. Create a tornado-leaned funnel chart

A tornado-leaned funnel chart is the combination of a tornado chart and a funnel chart. A tornado chart is used to compare different metrics between two objects, for example, the income difference and the education level difference between residents in two cities. A funnel chart is used to show the conversion rates between the stages of business processes, such as the percentage of visitors that become paying customers. Funnel charts are ideal for business process analysis.

Prerequisites

- The Quick BI service is purchased.
- A dataset is created.

Context

A tornado-leaned funnel chart combines the features of a tornado chart and a funnel chart. For example, assume you want to compare the percentage of the migrant population, employment rate, and commercial housing transactions in Beijing and Shanghai, and that a conversion relationship exists between these metrics. The tornado-leaned funnel chart shows the values of the metrics for the two cities and also the conversion rates between the metrics.

If no conversion relationship exists, the tornado-leaned funnel chart functions as a tornado chart. If a conversion relationship exists between metrics and but one comparison subject is defined, the chart functions as a funnel chart.

A tornado-leaned funnel chart consists of comparison subjects and metrics. Comparison subjects are determined by a dimension, such as area or product type. Metrics are determined by measures, such as order quantity and order price.

For each tornado-leaned funnel chart, you can specify only one dimension to determine the comparison subjects. Whereas, you must specify at least one measure to determine metrics.

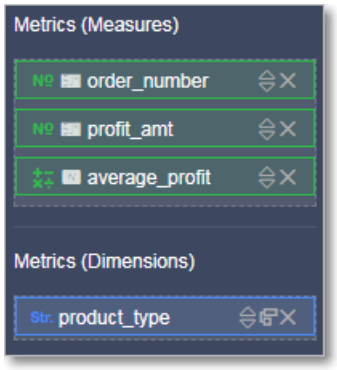
The following example uses the company_sales_record dataset to describe how to use a tornado-leaned funnel chart to compare the order quantities, profits, and average profits of different products.

Procedure

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** tab, click **Datasets** to go to the Datasets page.
3. Find the company_sales_record dataset, click the **Create Dashboard** icon in the Actions column, select **Standard** in the dialog box that appears, and click OK.
4. On the dashboard edit page, click the **Tornado-Leaned Funnel Chart** icon.
5. On the **Data** tab, select the required dimension and measures.

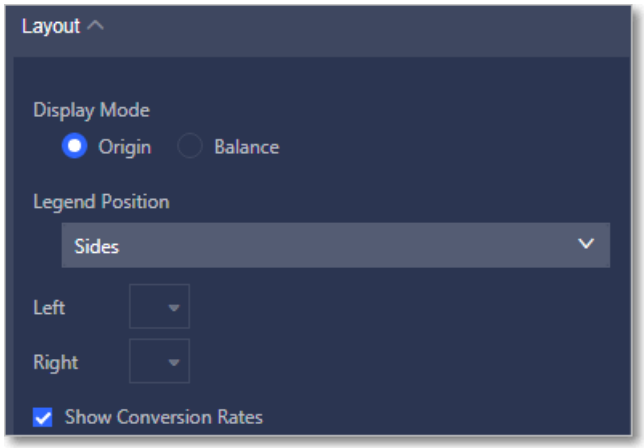
   In the Dimensions list, find and add the product_type dimension to the **Metrics (Dimensions)** field. In the Measures list, find and add the order_number, profit_amt, and average_profit measures to the **Metrics (Measures)** field, as shown in Specify fields for the tornado-leaned funnel chart.

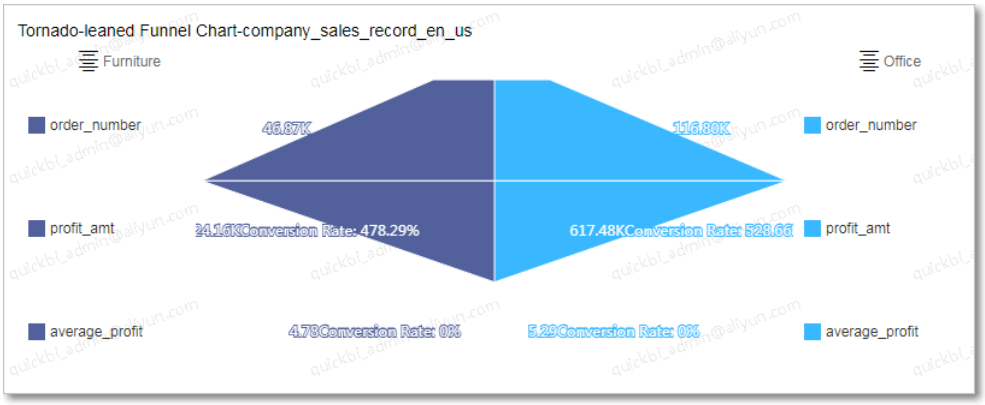
   Specify fields for the tornado-leaned funnel chart

6. Click **Update**. The chart is updated.
7. Click the **Style** tab, change the title, layout, legend position, and background color, and specify whether to show the conversion rate.
   i. Quick BI provides two types of layouts for tornado-leaned funnel charts. Select the layout as needed.
   ii. In the **Layout** section on the Style tab, change the legend position and background color, and specify whether to show the conversion rate, as shown in The tornado-learned funnel chart.

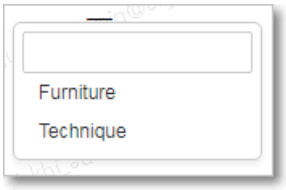
The tornado-learned funnel chart





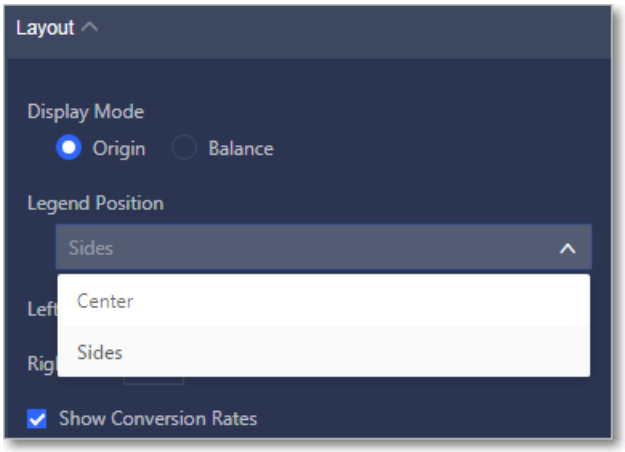
- You can move the pointer over the product type field on the chart to switch to another product, as shown in Switch to another product.

  Switch to another product

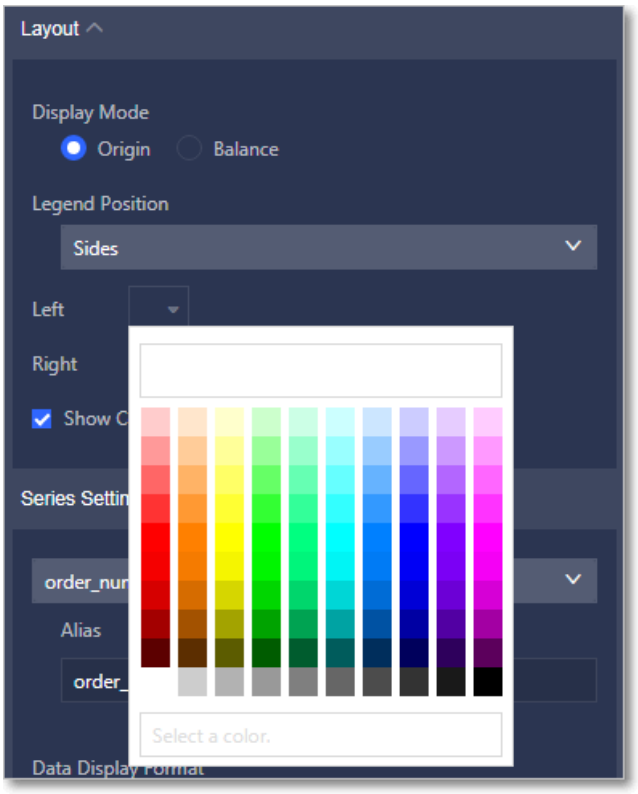
- Change the legend position, as shown in Change the legend position.

  Change the legend position

- Click the Color icon next to Left or Right and select a color from the drop-down list, as shown in Change legend colors.

  Change legend colors

- Hide or show the conversion rate, as shown in Hide or show the conversion rate.

  Hide or show the conversion rate

8. Click **Save** in the upper-right corner and enter a name for the dashboard in the Save Dashboard dialog box that appears.
9. Click **OK** to save the dashboard.

   If you want to delete the chart, click the **More** icon in the upper-right corner of the chart and select **Delete**.

5.4.4.24. Create a hierarchy chart

A hierarchy chart uses a tree structure to organize and display hierarchical data. It is an implementation of the enumeration method. For example, when you review revenues of cities in a province, the relationships between the province and the cities are displayed in a hierarchical structure. Hierarchy charts are ideal for analyzing data related to organizational structures, such as the staff structure of a company or department structure of a hospital.

Prerequisites

- The Quick BI service is purchased.

- A dataset is created.

Context

A hierarchy chart consists of node metrics and node labels. Node labels are determined by data dimensions, such as area and product type. Node metrics are determined by data measures, such as order quantity and order price.

This topic uses the following scenarios as examples to describe how to use a hierarchy chart and the filter:

- Scenario 1: Compare the order quantities of different products in the provinces of different regions.
- Scenario 2: View the average profits of different products in different municipalities.

In a hierarchy chart, you must specify at least two dimensions for the node labels. Data is displayed clear if these dimensions have a hierarchical relationship. You must specify at least one measure for the node metrics.

Scenario 1: Compare the order quantities of different products in the provinces of different regions

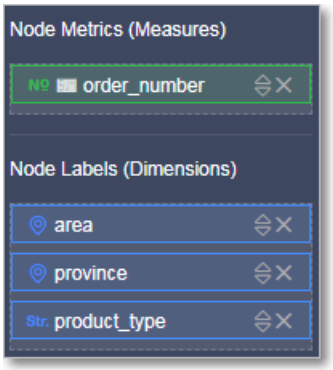
Procedure

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** tab, click **Datasets** to go to the Datasets page.
3. Find the company_sales_record dataset, click the **Create Dashboard** icon in the Actions column, select **Standard** in the dialog box that appears, and click OK.
4. On the dashboard edit page, click the **Hierarchy Chart** icon.
5. On the **Data** tab, select required dimensions and measures.

   In the Dimensions list, find and add the area, province, and product_type dimensions to the Node Labels (Dimensions) field. The sequence in which you add the dimensions determines the hierarchical relationship in the chart. In the Measures list, find and add the order_number measure to the Node Metrics (Measures) field, as shown in the following figure.

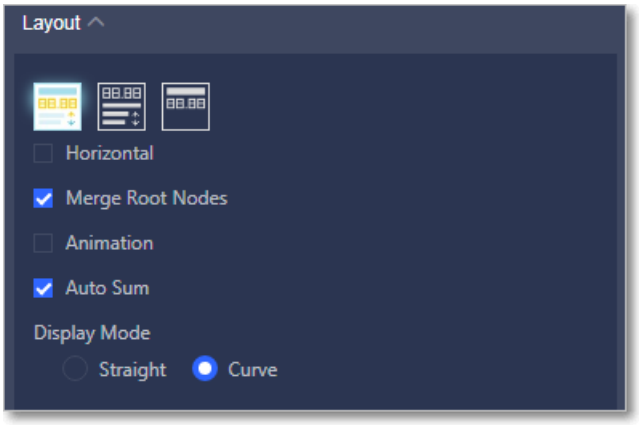
   > **Note** Ensure that you have converted the dimension type of area and province from String to Geo. For information about how to convert a dimension type, see Edit a dimension.

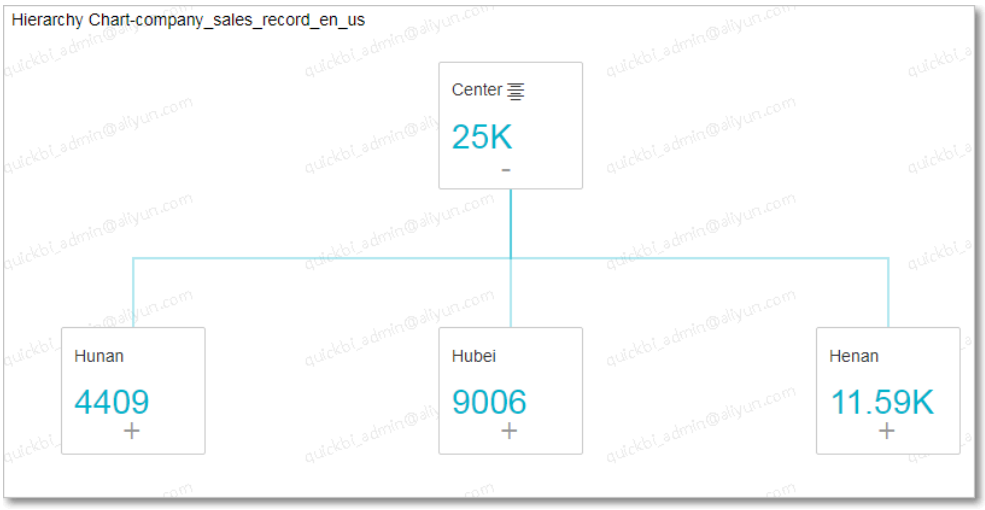
   Specify fields for the hierarchy chart



6. Click **Update**. The chart is updated.
7. Click the **Style** tab, and change the title, layout, and design of the chart.
   i. Quick BI provides three types of layouts for hierarchy charts. You can select the structure and display mode that best meet your business needs. The Merge Root Nodes check box is selected by default. In the following example, the **Straight** display mode is selected.

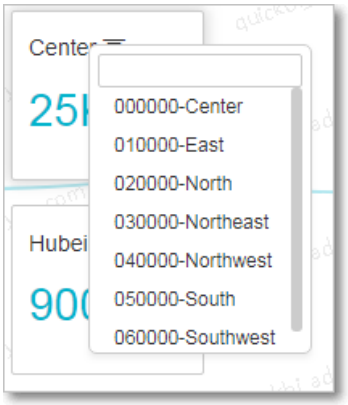
Layout





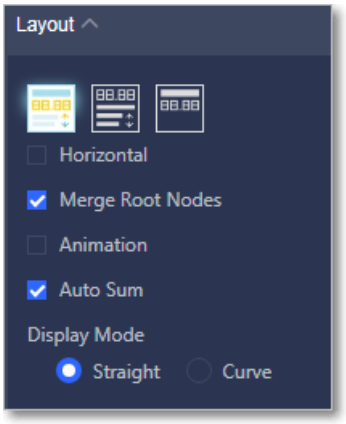
- Move the pointer over the area field in the chart and switch to another region from the drop-down list that appears, as shown in the following figure.

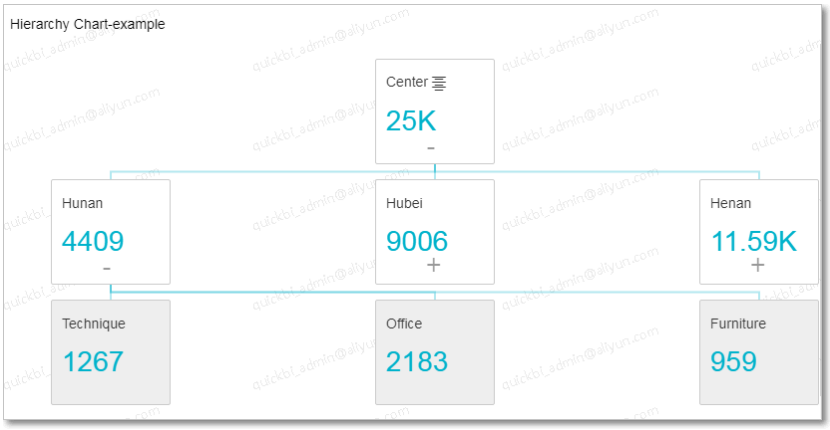
Switch to another region



- Click the minus sign (-) or plus sign (+) to fold or unfold the child nodes.
- In the Layout area, if you select **Auto Sum**, the chart displays the total amount in each node, as shown in the following figure.

Auto Sum

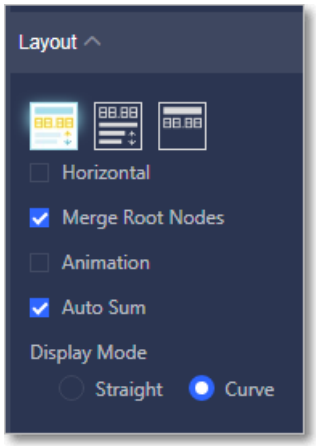


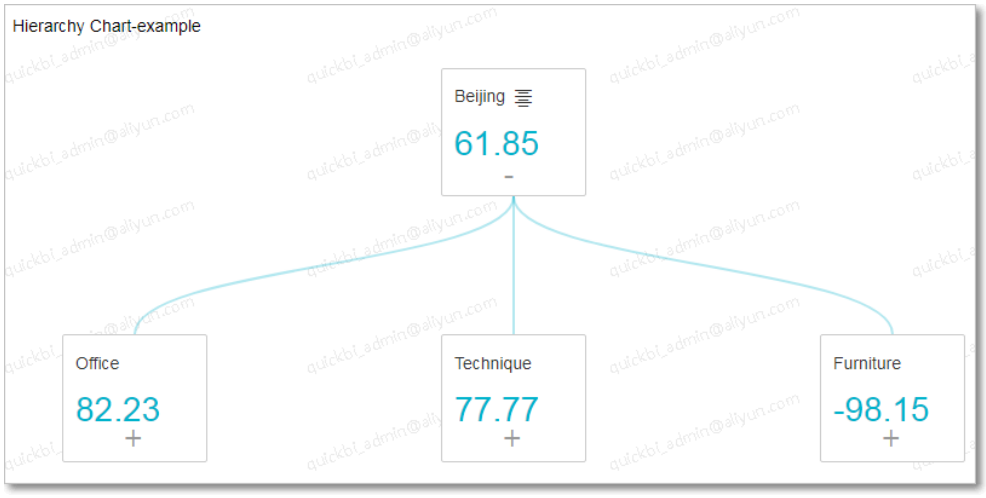


ii. On the Design tab, you can set the Levels field to specify the level of data to be displayed. You can also set a primary path, which is displayed in a different color in the chart. You can select the Show Filter Bar check box to add a toolbar to the chart. This allows you to edit the chart in the preview mode or in the dashboard.

In the following example, the Primary Path parameter is set to order_number, the Sort parameter is set to Ascend, the Show Filter Bar check box is selected, and the **Curve** display mode is selected, as shown in the following figure.

The hierarchy chart





8. Click **Save** in the upper-right corner and enter a name for the dashboard in the Save Dashboard dialog box that appears.
9. Click **OK** to save the dashboard.

   By default, the dashboard is saved to **My Items** on the Dashboards page.

Scenario 2: View the average profits of different products in different municipalities

Context

Data modeling may be required in this scenario. For information about data modeling, see Add a calculated field.

Procedure

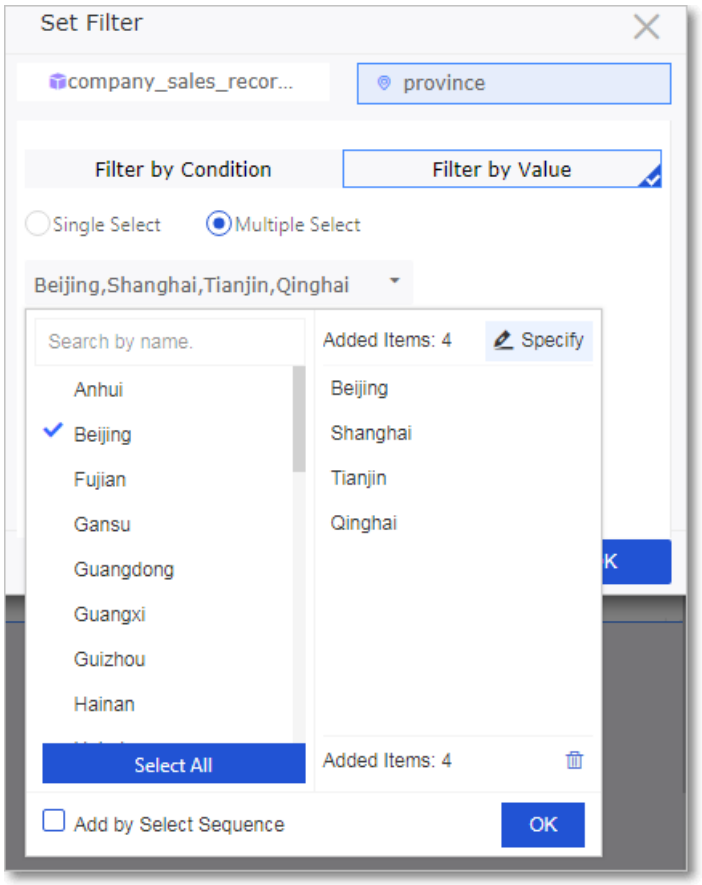
1. In the Dimensions list, find and add the province dimension to the Filters field.

   This way, you can filter municipalities.

2. Click the **Filter** icon. In the Set Filter dialog box that appears, select **Filter by Value** and **Multiple Select**, as shown in the following figure.

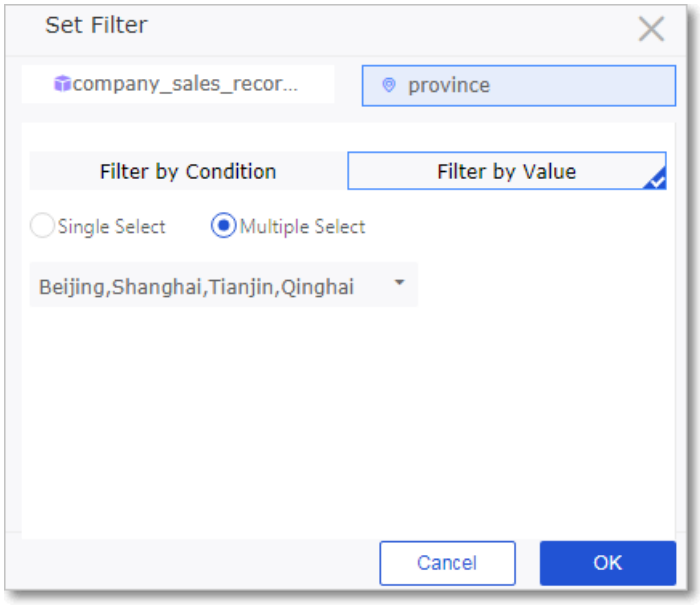
   The system automatically lists all available options of the province field in the drop-down list.

   Filter by value



3. Select the municipalities or manually enter their names.
4. Click **OK** to set the filter condition, as shown in the following figure.

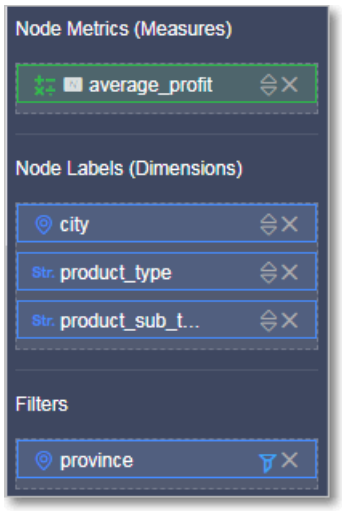
   Set the filter condition



5. In the Dimensions list, find and add the city, product_type, and product_sub_type dimensions to the Node Labels (Dimensions) field, as shown in the following figure.

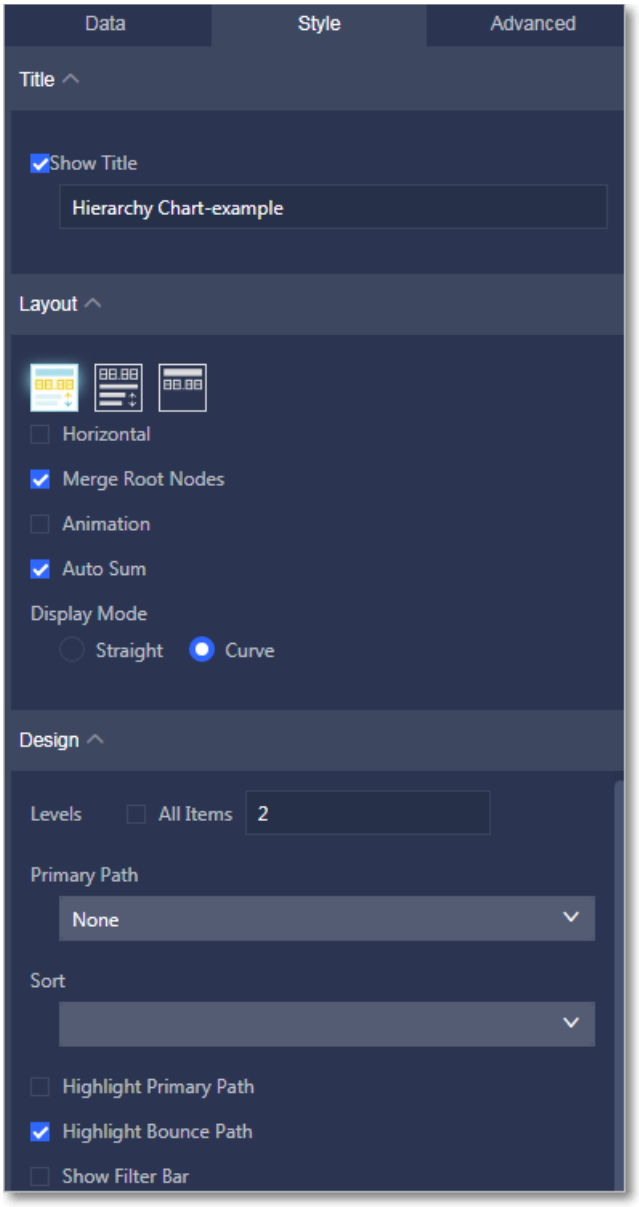
   The sequence in which you add these dimensions determines the hierarchical relationship displayed in the chart. In the Measures list, find and add the average_profit measure to the Node Metrics (Measures) field.

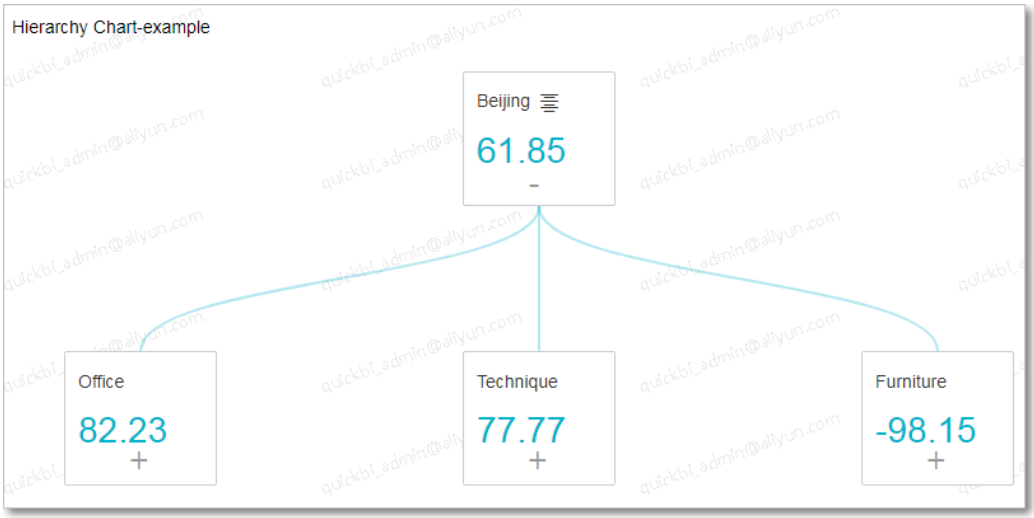
   Specify fields for the hierarchy chart



6. Click **Update**. The chart is updated.
7. Click the **Style** tab, and change the title, layout, and design of the chart, as shown in the following figure.

   The hierarchy chart





8. Click **Save** in the upper-right corner and enter a name for the dashboard in the Save Dashboard

dialog box that appears.

9. Click **OK** to save the dashboard.

   If you want to delete the chart, click the **More** icon in the upper-right corner of the chart and select **Delete**.

5.4.4.25. Create a flow analysis chart

A flow analysis chart illustrates the conversion rate of a website by comparing its page visits or Page Views (PV) and Unique Visitors (UV). This helps you understand the overall performance of marketing campaigns and measure the sales volume of certain products. Flow analysis charts are ideal for analyzing digital marketing campaigns and e-commerce websites. For example, you can use flow analysis charts to find out which products are in demand and determine the peak hours of your business.

Prerequisites

- The Quick BI service is purchased.
- A dataset is created.

Context

In a flow analysis chart, you must specify dimensions for the previous page, current page, and next page and a measure for the PV, UV, conversion rate, and bounce rate. Each page has respective PV and UV.

You can specify only one dimension for each of the three pages. The dimensions must have a hierarchical relationship. The sequence that you add the dimensions determines the hierarchical relationship. For the PVs or UVs, the conversion rate, and the bounce rate, you can specify only one measure.

The three dimensions, the conversion rate, and the bounce rate are mandatory fields. You can specify only the PV or UV for the previous, current, and next pages. The system prompts an error message if you add the wrong dimension or measure.

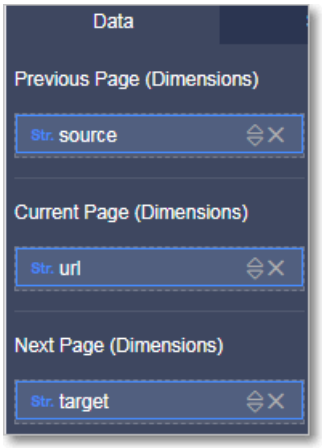
The following example uses the page_source_target_day_stat dataset to describe how to use a flow analysis chart to demonstrate the conversion rate and bounce rate between pages based on PV.

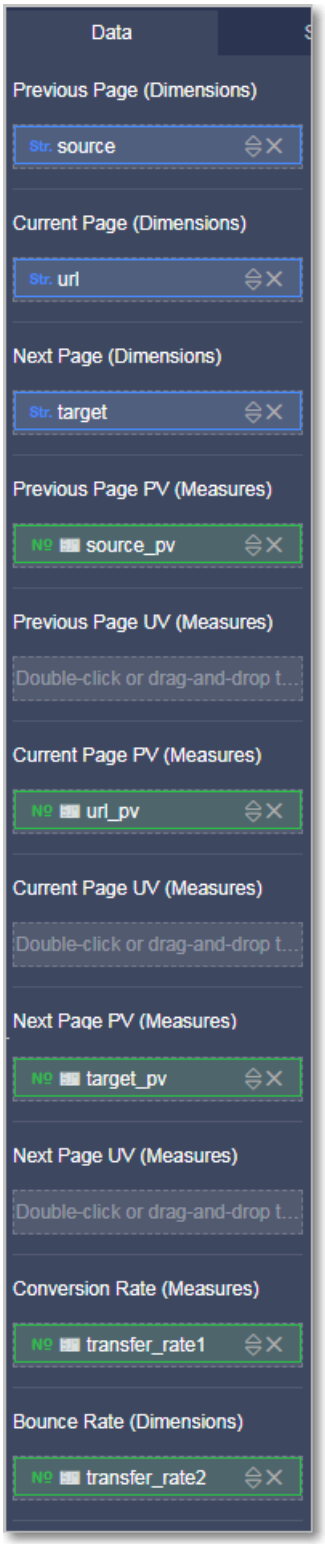
Procedure

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** tab, click **Datasets** to go to the Datasets page.
3. Find the page_source_target_day_stat dataset, click the **Create Dashboard** icon in the Actions column, and select **Standard** in the dialog box that appears.
4. On the dashboard edit page, click the **Flow Analysis** icon.
5. On the **Data** tab, select the required dimensions and measures.

In the Dimensions list, find the target dimensions and add them to the Previous Page (Dimensions), Current Page (Dimensions), and Next Page (Dimensions) fields. The sequence of these dimensions determines the hierarchical relationship in the chart. In the Measures list, find and add the target measures to the Conversion Rate (Measures), Bounce Rate (Measures), Previous Page PV (Measures), Current Page PV (Measures), Next Page PV (Measures), Previous Page UV (Measures), Current Page UV (Measures), and Next Page UV (Measures) fields.

Specify fields for the flow analysis chart

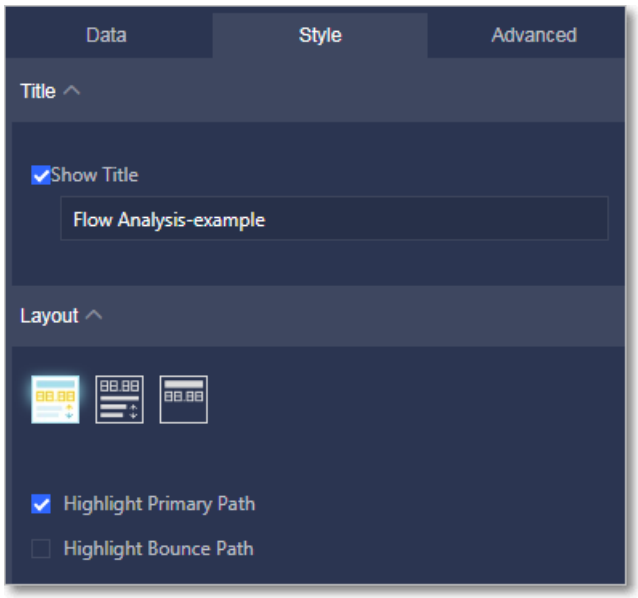


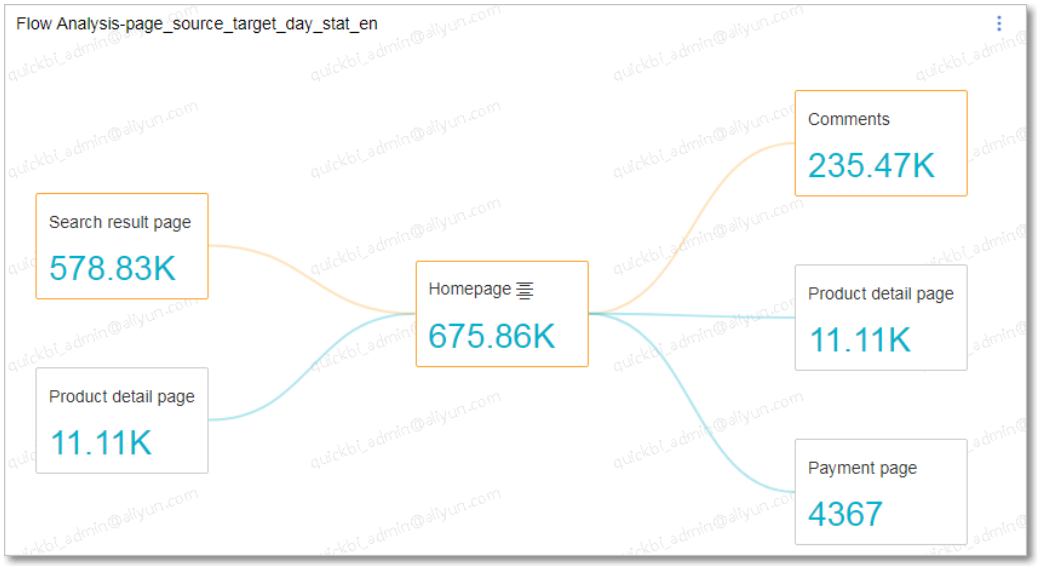


6. Click **Update**. The chart is updated.
7. On the **Style** tab, change the title and layout of the chart.

   Quick BI provides three types of layouts for flow analysis charts. You can also select Highlight Primary Path or Highlight Bounces as needed. In the following example, Highlight Primary Path is selected. The primary path is displayed in a different color in the chart, as shown in The flow analysis chart.

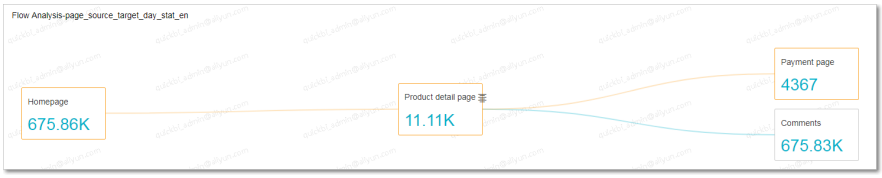
The flow analysis chart





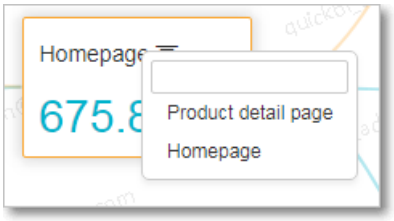
- Click the **View** icon to view the flow analysis of the page. If the View icon is not displayed, no flow analysis can be performed on this page, as shown in View flow analysis.

  View flow analysis

- You can move your pointer over the Switch icon to switch to another page for flow analysis, as shown in Switch to another page.

  Switch to another page



8. Click **Save** in the upper-right corner and specify a name for the dashboard in the Save Dashboard dialog box that appears.
9. Click **OK** to save the dashboard.

   If you want to delete the chart, click the **More** icon in the upper-right corner of the chart and select **Delete**.

5.4.5. Full Screen mode

This topic describes the basic features of the Full Screen mode.

The Full Screen mode allows you to perform the following operations in the display area of a dashboard.

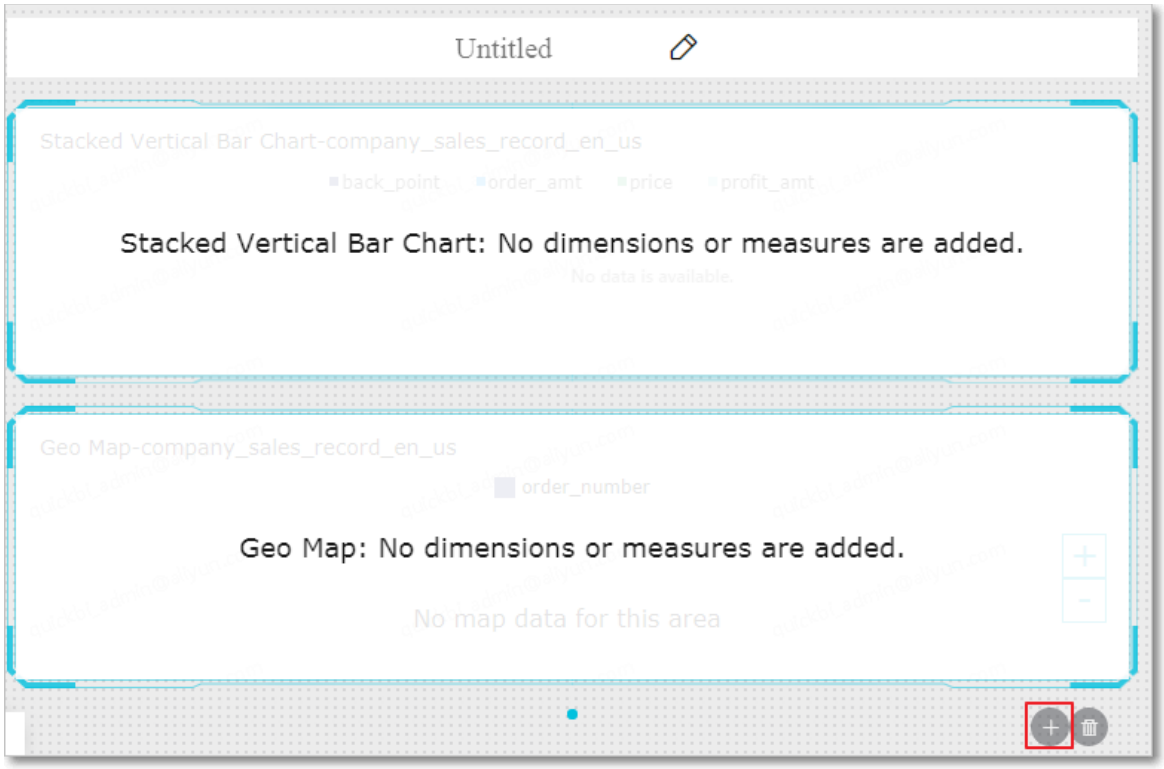
- Adjust chart positions
- Add a subscreen
- View chart data
- Delete a chart
- Change chart types
- Configure page settings

Adjust chart positions

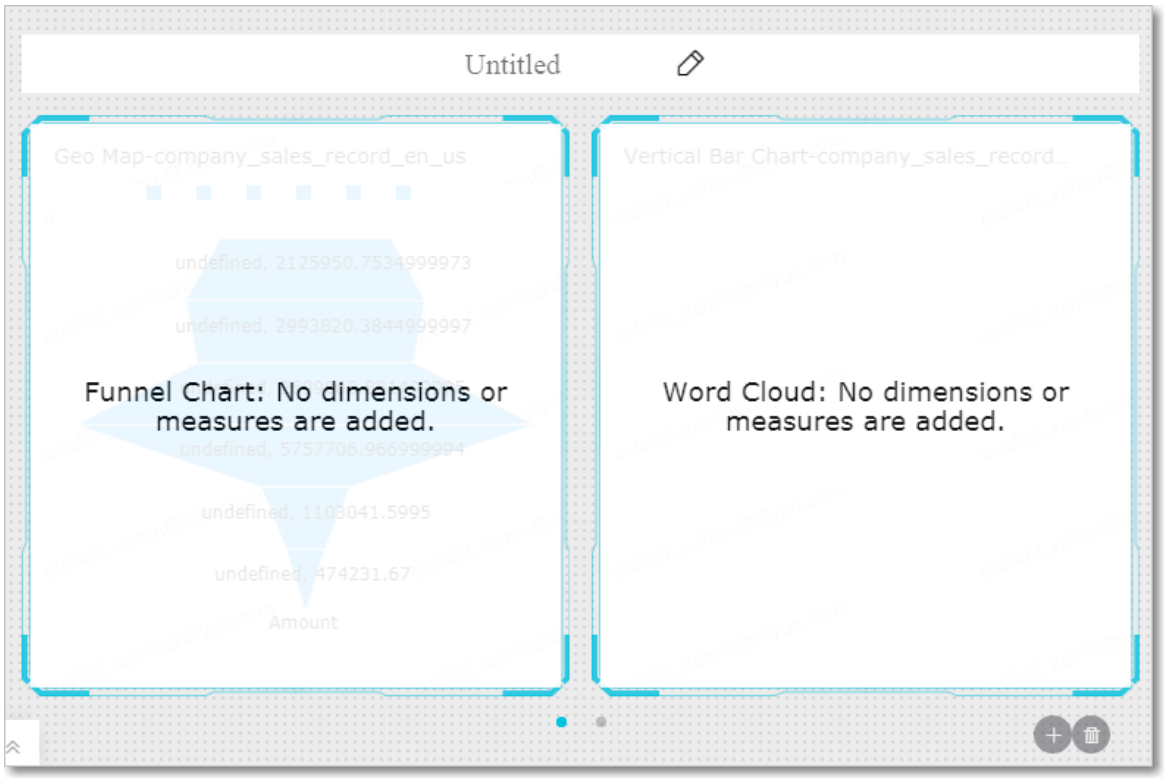
If you create a dashboard by using the Full Screen mode and you have created only one chart, the chart covers the entire display area. If you have created multiple charts, you can click the Move icon (an arrow cross symbol), and drag the chart to the target position.

Add a subscreen

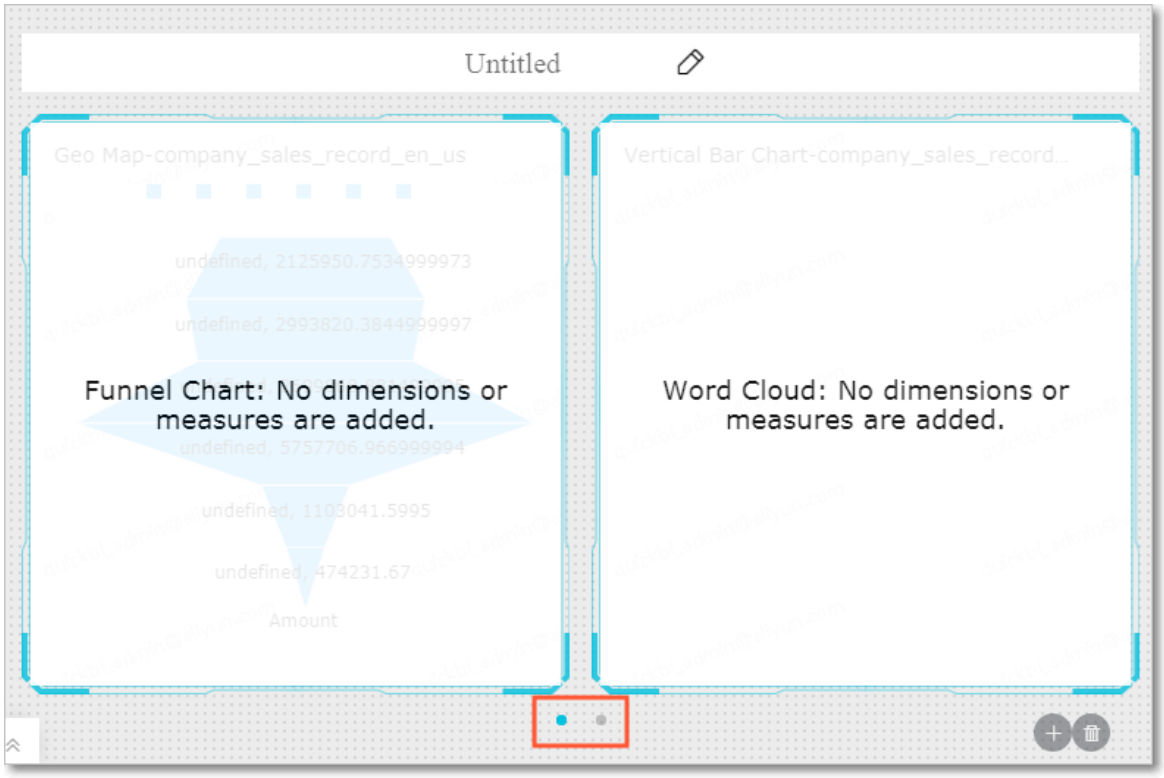
1. Click the plus sign in the lower-right corner.



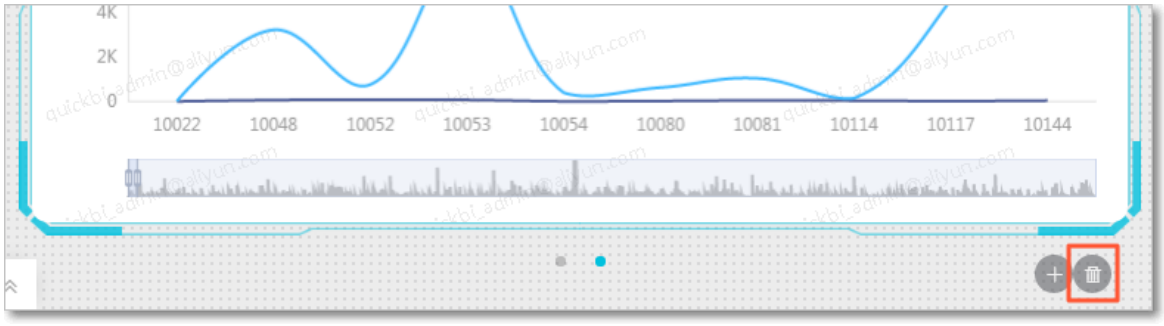
2. Add a chart to the subscreen.



3. Click the **Switch Screen** icon to switch from the current screen to another.



4. Click the **Delete** icon in the lower-right corner to delete a subscreen.



View data, export and view SQL statements, and delete a chart

1. In the target chart, click the More icon in the upper-right corner.
2. Select **View Data** to view chart data.
3. Select **Export** to export the chart data to a local device.
4. Select **View SQL Statements** to view the SQL statements.
5. Select **Delete** to delete the chart.

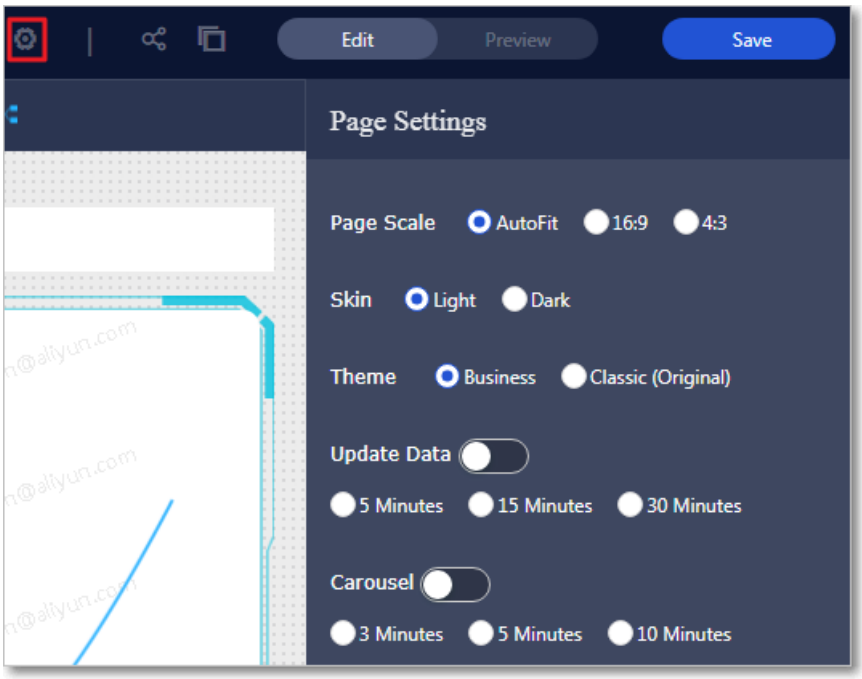
Change chart types

1. Select a chart in the display area of a dashboard.
2. In the Graphic Design area, click **Change Chart Type**.
3. Click the chart type you want.

> **Note**
>
> If the chart type fails to change, the fields of the current chart do not match those of the target chart. You must manually adjust fields before you change the chart type. The system provides instructions to help you adjust fields based on the current and target chart types. To change the chart type, you need to follow the instructions to adjust the dimensions and measures.

Page settings

You can click the **Page settings** icon to set the page scale, skin color, theme, data update interval, and time interval of data carousel.



5.4.6. Search for a dashboard

This topic describes how to search for a specific dashboard.

Prerequisites

- The Quick BI service is purchased.
- One or more dashboards are created.

Procedure

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** page, click **Dashboards**.
3. Enter a keyword in the search box to search for the target dashboard.

5.4.7. Create a dashboard folder

This topic describes how to create a dashboard folder.

Prerequisites

The Quick BI service is purchased.

Procedure

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** page, click **Dashboards**.
3. On the Dashboards page, click **Create Folder** in the upper-right corner.
4. In the **Create Folder** dialog box that appears, specify a name for the folder and click **OK**.

5.4.8. Rename a dashboard folder

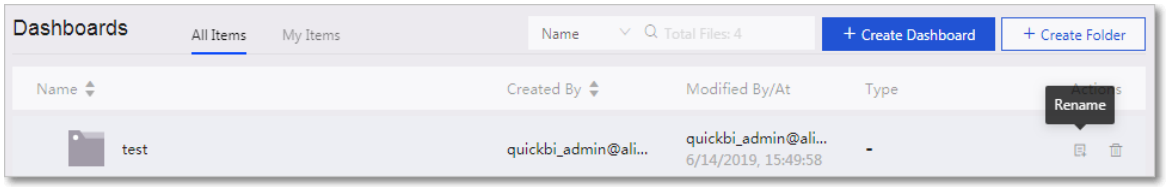
This topic describes how to rename a dashboard folder.

Prerequisites

- The Quick BI service is purchased.
- A dashboard folder is created. For information about how to create a dashboard folder, see Create a dashboard folder.

Procedure

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** page, click **Dashboards**.
3. On the Dashboards page, find the dashboard folder you want to rename.
4. Click the **Rename** icon in the Actions column.



5. In the dialog box that appears, enter a new folder name and click **OK**.

5.4.9. Share a dashboard

This topic describes how to share a dashboard with other users.

Prerequisites

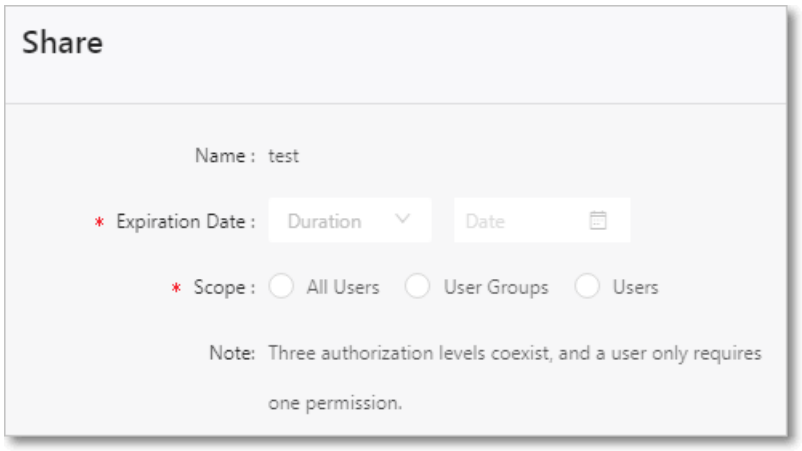
- The Quick BI service is purchased.
- A dashboard folder is created. For information about how to create a dashboard folder, see Create a dashboard folder.

Procedure

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** page, click **Dashboards**.
3. On the Dashboards page, right-click the dashboard you want to share with others.

4. Select **Share**.
5. Specify the user that you want to share the dashboard with and an expiration date, as shown in Share a dashboard.

   Share a dashboard



> **Note** You can set the Scope parameter to All Users, User Groups, or Users as needed.

6. Click **Save** to share the dashboard.

5.4.10. Make a dashboard public

After you make a dashboard public, users can access the dashboard by using a shared link.

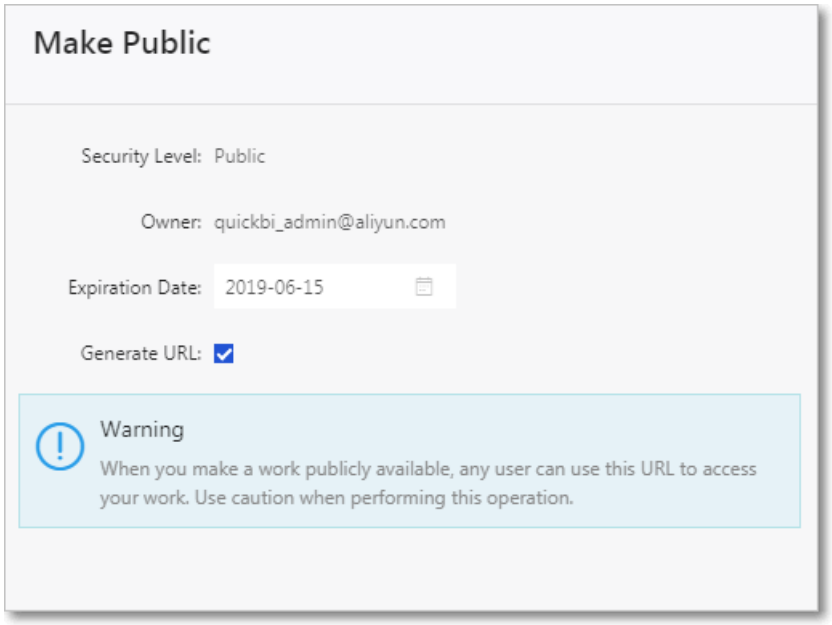
Prerequisites

- The Quick BI service is purchased.
- A dashboard folder is created. For information about how to create a dashboard folder, see Create a dashboard folder.

Procedure

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** page, click **Dashboards**.
3. On the Dashboards page, right-click the dashboard you want to make public or click the More icon in the Actions column corresponding to the dashboard you want to make public.
4. Select **Make Public**.
5. Set an expiration date and click **Make Public**, as shown in Make a dashboard public.

   Make a dashboard public



5.5. Workbooks

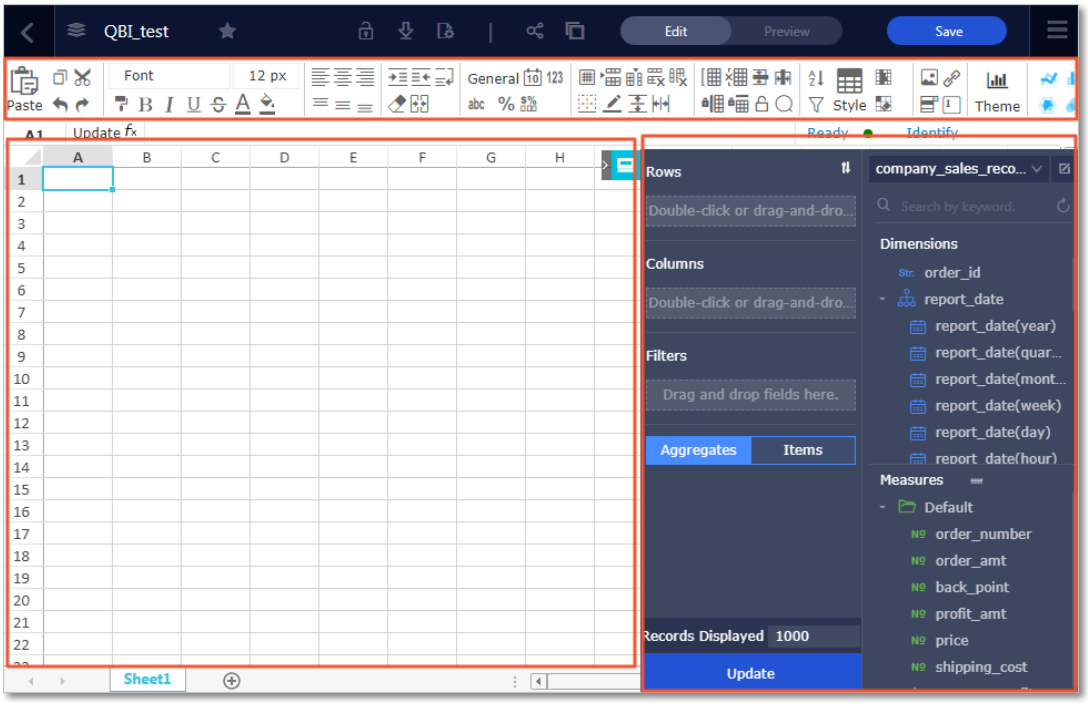
5.5.1. Overview

On the workbook edit page, you can filter and query data in a dataset. You can also visualize data by using different types of charts.

The workbook edit page contains three areas, as shown in Workbook edit page.

- Dataset selection area
- Workbook configuration area
- Workbook display area

Workbook edit page



- Dataset selection area: In this area, you can switch the current dataset to another. The fields of each dataset are displayed in the Dimensions and Measures lists based on the data types preset in the system. You can select dimensions and measures based on the data required by the chart.
- Workbook configuration area: In this area, you can select a chart type, and set the color, font, and data format of cells as needed.
- Workbook display area: In this area, you can reprocess data based on the displayed data in cells and reference data.

5.5.2. Create a workbook

This topic describes how to create a workbook.

Prerequisites

The Quick BI service is purchased.

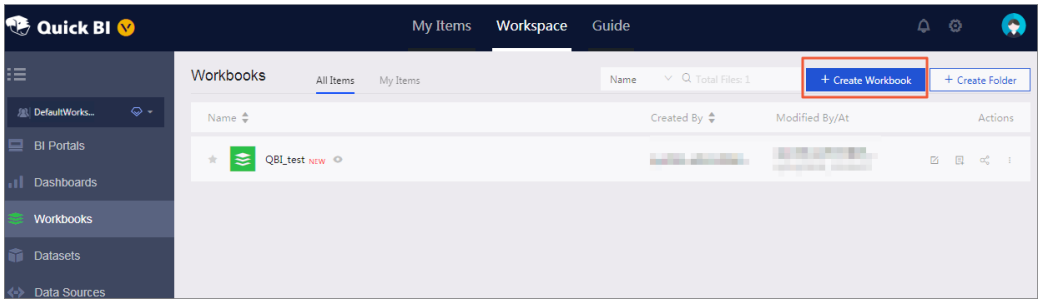
Context

You can create workbooks only in workspaces. Personal workspaces do not support workbooks.

Procedure

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** page, click **Workbooks**.
3. On the **Workbooks** page, click **Create Workbook** to go to the workbook edit page, as shown in Create a workbook.

   Create a workbook



4. Click **Save**. In the Save Workbook dialog box that appears, enter a name for the workbook and set the location where you want to store the workbook, and click **OK**.

5.5.3. Switch to another dataset

This topic describes how to switch from the current dataset to another dataset.

Prerequisites

The Quick BI service is purchased.

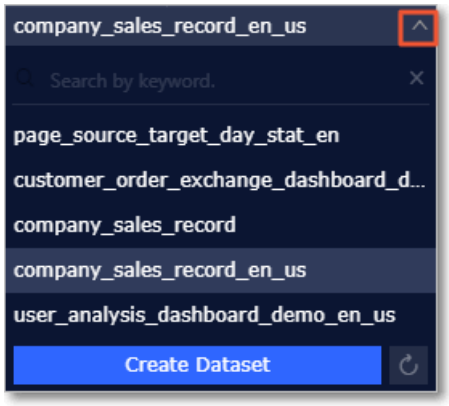
Context

If you cannot find the required dataset, go back to the dataset management page and ensure that the dataset has been created. For information about how to create a dataset, see Create datasets.

Procedure

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** page, click **Workbooks** to go to the **Workbooks** page.
3. Click the workbook you want to edit.
4. On the workbook edit page, click the drop-down arrow. In the drop-down list, select or search for the dataset you want to switch to, as shown in Switch to another dataset.

Switch to another dataset



5.5.4. Search for a dimension or measure

This topic describes how to search for a specific dimension or measure.

Prerequisites

The Quick BI service is purchased.

Context

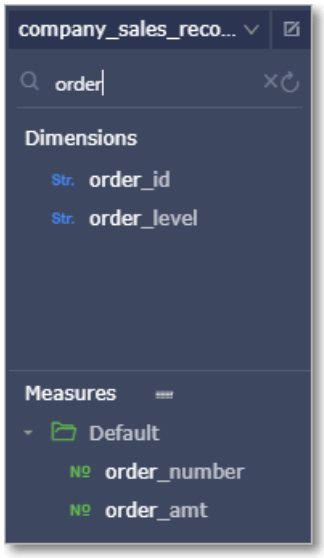
After you select a dataset, the system displays the dimensions in the Dimensions list and measures in the Measures list.

For information about how to edit dimensions and measures, see Edit a dimension and Edit a measure.

Procedure

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** page, click **Workbooks** to go to the **Workbooks** page.
3. Enter a keyword of the field you want to search in the search box.
4. Click the Search icon to search for the field.

Search for a field



5.5.5. Set the font

You can set a font for a specific text, such as the font size, font color, font style, and background color.

Prerequisites

The Quick BI service is purchased.

Procedure

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** page, click **Workbooks** to go to the **Workbooks** page.
3. On the Workbooks page, click the workbook that you want to set the font.

For information about how to create a workbook, see Create a workbook.

4. Click the specific icon to set the font size and style. Set the font style
   - Click the font area.
   - In the drop-down list that appears, select the target font, as shown in Select a font.

     Select a font

   Set the font size
   - Click the font size area.
   - In the drop-down list that appears, select the target font size, as shown in Select a font size.

     Select a font size

5.5.6. Set the alignment mode

You can set the alignment mode to adjust the layout of text.

Prerequisites

The Quick BI service is purchased.

Procedure

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** page, click **Workbooks** to go to the **Workbooks** page.
3. On the Workbooks page, click the workbook that you want to set the alignment mode.

   For information about how to create a workbook, see Create a workbook.
4. Click the specific alignment mode icon to adjust the layout of the text, as shown in Alignment modes.

   Alignment modes

5.5.7. Set text and number formats

You can set the format to display texts and numbers in a workbook.

Prerequisites

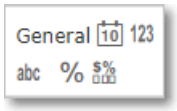
The Quick BI service is purchased.

Procedure

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** page, click **Workbooks** to go to the **Workbooks** page.
3. On the Workbooks page, click the workbook for which you want to set the text and number format.

   For information about how to create a workbook, see Create a workbook.
4. Click the specific icon to set the format, as shown in Display formats.

   Display formats

Parameter	Description
General	The General format directly displays numbers the way that you type them.
Date	The Date format displays data in the YYYY-MM-DD format.
Number	The Number format aligns numbers along the right side. It rounds numbers to two decimal places. You can double-click the cell or adjust the column width to show the complete number.
String	The String format aligns strings along the left side. You can double-click the cell or adjust the column width to show the complete string.
Percentage	The Percentage format aligns numbers along the right side. It rounds numbers to two decimal places. You can double-click the cell or adjust the column width to show the complete number.

5.5.8. Set the style, cell, and pane

You can change the style, cell, and pane settings to adjust the gridlines, row heights, and border styles.

Prerequisites

The Quick BI service is purchased.

Procedure

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** page, click **Workbooks** to go to the **Workbooks** page.
3. On the Workbooks page, click the workbook for which you want to change the style, cell, or pane settings.

   For information about how to create a workbook, see Create a workbook.

4. On the workbook edit page, click the specific icons to adjust the layout of the workbook, as shown in Style, cell, and pane settings.

   Style, cell, and pane settings

Parameter	Description
Gridlines	The gridlines are displayed by default. You can click the **Gridlines** icon to hide gridlines.
Borders	You can click the Borders icon to display a top border, bottom border, left border, right border, outside borders, or all borders, or remove all borders.
Border Color	You can specify a color for the borders.
Insert and Delete	You can insert rows and columns into a workbook, or delete rows and columns from a workbook. You can also insert and delete a workbook.
AutoFit Column Width	Double-click the AutoFit Column Width icon. The column width is automatically adjusted.
AutoFit Row Height	Double-click the AutoFit Row Height icon. The row height is automatically adjusted.

5.5.9. Insert images, hyperlinks, and drop-down list boxes

This topic describes how to insert images, hyperlinks, and drop-down list boxes into a workbook.

Prerequisites

The Quick BI service is purchased.

Procedure

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** page, click **Workbooks** to go to the **Workbooks** page.
3. On the Workbooks page, click the workbook for which you want to insert images, hyperlinks, or drop-down list boxes.

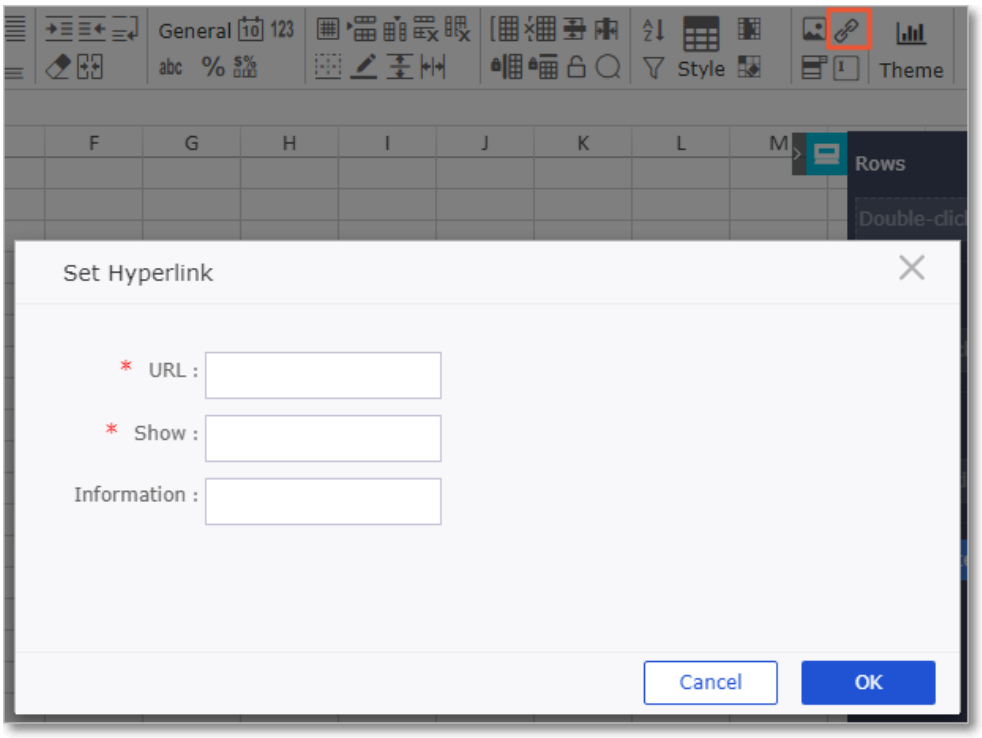
   For information about how to create a workbook, see Create a workbook.

   - Insert an image
     - Click the **Upload Image** icon.
     - In the Upload Image dialog box that appears, click **Select File** and select an image to upload.

- Click **OK** to insert the image.

- Insert a hyperlink
  - Click the **Hyperlink** icon.
  - In the Set Hyperlink dialog box that appears, enter the hyperlink that you want to insert and the text to display, as shown in Insert a hyperlink.

    Insert a hyperlink

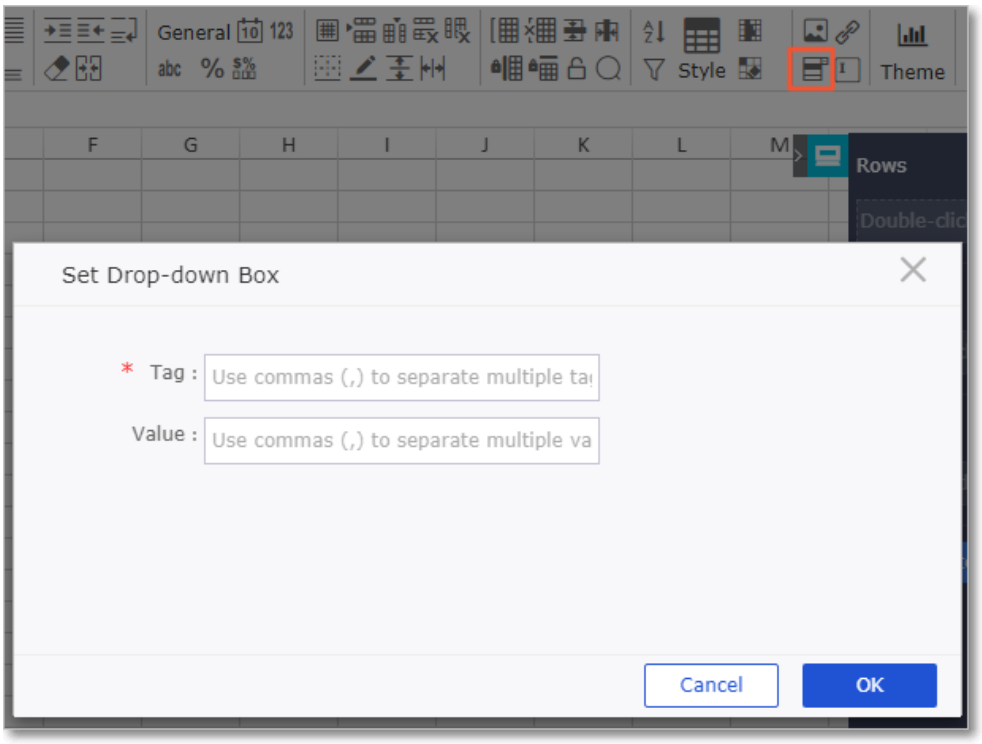
    

  - Click **OK** to insert the hyperlink.

- Insert a drop-down list box
  - Click the **Drop Down** icon.

- In the Set Drop-down Box dialog box that appears, specify tags and values, as shown in Set a drop-down box.

  Set a drop-down box



- Click **OK** to insert the drop-down list box.

5.5.10. Set the workbook style

This topic describes how to set the style for a workbook.

Prerequisites

The Quick BI service is purchased.

Procedure

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** page, click **Workbooks** to go to the **Workbooks** page.
3. On the Workbooks page, click the workbook for which you want to set the style.

   For information about how to create a workbook, see Create a workbook.
4. Click the **Style** icon.
5. Select an appropriate table style.

5.5.11. Set conditional formatting

This topic describes how to set conditional formatting, for example, highlight specific numbers or add an upward or downward arrow to indicate an ascending or descending order in a workbook.

Prerequisites

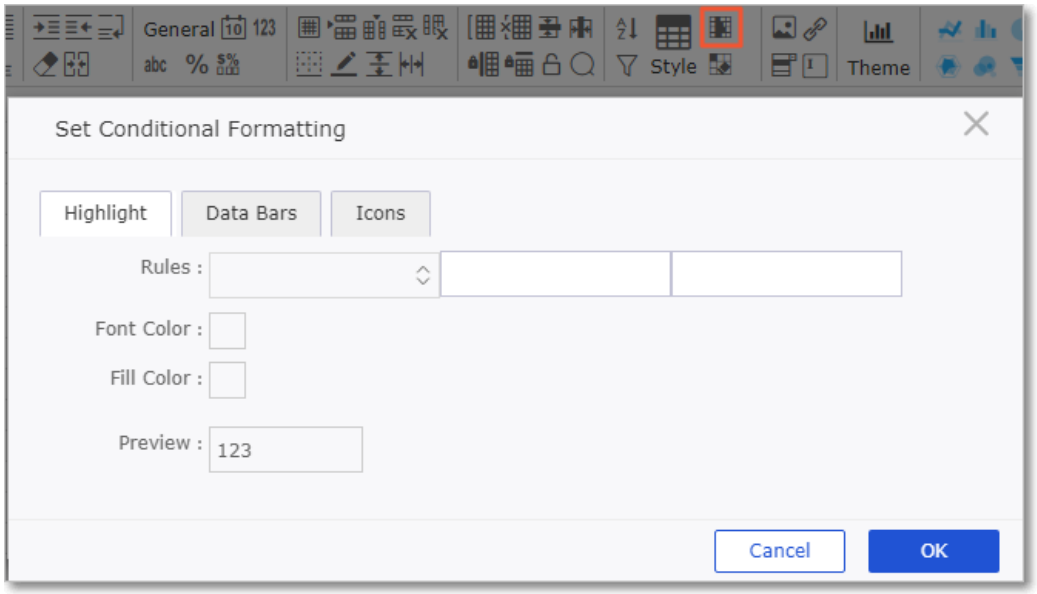
The Quick BI service is purchased.

Procedure

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** page, click **Workbooks** to go to the **Workbooks** page.
3. On the Workbooks page, click the workbook for which you want to set conditional formatting.

   For information about how to create a workbook, see Create a workbook.
4. Click the **Set Conditional Formatting** icon.
5. In the Set Conditional Formatting dialog box that appears, click the **Highlight** tab, as shown in Highlight settings.

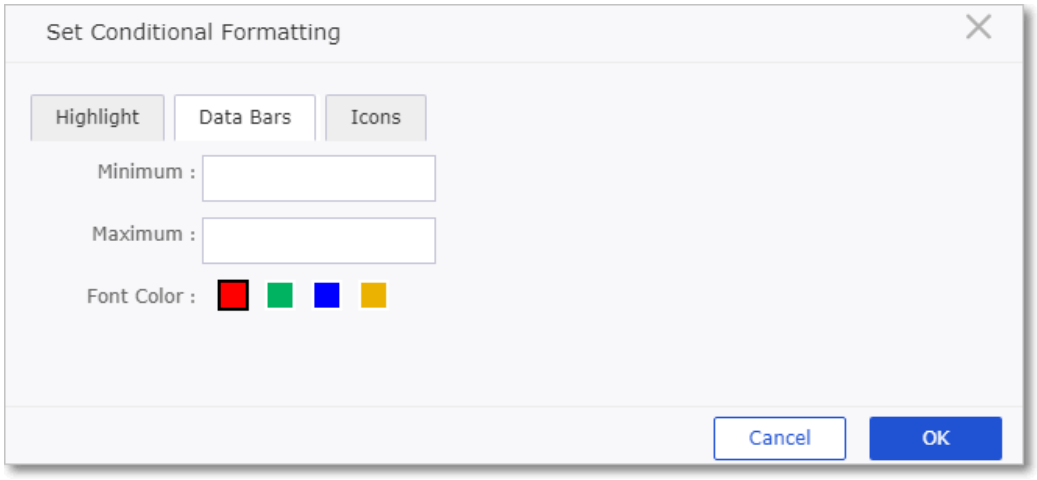
   Highlight settings



Parameter	Description
Rules	Click the drop-down icon to select a highlighting rule from the drop-down list, and specify a value or value range in the input boxes.
Font Color	Click the Color icon and select a color.
Fill Color	Click the Color icon and select a color.
Preview	Displays the highlight effect after you set the colors.

6. Click the **Data Bars** tab, as shown in Data Bars.

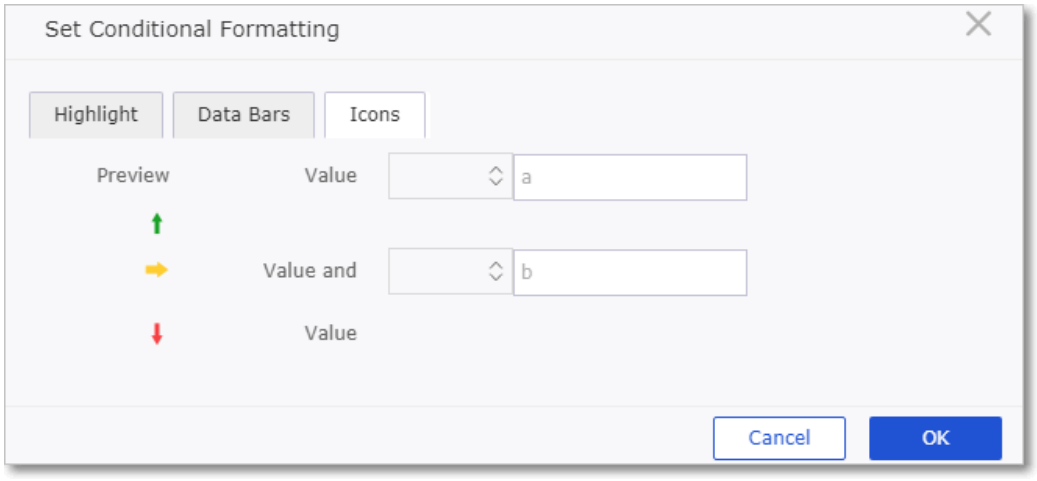
   Data Bars

Parameter	Description
Minimum	Enter a value in the input box.
Maximum	Enter a value in the input box.
Font Color	Click the Color icon and select a color.

7. Click the **Icons** tab, as shown in Icons.

   Icons

   Click the drop-down icon, select a mathematical notation from the drop-down list, and enter a value in the input box. A green, yellow, or red arrow appears next to the values that fit the specific value ranges.

8. After you set the parameters, click **OK**.

5.5.12. Search for a workbook

This topic describes how to search for a specific workbook.

Prerequisites

The Quick BI service is purchased.

Procedure

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** page, click **Workbooks** to go to the **Workbooks** page.
3. Enter a keyword in the search box.
4. Click the Search icon to search for the workbook.

5.5.13. Create a workbook folder

This topic describes how to create a workbook folder. Workbook folders help you manage workbooks.

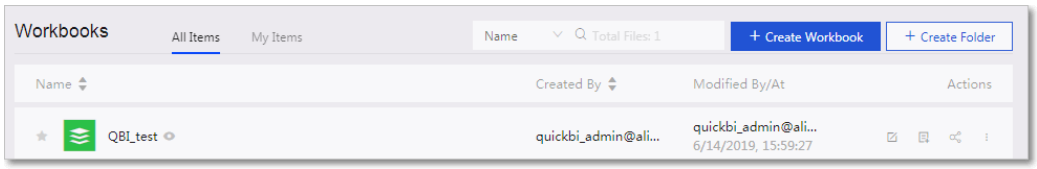
Prerequisites

The Quick BI service is purchased.

Procedure

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** page, click **Workbooks** to go to the **Workbooks** page.
3. Click **Create Folder**, as shown in Create a folder.

   Create a folder



4. In the Create Folder dialog box that appears, specify a name for the folder and click **OK**.

5.5.14. Rename a workbook folder

This topic describes how to rename a workbook folder.

Prerequisites

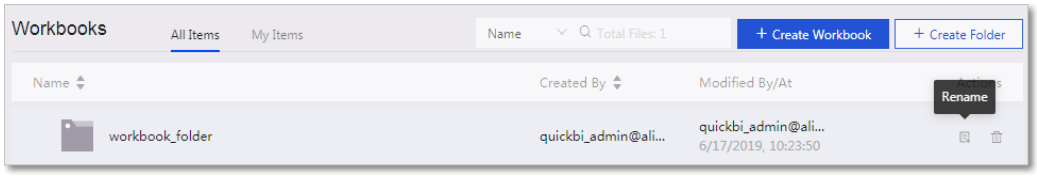
The Quick BI service is purchased.

Procedure

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** page, click **Workbooks** to go to the **Workbooks** page.
3. Find the workbook folder you want to rename and click the **Rename** icon in the Actions column, as

shown in Rename a workbook folder.

Rename a workbook folder



4. In the **Rename** dialog box that appears, enter a new folder name and click **OK**.

5.5.15. Share a workbook

This topic describes how to share a workbook with other users.

Prerequisites

The Quick BI service is purchased.

Procedure

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** page, click **Workbooks** to go to the **Workbooks** page.
3. Find the workbook that you want to share with other users.
4. Click the **Share** icon in the Actions column, as shown in Share a workbook

Share a workbook

5. In the Share pane that appears, specify the users with which you want to share the workbook.
6. Specify an expiration date.
7. Click **Save** to share the workbook.

5.5.16. Make a workbook public

After you create a workbook, you can make it public to allow other users to access the workbook.

Prerequisites

The Quick BI service is purchased.

Procedure

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** page, click **Workbooks** to go to the **Workbooks** page.
3. Find the workbook that you want to make public and click the **More** icon in the Actions column.

4. Select **Make Public**.
5. In the Make Public pane that appears, specify an expiration date.
6. Select **Generate URL** and click **Make Public**.

5.6. BI portals

5.6.1. Overview

A BI portal is a collection of dashboards, workbooks, and external links organized with menus. You can create a BI portal to perform complex thematic analysis with navigation panes.

5.6.2. Create a BI portal

This topic describes how to create a BI portal.

Prerequisites

The Quick BI service is purchased.

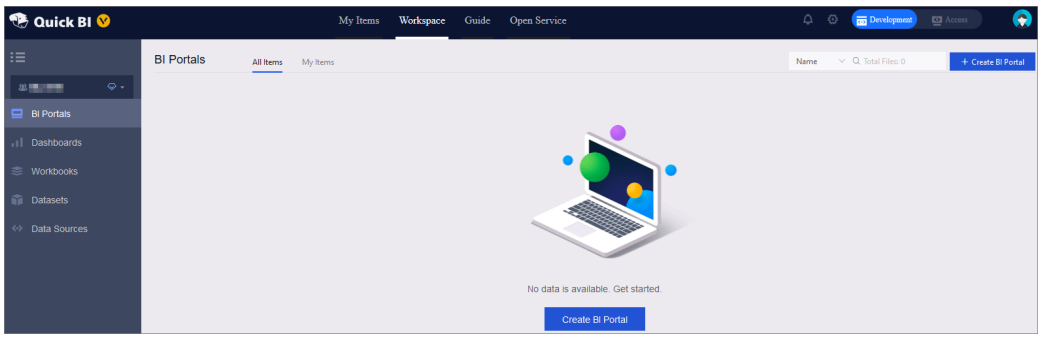
Context

You can create BI portals in workspaces only. Personal workspaces do not support BI portals.

Procedure

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** tab, click **BI Portals**.
3. On the BI Portals page, click **Create BI Portal** in the upper-right corner, as shown in Create a BI portal.

   Create a BI portal



4. On the Page Settings page, set the parameters and click **Save** in the top navigation bar.

5.6.3. Page settings

This topic describes how to edit a BI portal page, such as the title, layout, logo, and footer.

Procedure

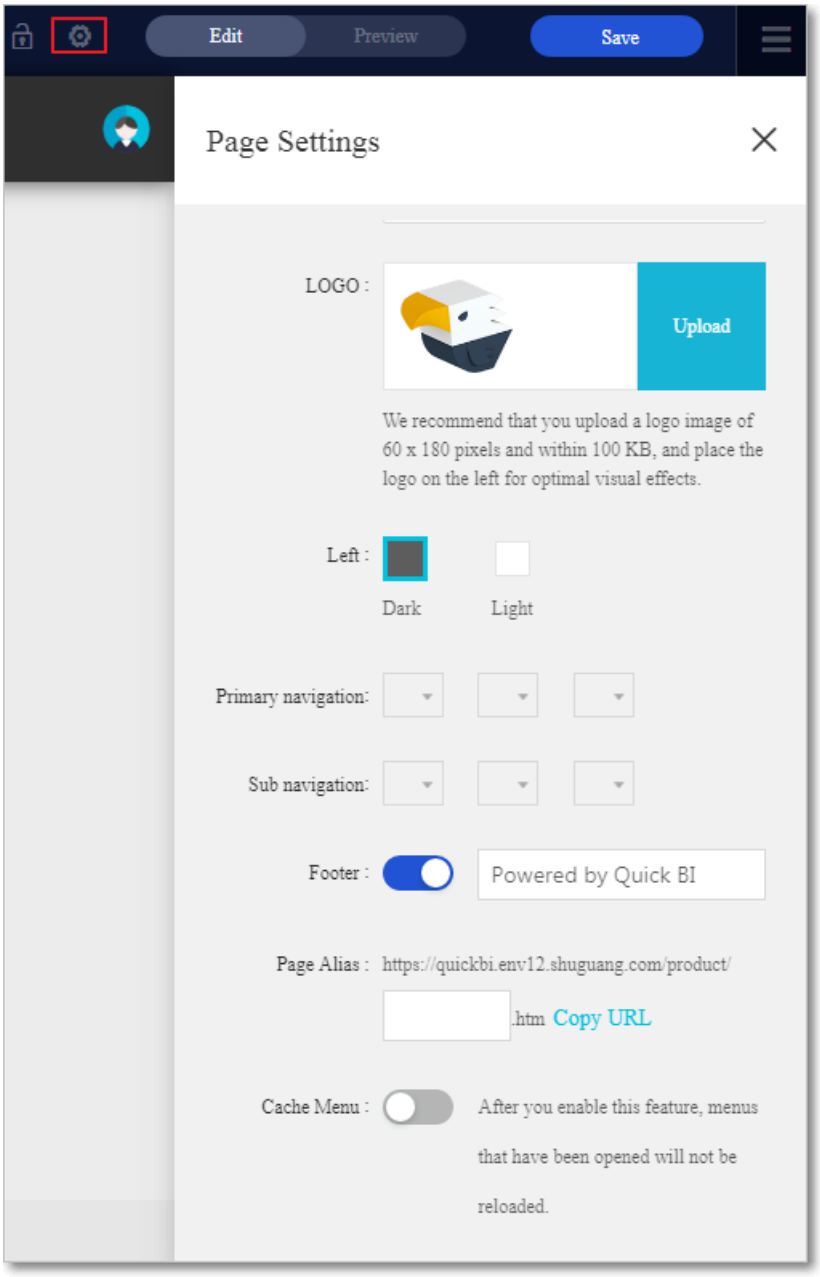
1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** tab, click **BI Portals**.

3. On the BI Portals page, click a BI portal.

   For information about how to create a BI portal, see Create a BI portal.

4. Click the **Settings** icon in the top navigation bar to edit the BI portal page, as shown in Template settings.

   Template settings



5. Click **Save**.

5.6.4. Menu settings

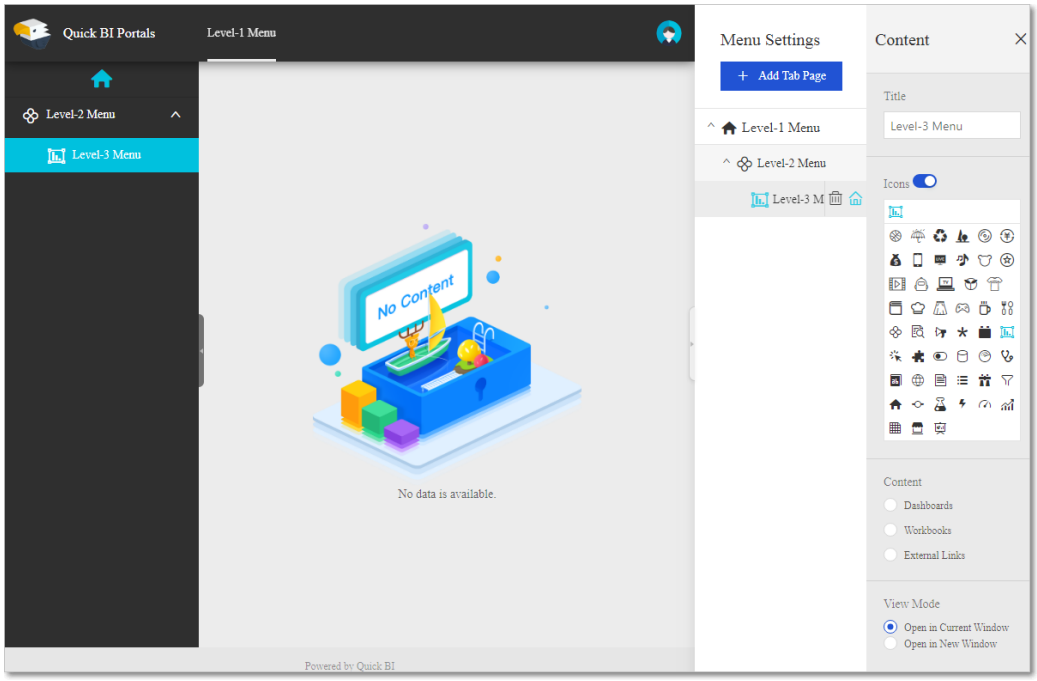
This topic describes how to edit the menu content, such as menu titles and URLs, on the Menu Settings tab.

Procedure

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the **Workspace** tab, click **BI Portals**.
3. On the BI Portals page, click a BI portal.

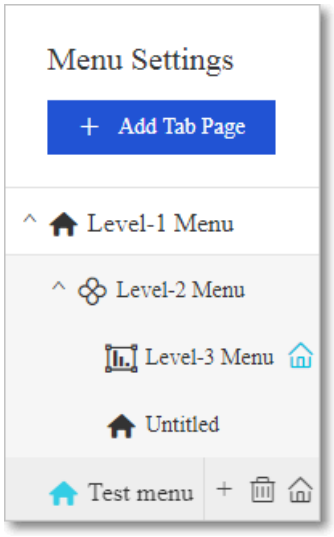
   For information about how to create a BI portal, see Create a BI portal.
4. In the left-side navigation pane, click the target menu, and edit the menu on the right-side **Content** tab, as shown in the following figure.

   Menu settings

   - On the **Menu Settings** tab, you can edit menu settings, as shown in the following figure.

     Edit the menu structure

   - You can add a dashboard or workbook as a menu.

5. Click **Save**.

5.7. Organization

5.7.1. Overview

An organization typically refers to a small or medium enterprise, public institution, college department, or a department of a large enterprise.

If your organization has a large number of members, requires multiple members to collaborate on data analysis, and has high requirements on data security, Quick BI provides the following features to meet your requirements:

- Different departments have access to different reports.
- Members with different roles have access to different data.

Members in an organization are classified into two types: administrators and common members.

5.7.2. Create an organization

This topic describes how to create an organization.

Prerequisites

Before you create an organization, you must create an Apsara Stack tenant account in the Apsara Stack console. Each Apsara Stack tenant account can be used to create or join in only one organization. Ensure that your Apsara Stack tenant account has neither been used to create an organization nor been added to an organization before.

Procedure

1. Log on to the Quick BI console.
2. On the homepage of the **Quick BI** console, or in a workspace, click the **Settings** icon.

3. Click **Organization** in the left-side navigation pane.
4. Select the **Agree** check box and click **Create Organization**.
5. In the **Create Organization** dialog box, enter an organization name.

5.7.3. Modify organization information

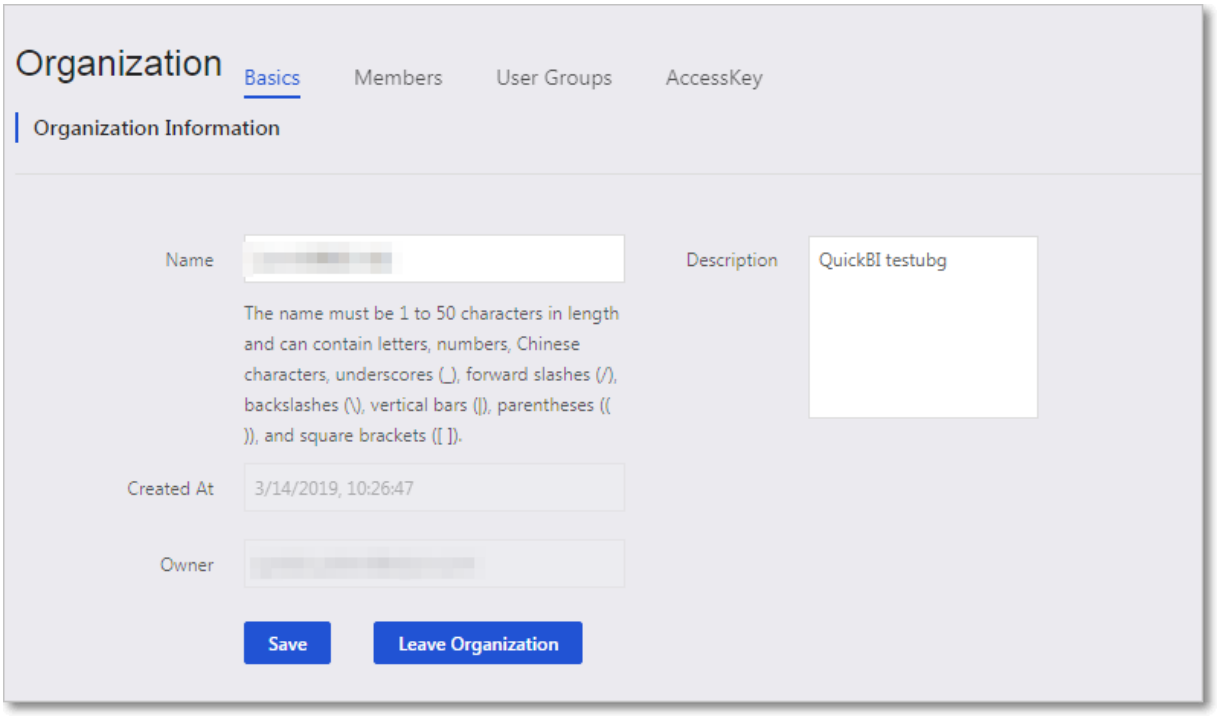
Quick BI allows you to modify the information about an organization as needed.

Prerequisites

The Quick BI service is purchased.

Context

Administrators of an organization have the permissions to modify the information about the organization.



Administrators of an organization have the permissions to add members to the organization to collaborate on tasks.

Administrators of workspaces have the permissions to add members to their workspaces based on the roles and responsibilities of the members. You can create workspaces that correspond to the departments of the organization. For example, if an organization has a sales department and an HR department, administrators can create a workspace for each of the two departments, and then add the employees as members to the corresponding workspaces.

Only administrators of an organization have permissions to manage members in the organization. By default, the creator of an organization is one of the administrators of the organization.

Members in an organization are classified into administrators and common members.

Procedure

1. Log on to the Quick BI console.
2. On the homepage of the **Quick BI console**, or in a workspace, click the **Settings** icon.
3. On the Organization page, click the **Basics** tab.
4. Modify the organization information and click **Save**.

5.7.4. Leave an organization

Quick BI allows you to leave an organization.

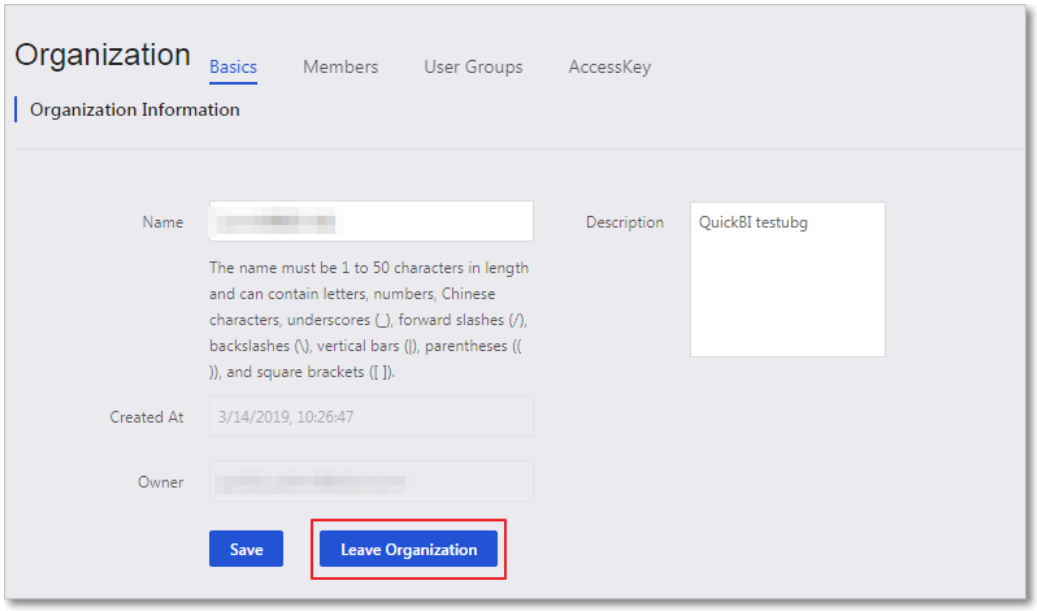
Prerequisites

The Quick BI service is purchased.

Procedure

1. Log on to the Quick BI console.
2. On the homepage of the **Quick BI console**, or in a workspace, click the **Settings** icon.
3. On the Organization page, click the Basics tab and then click **Leave Organization**, as shown in Leave an organization.

Leave an organization



5.7.5. Add a member to an organization

You can add a member to an organization by **adding an Apsara Stack tenant account** or **adding a RAM user**.

Prerequisites

- The Quick BI service is purchased.
- The Apsara Stack tenant account is obtained.

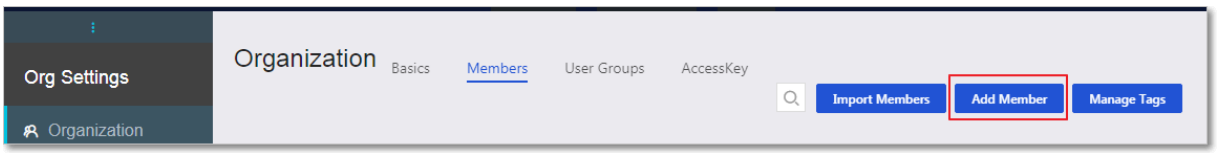
  Each department created in department management in the Apsara Stack console has an Apsara Stack tenant account. The Apsara Stack tenant account of a user can be queried by using the department to which the user belongs.

- The RAM user information is obtained.

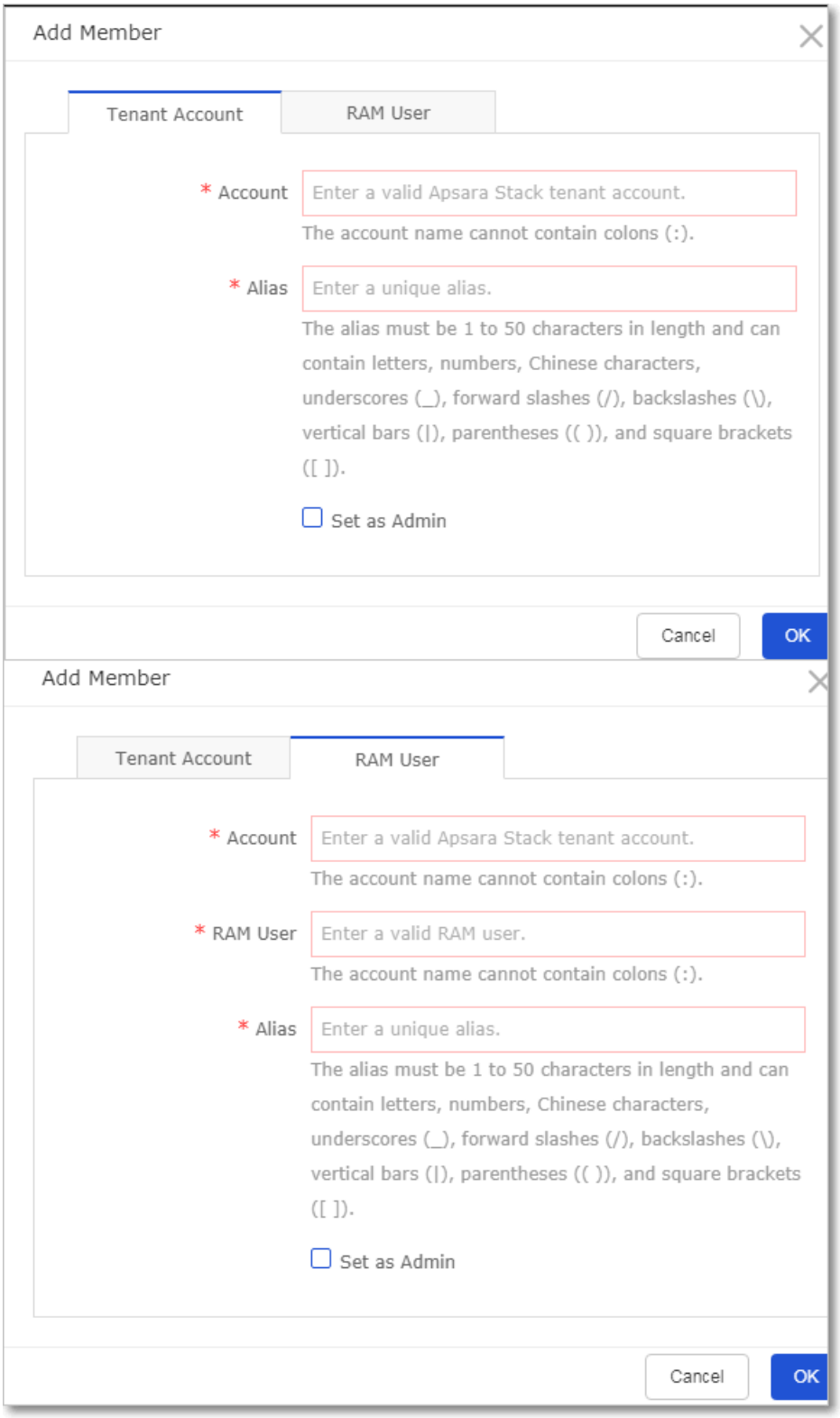
  When you **add a RAM user** in the Quick BI console, you must know both the Apsara Stack tenant account and the RAM user information. The RAM user name is displayed in user management.

Context

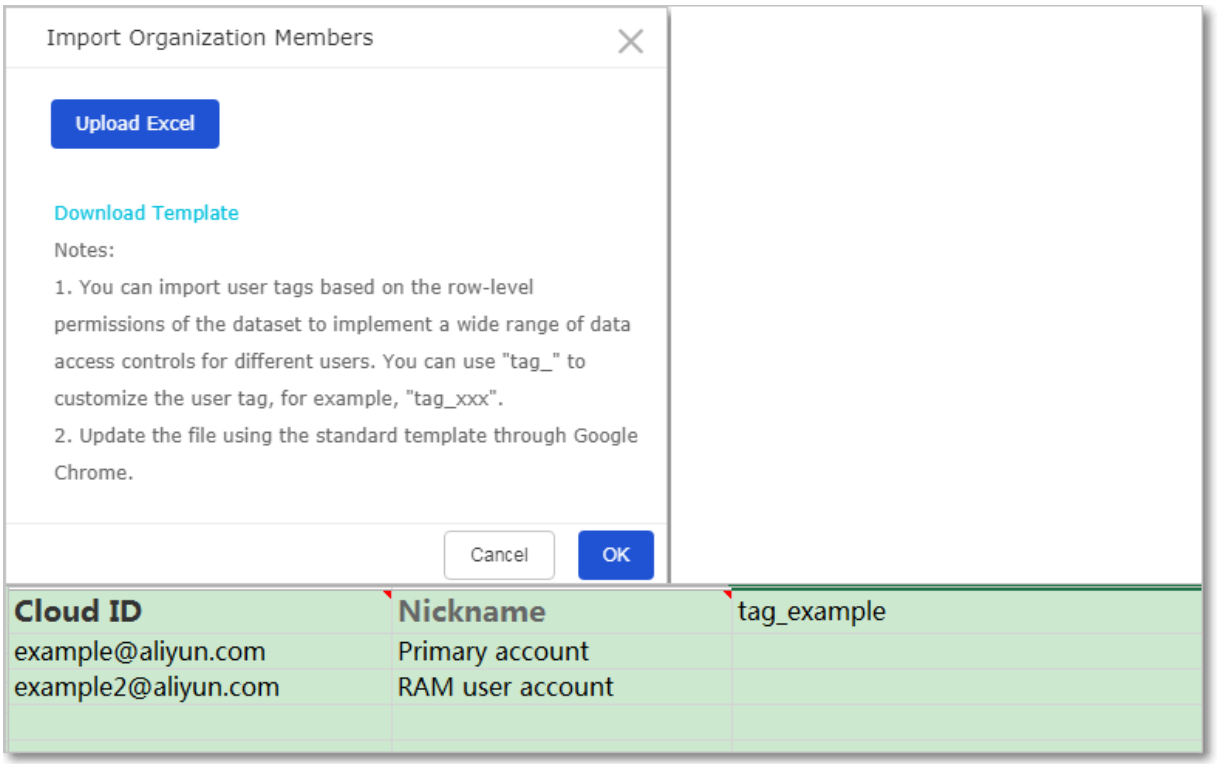
Quick BI allows you to add one member at a time or multiple members at the same time to an organization.



When you add one member at a time, you can add an Apsara Stack tenant account or a RAM user.



To add multiple members at the same time, you need to download a template and enter the Apsara Stack tenant accounts and aliases of the members you want to add into the template. Pay attention to the differences between the Apsara Stack tenant account and the RAM user information. When you add a member by using RAM user information, the format of the user account is Apsara Stack tenant account:RAM user.



Add a member to an organization

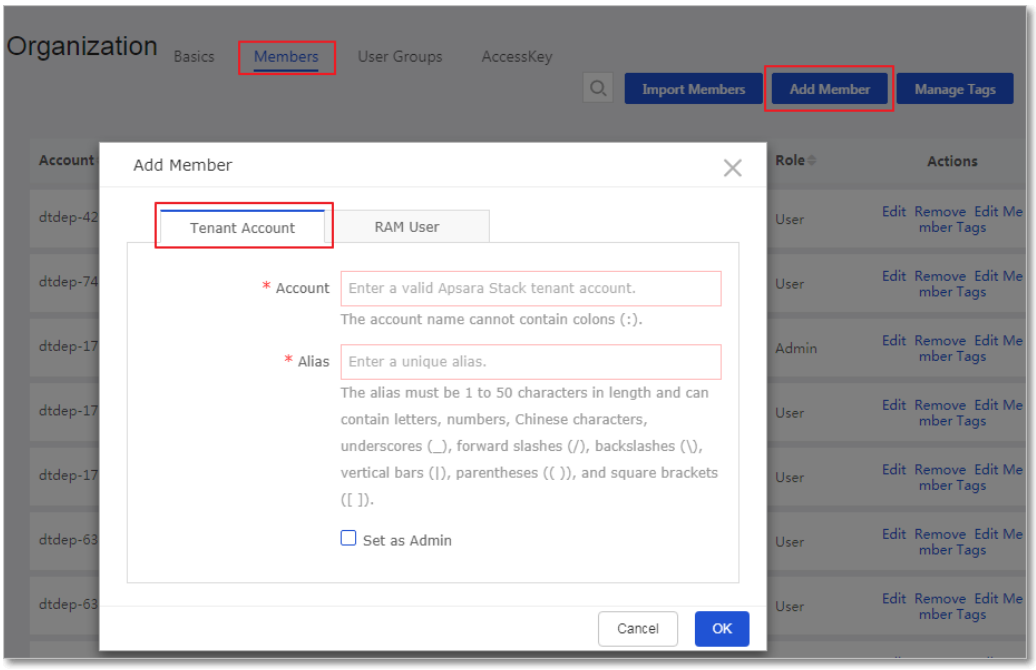
Procedure

1. Log on to the Quick BI console.
2. On the homepage of the **Quick BI** console, or in a workspace, click the **Settings** icon.
3. On the Organization page, click the **Members** tab.
4. Click **Add Member**.

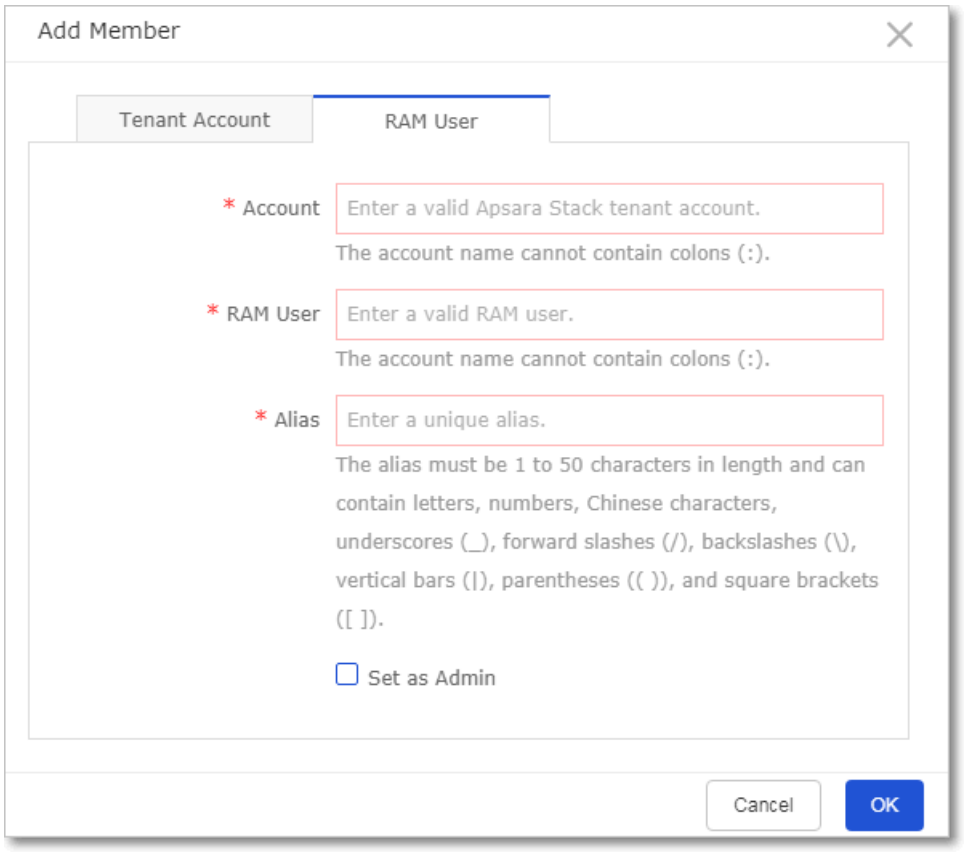
Operation	Procedure
Add an Apsara Stack tenant account	i. In the Add Member dialog box that appears, click the **Tenant Account** tab. ii. Enter the **Apsara Stack tenant account** and **alias**, and select the Set as Admin check box as needed. iii. Click **OK** to add the member.

Operation	Procedure
Add a RAM user	i. In the Add Member dialog box that appears, select **RAM User**. ii. Enter the **Apsara Stack tenant account**, **RAM user**, and **alias**, and select the Set as Admin check box as needed. iii. Click **OK** to add the member. **Note** If the user has been added to another organization, the system prompts an error.

Add an Apsara Stack tenant account



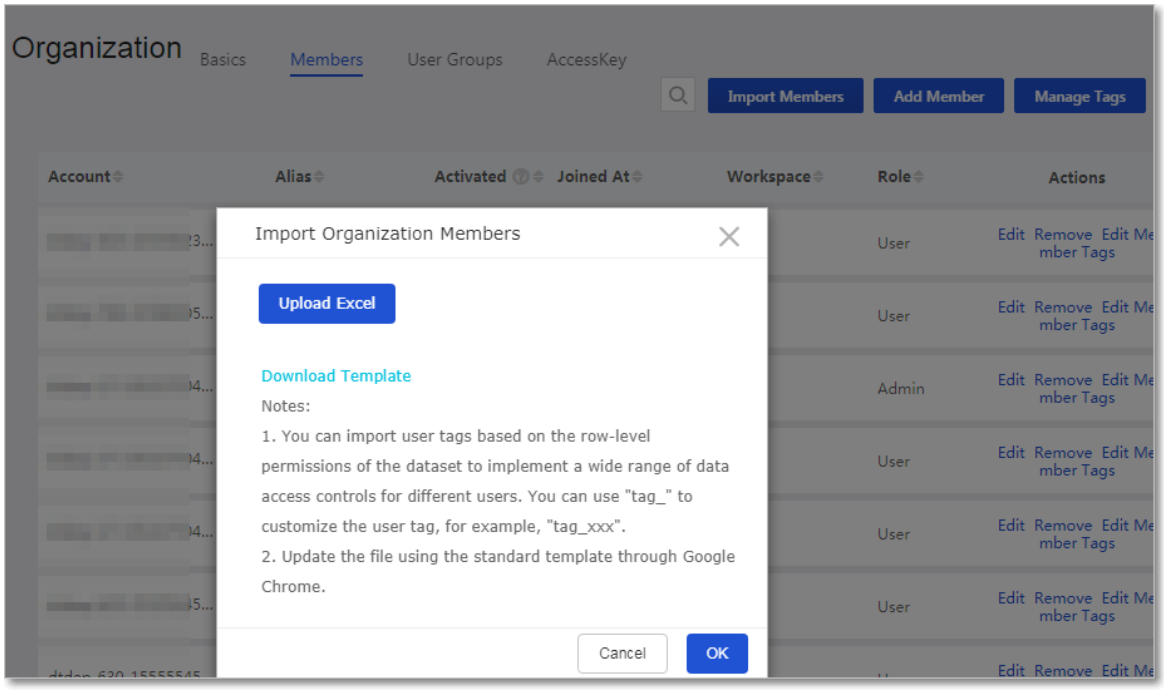
Add a RAM user



Add multiple members at a time

Procedure

1. Log on to the Quick BI console.
2. On the homepage of the **Quick BI** console, or in a workspace, click the **Settings** icon.
3. On the Organization page, click the **Members** tab.
4. On the Organization page, click **Import Members**.
5. In the Import Organization Members dialog box that appears, click **Upload Excel** and select the local file that contains the member list.



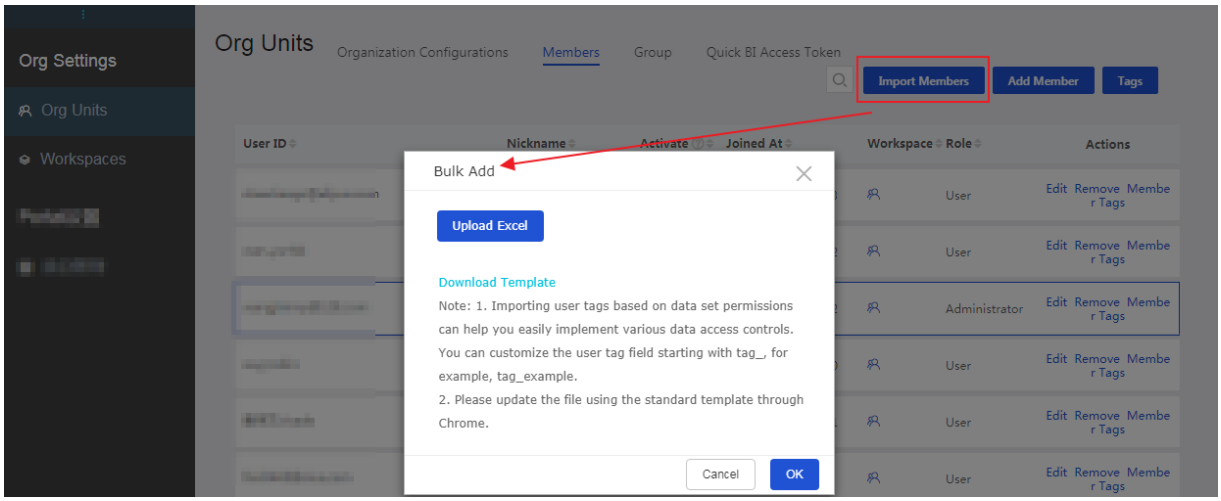
6. Click **OK** to add the members.

5.7.6. Manage member tags

This topic describes how to manage member tags, which are used to configure row-level permissions for datasets.

For information about how to configure row-level permissions, see Set row-level permissions.

You can click the **Import members** icon to add member tags.



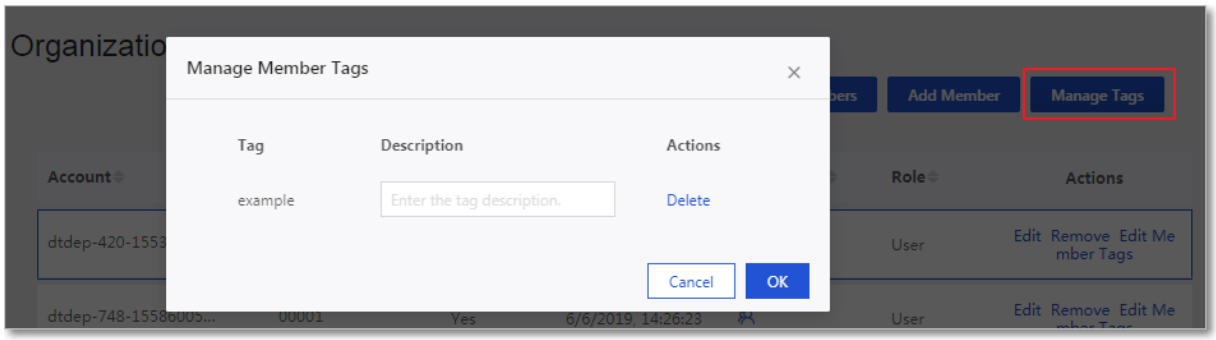
You can click **Download Template** to download the member template. The following figure shows member information.

Account	Nickname	tag_tagArea	tag_tagProvince
example1@aliyun.com	example1	East	Anhui
example2@aliyun.com	example2	East	Anhui

> **Note** If you do not need to set row-level permissions for a member, set the member tag to $ALL_MEMBERS$.

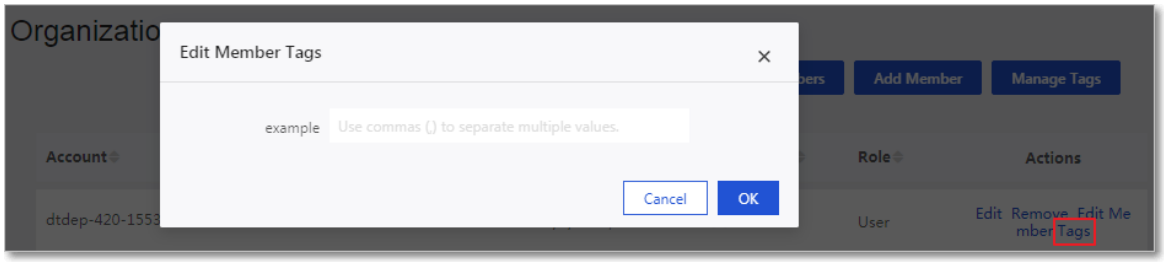
Manage member tags

You can manage tags as shown in the following figure.



Edit a tag

1. Find the member for which you want to set the row-level permissions, and click Edit Member Tags in the Actions column.
2. In the Edit Member Tags dialog box that appears, enter a new tag and click **OK**.



5.7.7. Edit a member

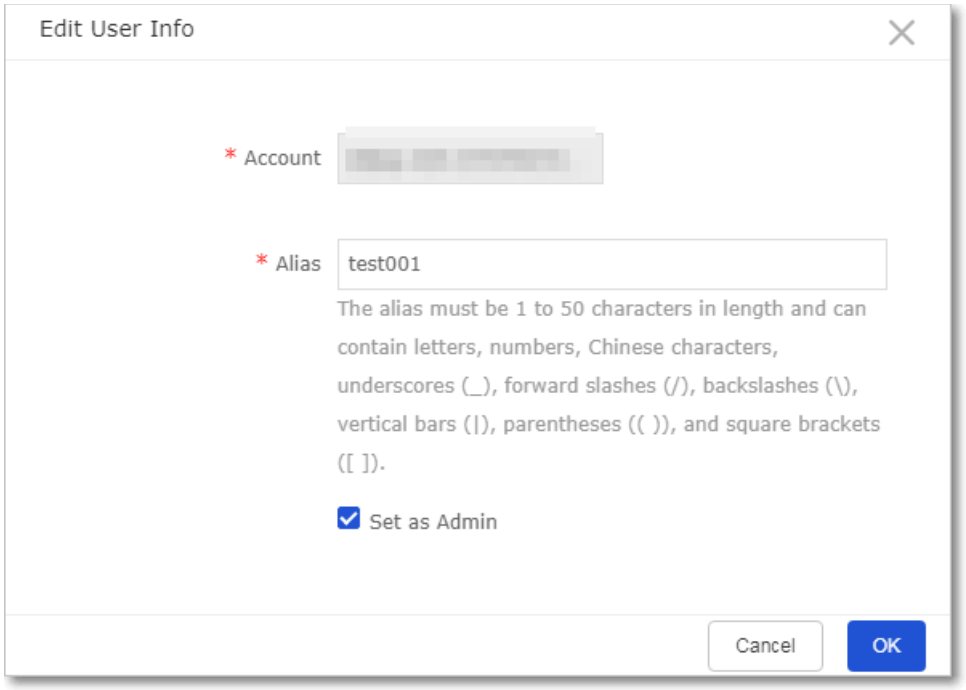
You can set an alias and role for a member in the organization. This makes it easier for you to search for members in the organization.

Prerequisites

The Quick BI service is purchased.

Procedure

1. Log on to the Quick BI console.
2. On the homepage of the **Quick BI console** or in a workspace, click the **Settings** icon.
3. On the Organization page, click the **Members** tab.
4. Find the member you want to edit and click **Edit** in the Actions column.
5. Modify the information about the member.



6. Click **OK** to save the changes.

5.7.8. Remove a member

This topic describes how to remove a member from an organization.

Prerequisites

The Quick BI service is purchased.

Context

Only administrators of an organization have the permissions to remove members from the organization. Before you remove a member that has been added to a workspace, you must remove the member from the workspace. Otherwise, you cannot remove the member from the organization.

> **Note** The removal operation is irreversible. If a member that you previously removed is needed, you need to add the member to the organization again. Remove a member with caution.

Procedure

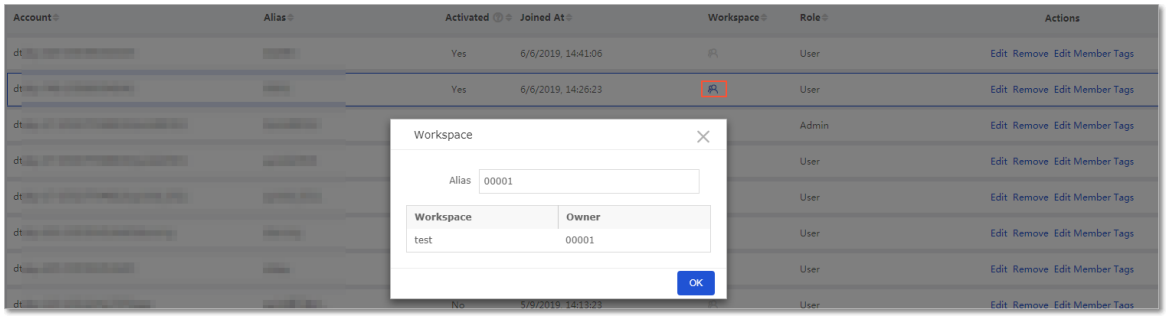
1. Log on to the Quick BI console.
2. On the homepage of the **Quick BI console** or in a workspace, click the **Settings** icon.
3. On the Organization page, click the **Members** tab.
4. Find the member you want to remove and click **Remove** in the Actions column.
5. Click **OK** to remove the member.

5.7.9. Query the workspace to which a user belongs

You can query the workspace to which a user belongs.

Procedure

1. Log on to the Quick BI console.
2. On the homepage of the **Quick BI console** or in a workspace, click the **Settings** icon.
3. On the Organization page, click the **Members** tab.
4. Find the organization member that you want to query and click the **Workspace** icon to view the workspace that the user belongs to.

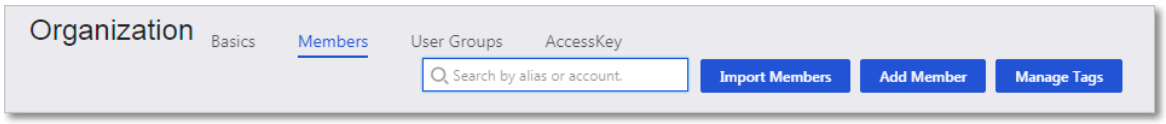


5.7.10. Search for a member of an organization

You can search for a specific member in an organization by its alias or Alibaba Cloud account.

Procedure

1. Log on to the Quick BI console.
2. On the homepage of the **Quick BI console** or in a workspace, click the **Settings** icon.
3. On the Organization page, click the **Members** tab.
4. Enter the alias or Apsara Stack tenant account of the member you want to search for in the search box, and click the **Search** icon.



5.7.11. Workspaces

5.7.11.1. Overview

A workspace is managed by its administrators. The role of a workspace administrator is assigned to members by the organization administrator that creates the workspace. A workspace administrator can specify other members in the workspace as administrators of the workspace.

A workspace administrator can:

- Create a workspace

- Modify a workspace
- Set a default workspace

5.7.11.2. What is a workspace?

A workspace enables members in the same organization to collaborate on tasks. In a workspace, each member is assigned a role to perform operations such as creating and modifying data sources, datasets, workbooks, dashboards, and BI portals. Data objects are stored in their workspaces. Each workspace has its own data objects.

A workspace has the following properties:

- Name
- Description
- Function permissions: Data objects can be shared and made public by default.
- Preference settings:
  - Use physical field names as dimension and measurement names.
  - Use field annotations as dimension and measurement names.

  Datasets created in this workspace are named based on the new settings. Existing datasets are not affected.

Members of a workspace can be assigned the same role or different roles. The roles in a workspace include:

- Administrator
- Developer
- Analyst
- Viewer

Mapping between roles and permissions

Permissions of a role cannot be changed. If you want to grant specific permissions to a member, you only need to assign the appropriate role to the member. The following tables list the permissions of each role.

- Supported operations on data objects

Supported operations on data objects

Permission	Developer	Analyst	Viewer
Dataset	Yes	No	No
Supported operations on workbooks	Yes	Yes	Yes
Dashboards	Yes	Yes	Yes
BI Portals	Yes	Yes	Yes

- Supported operations on data

Supported operations on data

Permission	Developer	Analyst	Viewer
Create a data source	Yes	No	No
Modify a data source	Developers can modify only data sources created by themselves.	No	No
Delete a data source	Developers can only delete data sources created by themselves.	No	No
Use a data source	Yes	No	No
Create a dataset	Yes	No	No
Modify a dataset	Developers can modify only datasets created by themselves.	No	No
Delete a dataset	Developers can only delete datasets created by themselves.	No	No
Use a dataset	Yes	Yes	No

- Supported operations on workbooks

Supported operations on workbooks

Permission	Developer	Analyst	Viewer
Create a workbook	Yes	Yes	No
Modify a workbook	Developers can modify only workbooks created by themselves.	Analysts can modify only workbooks created by themselves.	No
Delete a workbook	Developers can only delete workbooks created by themselves.	Analysts can only delete workbooks created by themselves.	No
Preview a workbook	Yes	Yes	Yes
Share a workbook	Developers can only share workbooks created by themselves.	Analysts can only share workbooks created by themselves.	No
Reference a workbook	Yes	Yes	No

- Supported operations on dashboards

Supported operations on dashboards

Permission	Developer	Analyst	Viewer
Create a dashboard	Yes	Yes	No
Modify a dashboard	Developers can modify only dashboards created by themselves.	Analysts can modify only dashboards created by themselves.	No
Delete a dashboard	Developers can only delete dashboards created by themselves.	Analysts can only delete dashboards created by themselves.	No
View a dashboard	Yes	Yes	Yes
Share a dashboard	Developers can only share dashboards created by themselves.	Analysts can only share dashboards created by themselves.	No
Reference a dashboard	Yes	Yes	No
Publish a dashboard	Developers can only publish dashboards created by themselves.	Analysts can only publish dashboards created by themselves.	No

- Supported operations on BI portals

Supported operations on BI portals

Permission	Developer	Analyst	Viewer
Create a BI portal	Yes	Yes	No
Modify a BI portal	Developers can modify only BI portals created by themselves.	Analysts can modify only BI portals created by themselves.	No
Delete a BI portal	Developers can only delete BI portals created by themselves.	Analysts can only delete BI portals created by themselves.	No
View a BI portal	Yes	Yes	Yes
Share a BI portal	Developers can only share BI portals created by themselves.	Analysts can only share BI portals created by themselves.	No

5.7.11.3. Differences between a personal workspace and a group workspace

Workspaces of a user are classified into a personal workspace and group workspaces. The personal workspace is automatically created when the user first logs on to the Quick BI console. A group workspace is created for group members to collaborate. Differences between the two types of workspaces are as follows:

- A personal workspace is automatically created when you log on to the Quick BI console for the first time. A group workspace needs to be manually created by an organization administrator.
- You cannot create or delete a personal workspace.
- You cannot add other users to your personal workspace, nor can you collaboratively edit or transfer it.
- A group workspace can be transferred to any member in the group workspace and shared with all members in the organization. A personal workspace can be shared with Apsara Stack tenant accounts.

5.7.12. Create a workspace

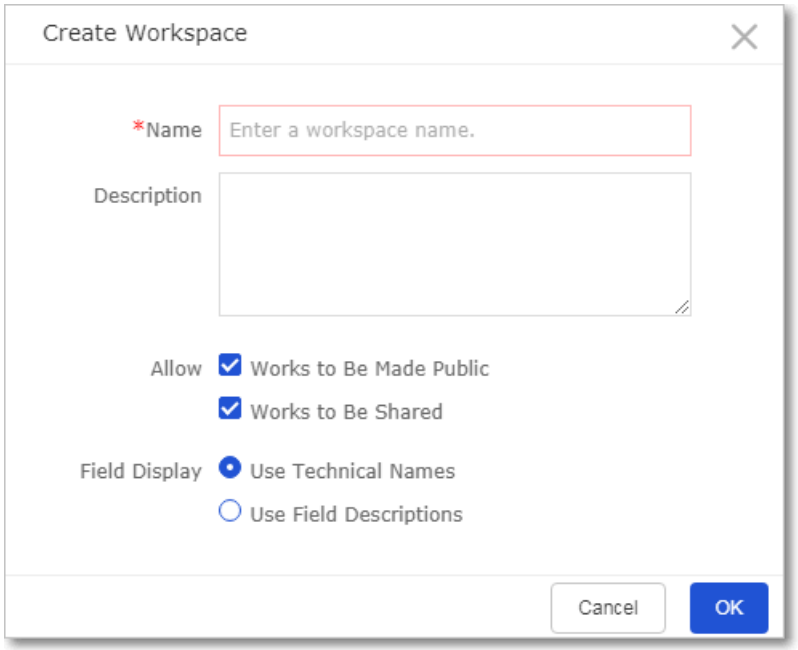
This topic describes how to create a workspace.

Prerequisites

The Quick BI service is purchased.

Procedure

1. Log on to the Quick BI console.
2. On the homepage of the **Quick BI console** or in a workspace, click the **Settings** icon.
3. On the Organization page that appears, click **Workspaces** in the left-side navigation pane. Then, click **Create Workspace**.
4. In the Create Workspace dialog box that appears, enter a name for the workspace.



5. Click **OK** to create the workspace.

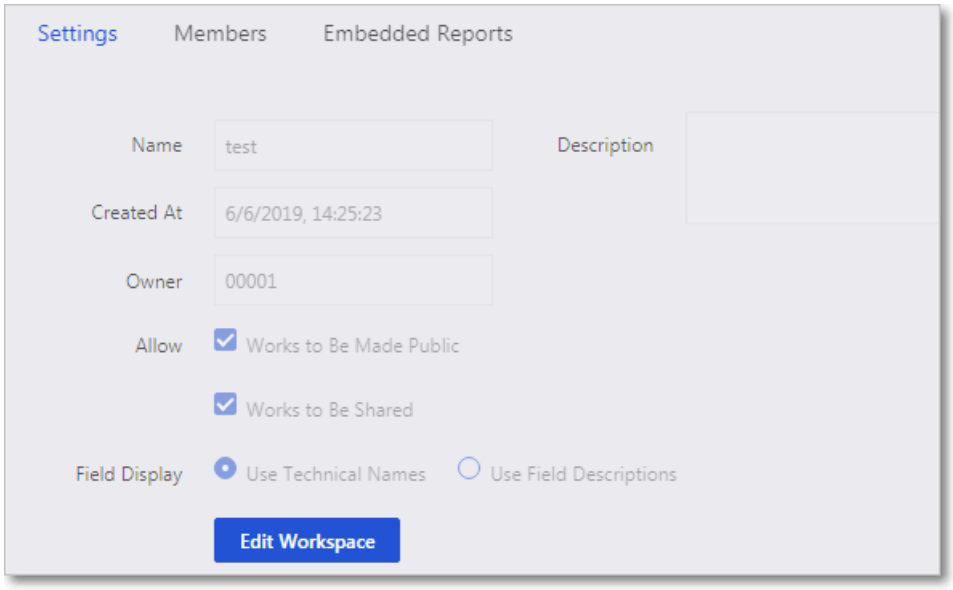
5.7.13. Edit workspace information

The information about the personal workspace can be edited by the owner only. The information about a workspace can be edited by an administrator of the workspace.

Procedure

1. Log on to the Quick BI console.
2. On the homepage of the **Quick BI console**, or in a workspace, click the **Settings** icon.
3. In the left-side navigation pane, click **Workspaces**.
4. Click the **Settings** tab.
5. Click **Edit Workspace** and edit the information about the workspace.

   Edit the information about the workspace

6. Click **OK** to save the new information.

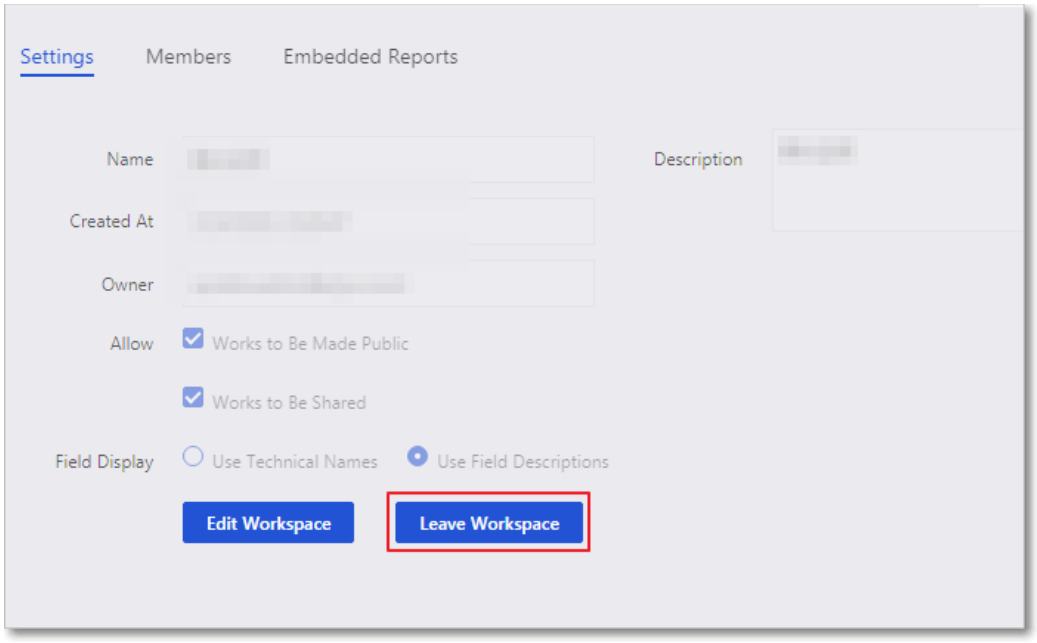
5.7.14. Leave a workspace

This topic describes how to leave a workspace.

Procedure

1. Log on to the Quick BI console.
2. On the homepage of the **Quick BI console**, or in a workspace, click the **Settings** icon.
3. In the left-side navigation pane, click **Workspaces**.
4. Find the target workspace and click the **Settings** tab.
5. Click **Leave Workspace** to leave the current workspace, as shown in Leave the workspace.

   Leave the workspace



5.7.15. Transfer a workspace to another owner

This topic describes how to transfer a workspace to another owner.

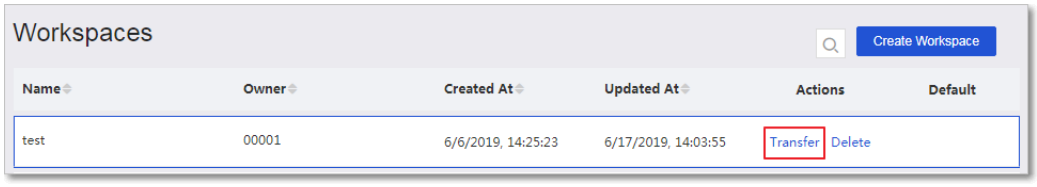
Context

If the owner of a workspace needs to be removed from the workspace, you can transfer the workspace to another member. The new owner does not need to be an administrator of the workspace. You can transfer the workspace to any member in the workspace.

Procedure

1. Log on to the Quick BI console.
2. On the homepage of the **Quick BI console**, or in a workspace, click the **Settings** icon.
3. In the left-side navigation pane, click **Workspaces**.
4. Find the target workspace and click **Transfer** in the Actions column.
5. Enter the alias of the new owner and click **OK**, as shown in Transfer a workspace.

Transfer a workspace



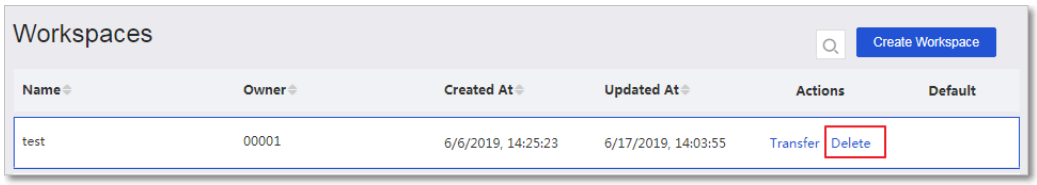
5.7.16. Delete a workspace

This topic describes how to delete a workspace.

Procedure

1. Log on to the Quick BI console.
2. On the homepage of the **Quick BI console**, or in a workspace, click the **Settings** icon.
3. In the left-side navigation pane, click **Workspaces**.
4. On the Workspaces page, find the target workspace and click **Delete** in the Actions column, as shown in Delete the workspace.

Delete the workspace



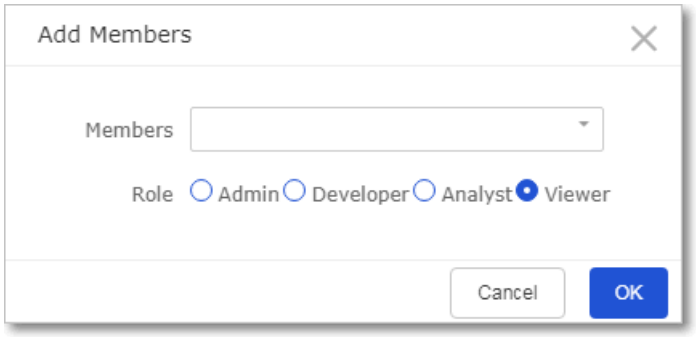
5.7.17. Add a member to a workspace

This topic describes how to add a member to a workspace.

Procedure

1. Log on to the Quick BI console.
2. On the homepage of the **Quick BI console**, or in a workspace, click the **Settings** icon and navigate to the Workspaces page.
3. Click the **Members** tab.
4. Click **Add Members**.
5. Enter the member account and specify a role for the member, as shown in Add a member to the workspace.

Add a member to the workspace



5.7.18. Edit settings of a workspace member

This topic describes how to edit settings of a workspace member.

Procedure

1. Log on to the Quick BI console.
2. On the homepage of the **Quick BI console**, or in a workspace, click the **Settings** icon and navigate to the Workspaces page.

3. Click the **Members** tab.
4. Find the target member and click **Edit** in the Actions column.
5. Change the settings of the member and click **OK**.

5.7.19. Search for a member in a workspace

You can search for members on the **Members** tab page.

Procedure

1. Log on to the Quick BI console.
2. On the homepage of the **Quick BI console**, or in a workspace, click the **Settings** icon and navigate to the Workspaces page.
3. On the Workspaces page, select the target workspace.
4. Click the **Members** tab. All members in the current workspace are listed on this page.
5. Enter an alias or account in the search box.
6. Click the Search icon to search for the member, as shown in Search for a member in the workspace.

Search for a member in the workspace

5.7.20. Delete a member from a workspace

This topic describes how to delete members from a workspace.

Procedure

1. Log on to the Quick BI console.
2. On the homepage of the **Quick BI console**, or in a workspace, click the **Settings** icon and navigate to the Workspaces page.
3. On the Workspaces page, click the **Members** tab.
4. Find the target member and click **Delete**.
5. Select a new owner from the drop-down list. Data object owned by the member to be deleted will be transferred to the new owner.
6. Click **OK** to delete the member.

5.8. Permissions

5.8.1. Overview

Permission control includes data object management and row-level permission control.

Data object management

Data objects include data sources, datasets, dashboards, workbooks, and BI portals. You can manage the data objects in personal workspaces and group workspaces. For information about differences between personal workspaces and group workspaces, see Data objects.

Row-level permission control

You do not need to configure row-level permissions for all fields in a dataset. Configure row-level permissions for specific fields based on your business needs.

> **Note** Only datasets in group workspaces) support row-level permission control.

5.8.2. Manage data objects

This topic describes how to manage data objects. Data objects include data sources, datasets, dashboards, workbooks, and BI portals.

The following table lists differences between data object management in a personal workspace and that in a workspace, also referred to as a group workspace.

Item	Workspace (Group workspace)	Personal workspace
Permissions	Data objects can be shared or made public. **Note** Data sources and datasets cannot be shared or made public.	Only the owner of a personal workspace can perform operations on data objects.
Share data objects	Workbooks, dashboards, and BI portals can be shared. Shared data objects are read-only for other Apsara Stack tenant accounts and RAM users. Other Apsara Stack tenant accounts and RAM users cannot modify, delete or save data objects. • Only the data object owner and the administrators of the workspace have the permissions to share the data object. • If the Works to Be Shared check box is cleared in workspace settings, data objects in the workspace cannot be shared. • Data objects can only be shared with Apsara Stack tenant accounts and RAM users of the same organization. Members can view the data objects in the workspace to which the members belong. Data objects can be shared with users in different workspaces within an organization. Authorized users can view the shared data objects in their own personal workspaces.	Workbooks, dashboards, and BI portals can be shared. Shared data objects are read-only for other Apsara Stack tenant accounts and RAM users. Other Apsara Stack tenant accounts and RAM users cannot modify, delete or save data objects. • Only data object owners have the permissions to share the data objects. • Data objects can only be shared with users of Apsara Stack Quick BI. Authorized users can view shared data objects in their own personal workspaces.

Item	Workspace (Group workspace)	Personal workspace
Make data objects public	Everyone can access data objects that have been made public by using URLs. We recommend that you do not make the data objects that contain private business data public.	Everyone can access data objects that have been made public by using URLs. We recommend that you do not make the data objects that contain private business data public.

5.8.3. Manage row-level permissions

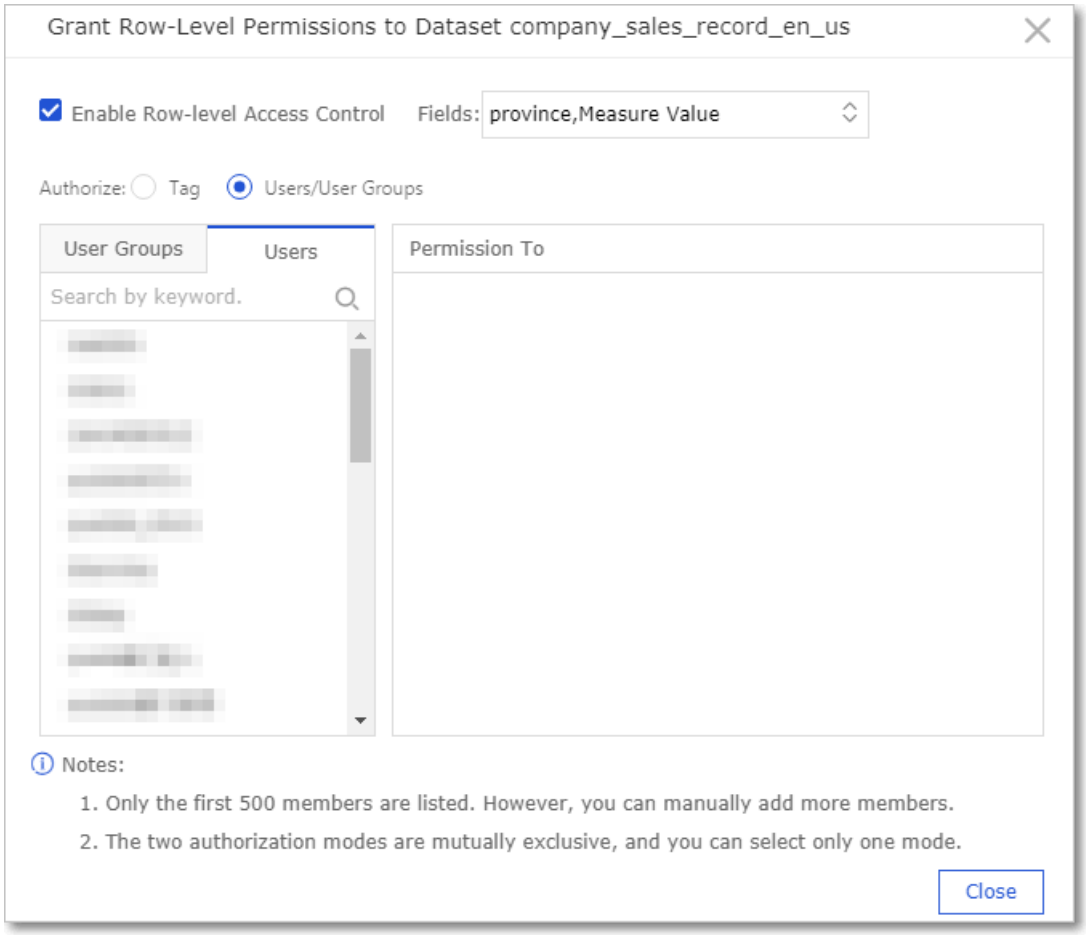
Row-level permissions are managed based on datasets. Quick BI supports the following authorization modes: **user/user group-based authorization** and **tag-based authorization**. **User/user group-based authorization** is ideal for organizations with a small number of members. **Tag-based authorization** is ideal for organizations with a large number of members.

User/user group-based authorization

1. Log on to the Quick BI console
2. Select a workspace. For information about how to create a workspace, see Create a workspace.
3. In the left-side navigation pane of the Workspace page, click **Datasets**.

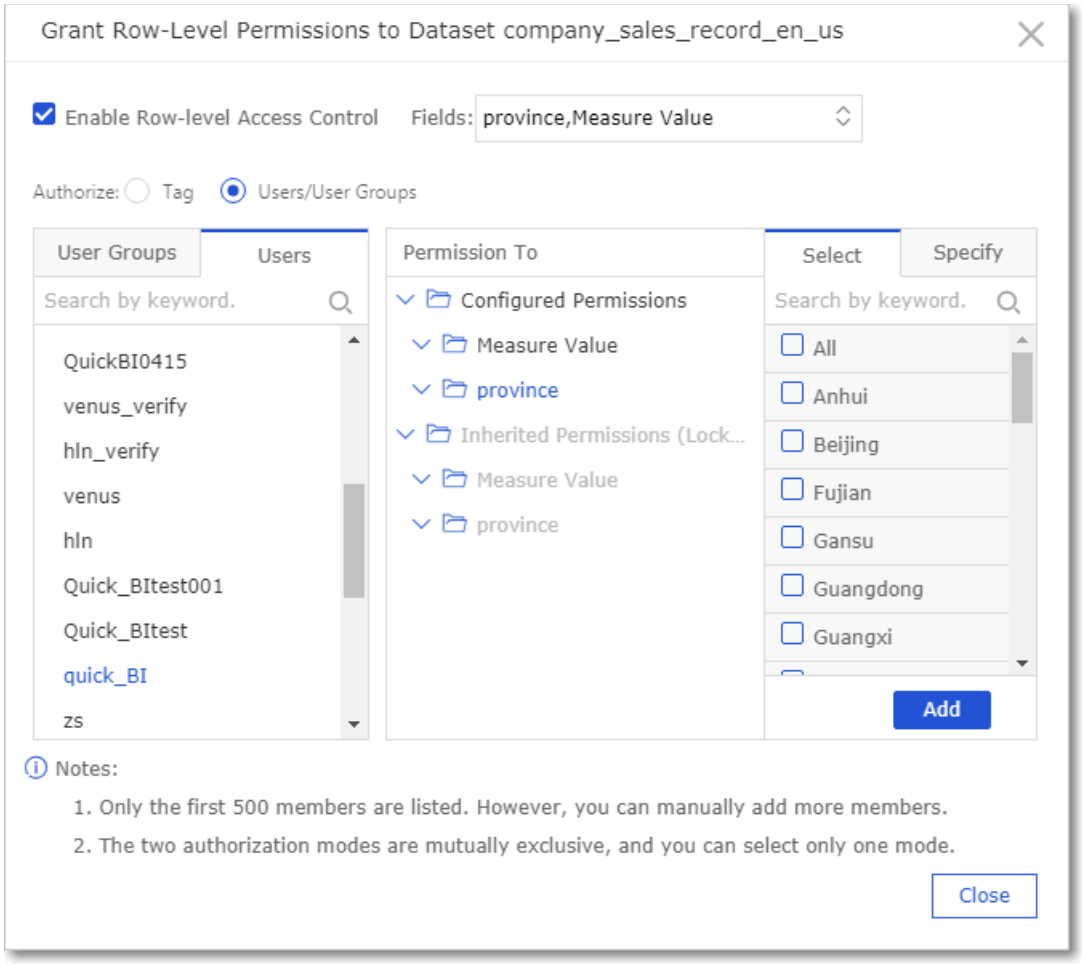
   > **Note** Datasets in a personal workspace do not support row-level permission control.

4. Find the target dataset. Click the **More** icon in the Actions column or right-click the dataset.
5. Select **Grant Row-Level Permissions**.
6. On the Grant Row-Level Permissions page, select **Enable Row-level Access Control** and select **Users/User Groups** for Authorize.
7. Click the drop-down arrow of Fields. Select the fields that the authorization is based on, such as province and Measure Value, as shown in the following figure.



The values of the **Measure Value** field are the measures in the dataset. By granting row-level permissions based on the Measure Value field, you can specify the measures available to different users.

8. In the **Permission To** section, click the **province** field. A list of provinces appear.
9. Select a member and choose values of the **province** field to grant permissions to the member, as shown in the following figure.



In this example, the member can view the data of Shanghai and Yunnan.

> **Note** If you grant permissions based on a field of a dataset, you must specify whether all members of the workspace have permissions to access the dataset. Otherwise, when other users attempt to access reports created based on the dataset, the system denies the access requests by default

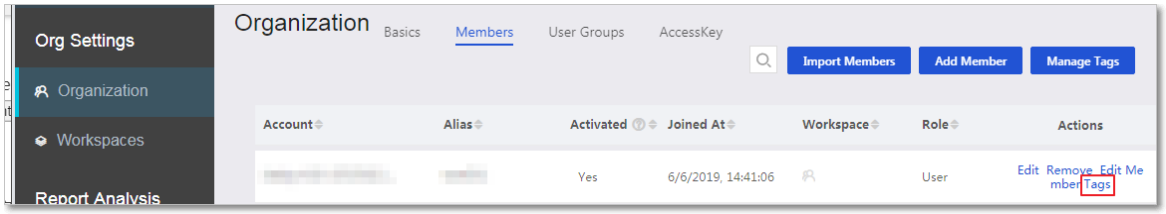
10. Click **Add** to complete the authorization.

Tag-based authentication

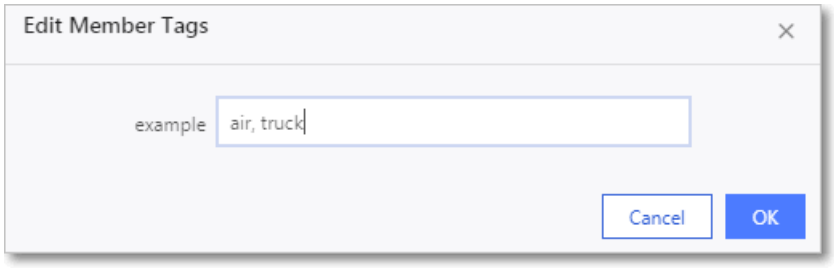
Scenario: Users can only access the data rows in the company_sales_record dataset with **shipping_type** set to **truck** and **air**.

Set member tags

1. In the target workspace, click the **Settings** icon.
2. On the **Settings** page, find the member you want to authorize and click **Edit Member Tags** in the Actions column.



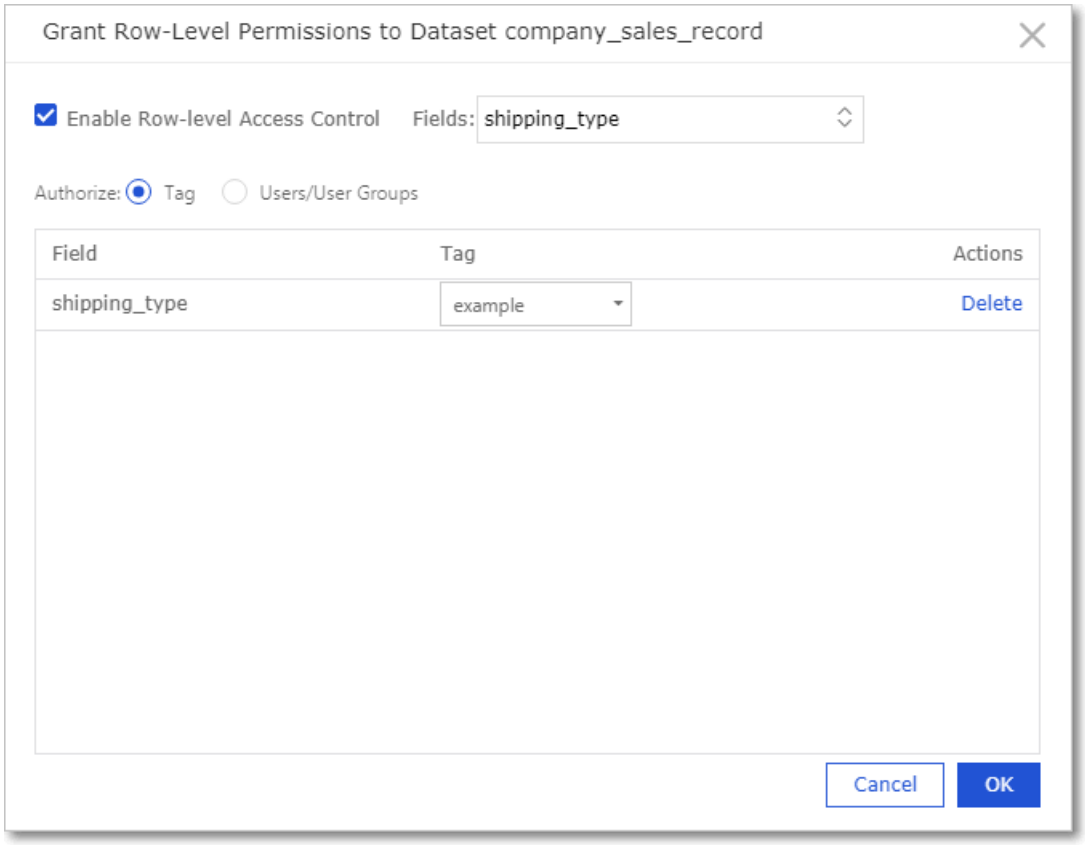
3. In the **Edit Member Tags** dialog box that appears, set the value of the **example** tag to air, truck and click **OK**.



After you set the member tag, you must specify the tag in the Grant Row-Level Permissions dialog box.

Set tag-based authorization

1. Find the company_sales_record dataset. Click the **More** icon in the Actions column or right-click the dataset.
2. Select **Grant Row-level Permissions**.
3. On the Grant Row-Level Permissions page, select **Enable Row-level Access Control** and select **Tag** for Authorize.
4. From the **Fields** drop-down list, select **shipping_type**. Select **example** in the **Tag** column, and click **OK** to complete the settings.



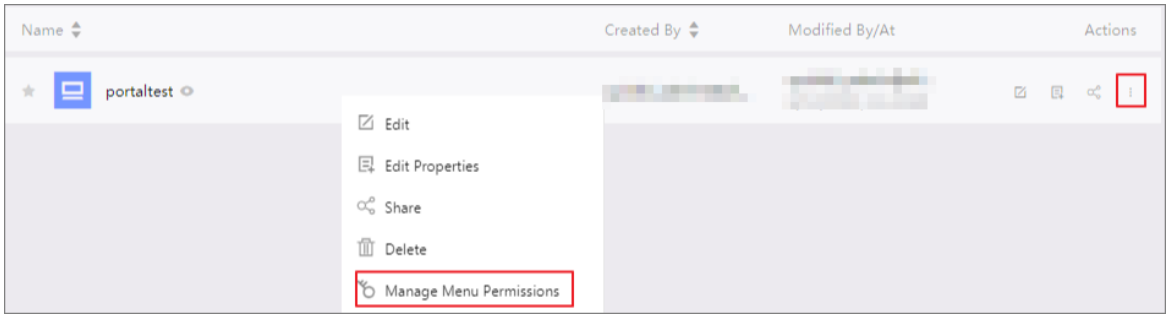
After tag authorization is complete, the user can only access data rows with **shipping_type** set to air or truck.

5.8.4. Configure menu permissions for a BI portal

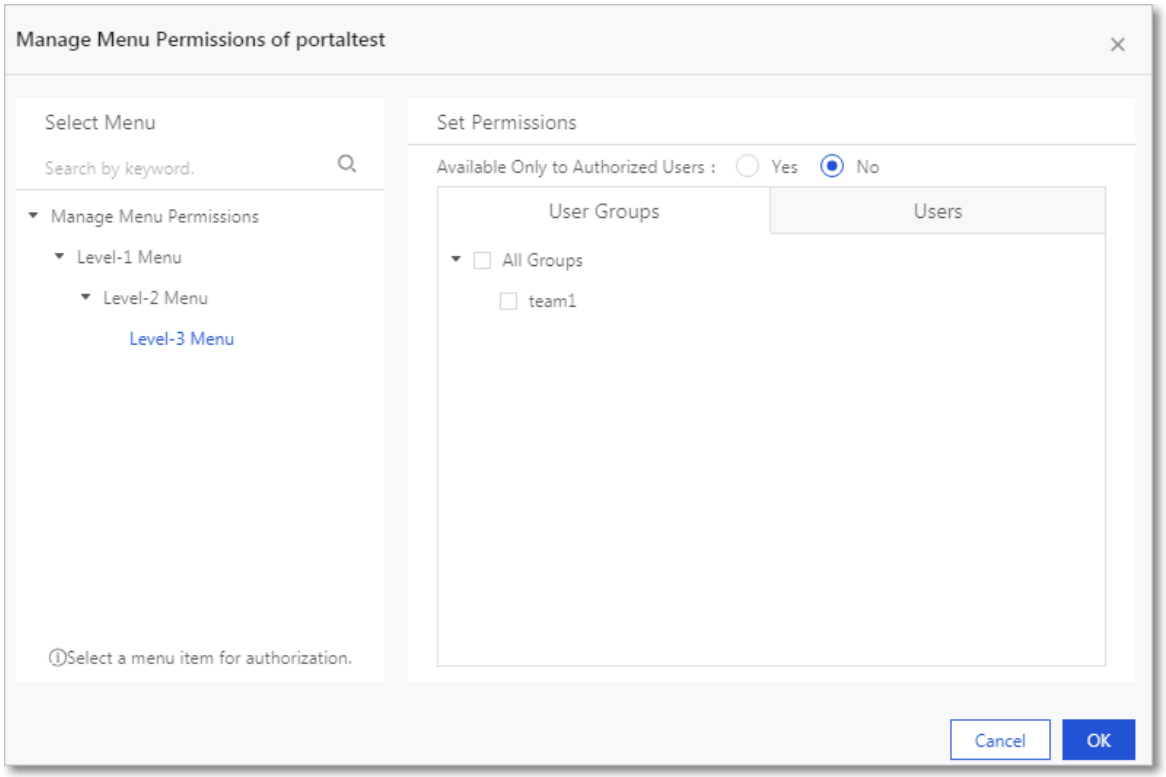
Workspace administrators can configure permissions on viewing BI portal menus in a workspace, also referred to as a group workspace.

You can grant the permissions to user groups and individual users as follows:

1. Log on to the Quick BI console
2. Select a workspace. For information about how to create a workspace, see Create a workspace.
3. In the left-side navigation pane of the Workspace page, click **BI Portals**.
4. On the BI Portals page, select the BI portal that you want to configure the menu permissions, click the **More** icon in the Actions column or right-click the BI portal, and select **Manage Menu Permissions**.



5. In the **Manage Menu Permissions** dialog box that appears, select the target menu, specify whether the menu is available only to authorized users, and select the users or user groups that you need to authorize.



> **Note** The meanings of values of **Available Only to Authorized Users** are as follows:
>
> - Yes: Only authorized user groups and users can access this menu.
> - No: All user groups and users can access this menu.

6. Click **OK** to complete configuring the menu permissions.

5.8.5. Share a data object in a personal workspace

Only the owner of a data object has the permissions to share the data object.

Prerequisites

The Quick BI service is purchased.

Context

In a personal workspace, you can share **workbooks**, **dashboards**, and **BI portals**. Shared data objects are read-only for other Apsara Stack tenant accounts and RAM users. Other Apsara Stack tenant accounts and RAM users do not have the permissions to modify, delete, or save the data objects.

Members with whom a data object is shared can log on to the Quick BI console and view the data object on the **My Items** page.

This topic uses a dashboard as an example to describe how to share data objects in a personal workspace.

Procedure

1. Log on to the Quick BI console.
2. In the left-side navigation pane of the Workspace page, click **Dashboards**.
3. On the Dashboards page, select the dashboard that you want to share with others and click the **Share** icon in the Actions column.
4. Enter the account of the user that you want to share the dashboard with, and specify an expiration date.
5. Click **Save** to share the dashboard.

5.8.6. Share a data object in a workspace

In a workspace, you can share **workbooks**, **dashboards**, and **BI portals**. Shared data objects are read-only for other Apsara Stack tenant accounts and RAM users. Other Apsara Stack tenant accounts and RAM users do not have the permissions to modify, delete, or save the data objects.

Prerequisites

The Quick BI service is purchased.

Context

Only the owner of a data object or administrators of the workspace have the permissions to share the data object. Data objects can only be shared with Apsara Stack tenant accounts and RAM users within the same organization.

If the Works to Be Shared check box is cleared for a workspace, the data objects in the workspace cannot be shared.

This topic takes a dashboard as an example to describe how to share data objects in a workspace.

Procedure

1. Log on to the Quick BI console.
2. Select a workspace.
3. In the left-side navigation pane of the Workspace page, click **Dashboards**.
4. On the Dashboards page, select the dashboard you want to share with others and click the **Share** icon in the Actions column.
5. Enter the alias or account of the user that you want to share the dashboard with, and specify an

expiration date.

6. Click **Save** to share the dashboard.

5.8.7. Publish data objects that are stored in a personal workspace

You can publish data objects that are stored in a personal workspace. All Internet users can visit the URLs that point to published data objects. We recommend that you do not publish data objects that include sensitive business data.

Prerequisites

You have purchased Quick BI.

Context

In a personal workspace, you can publish **dashboards** and **workbooks**.

This topic takes a dashboard as an example to describe how to publish data objects in a personal workspace.

Procedure

1. Log on to the Quick BI console.
2. Select a workspace.
3. Click **Dashboards** to go to the Dashboards page.
4. Select the target dashboard and click the **More** icon and select Make Public.
5. Specify an expiration date and click **Make Public**.

   A URL is generated and appears in the Make Public dialog box. You can copy and paste the URL into the address bar of your browser, and then access the dashboard by using the URL.

5.8.8. Make a data object in a workspace public

This topic describes how to make a data object in a workspace, also referred to as a group workspace, public. All Internet users can visit public data objects by using the provided URLs. We recommend that you do not publish data objects that contain sensitive business data.

Prerequisites

The Quick BI service is purchased.

Context

In a workspace, you can make **dashboards** and **workbooks** public.

This topic uses a dashboard as an example to describe how to make data objects in a workspace public.

Procedure

1. Log on to the Quick BI console.
2. Select a workspace.

3. In the left-side navigation pane of the Workspace page, click **Dashboards**.
4. On the Dashboards page, select the dashboard that you want to make public, click the **More** icon in the Actions column, and select Make Public.
5. In the Make Public dialog box, specify an expiration date and click **Make Public**.

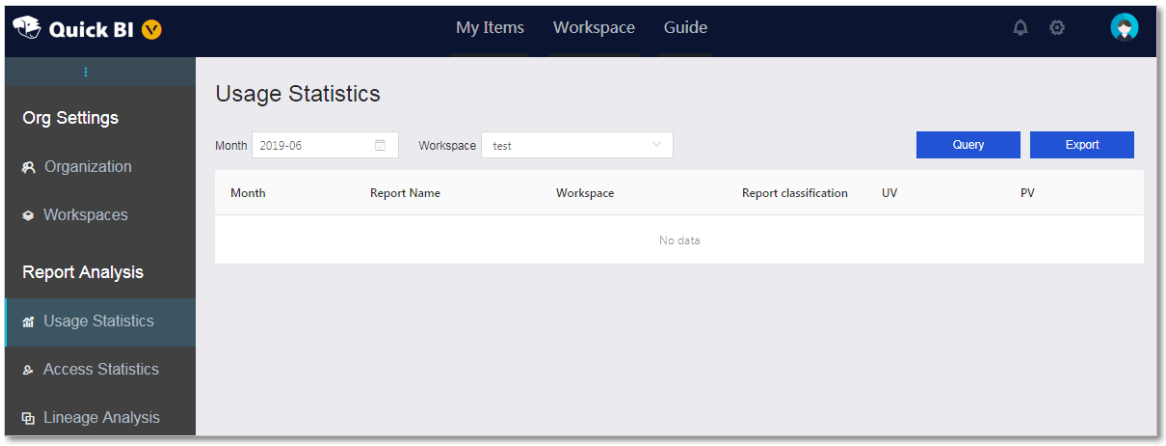
   A URL is generated and appears in the Make Public dialog box. You can copy and paste the URL into the address bar of your browser to access the dashboard.

5.9. Report statistics

5.9.1. Usage statistics

Usage statistics allow you to track the Unique Visitor (UV) and Page View (PV) values of a specific report in a specific month.

1. On the homepage of the Quick BI console, click the **Settings** icon.
2. In the left-side navigation pane, click **Usage Statistics**.
3. On the Usage Statistics page, select a month and workspace and click **Query**.

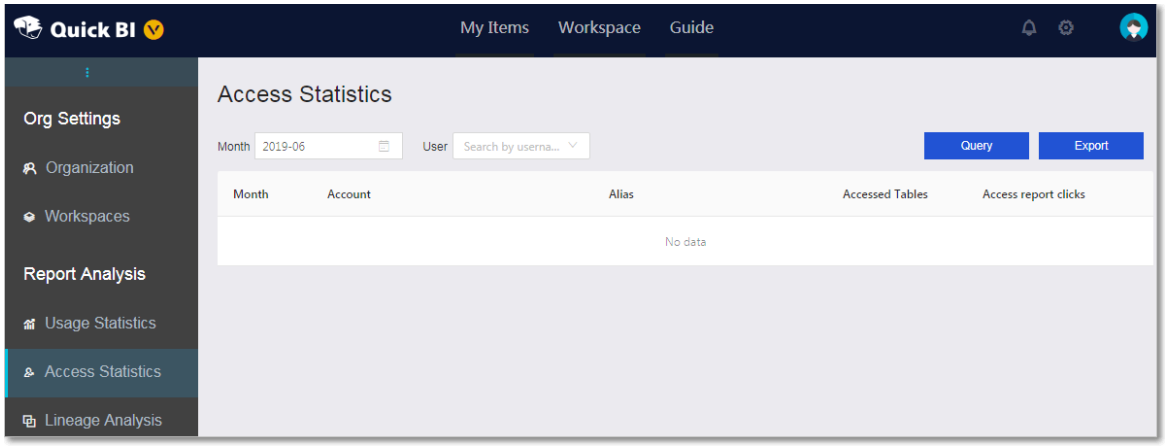


4. Click **Export** to export the statistics data to a local device in an Excel file.

5.9.2. Access statistics

Access statistics allow you to track the number of reports that you have accessed in a specific month and the number of clicks on a specific report.

1. On the homepage of the Quick BI console, click the **Settings** icon.
2. In the left-side navigation pane, click **Access Statistics**.
3. On the Access Statistics page, select a month, enter the member alias, and click **Query**.

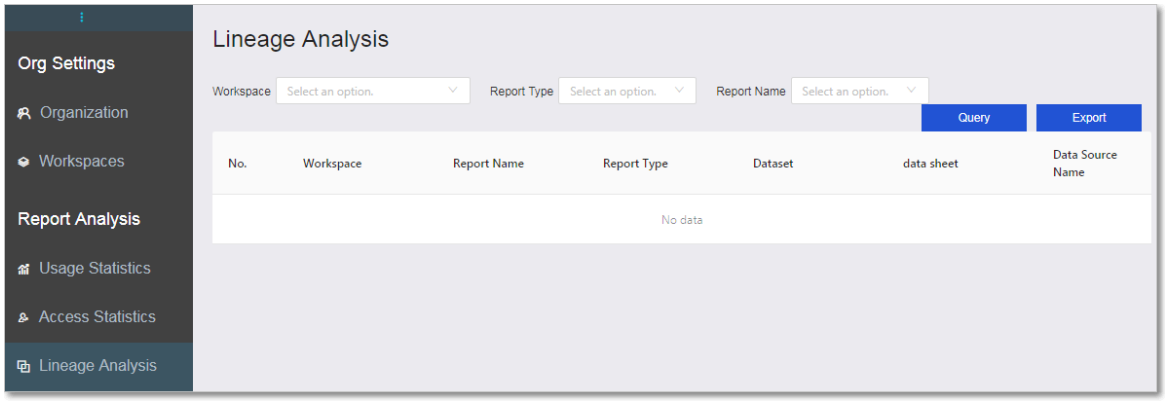


4. Click **Export** to export the statistics data as an Excel file to a local device.

5.9.3. Lineage analysis

Lineage analysis allows you to query information about a specific report, such as the workspace, report type, dataset, chart, and data source name.

1. On the homepage of the Quick BI console, click the **Settings** icon next to the profile picture.
2. In the left-side navigation pane, click **Lineage Analysis**.
3. On the Lineage Analysis page, select the workspace, report type, and report name of the report you want to query, and click **Query**.



4. Click **Export** to export the analysis results as an Excel file to a local device.