Alibaba Cloud MaxCompute

User Guide

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Generic conventions

Table -1: Style conventions

Style	Description	Example
	This warning information 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.
	This warning information 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 restore business.
	This indicates warning informatio n, supplementary instructions, and other content that the user must understand.	Notice: Take the necessary precautions to save exported data containing sensitive information.
	This indicates supplemental instructions, best practices, tips, and other content that is good to know for the user.	Note: You can use Ctrl + A to select all files.
>	Multi-level menu cascade.	Settings > Network > Set network type
Bold	It is used for buttons, menus , page names, and other UI elements.	Click OK.
`Courier font`	It is used for commands.	Run the `cd / d C :/ windows` command to enter the Windows system folder.
Italics	It is used for parameters and variables.	`bae log list --instanceid` *`Instance_ID`*
[] or [a|b]	It indicates that it is a optional value, and only one item can be selected.	`ipconfig` *`[-all|-t]`*

Style	Description	Example
{} or {a|b}	It indicates that it is a required value, and only one item can be selected.	`swich` *{stand | slave}*

Contents

1 Data types

This topic describes the data types supported by MaxCompute 2.0, including basic data types and complex data types.

Basic data types

The following table lists the basic data types supported by MaxCompute 2.0. To use a new data type, you must configure the set odps.sql.type.system.odps2=true; or setproject odps.sql.type.system.odps2=true; statement as needed, and pay attention to the impact on the existing tasks. If you do not set the statement, an error `xxxx type is not enabled in current mode` will occur.

Note:
The statement `odps . sql . type . system . odps2` for enabling new data types supports only lowercase letters.

Type	New in MaxCompute 2.0?	Constant	Description
TINYINT	Yes	1Y, -127Y	The 8-bit signed integer type. Range: -128 to 127
SMALLINT	Yes	32767S, -100S	The 16-bit signed integer type. Range: -32768 to 32767
INT	Yes	1000, -15645787	The 32-bit signed integer type. Range: $(-2)^{31}$ to $2^{31} - 1$ (note 1 and note 2)
BIGINT	No	100000000000L, -1L	The 64-bit signed integer type. Range: $(-2)^{63} + 1$ to $2^{63} - 1$
FLOAT	Yes	N/A	The 32-bit binary float type
DOUBLE	No	3.1415926 1E+7	The 64-bit binary float type

Type	New in MaxCompute 2 .0?	Constant	Description
DECIMAL	No	3.5BD, 99999999999. 9999999BD	The decimal precision number type. Integer range: $(-10)^{36} + 1$ to $10^{36} - 1$; decimal part: accurate to 10^{-18} (note 5)
VARCHAR(n)	Yes	N/A	The variable-length character type. 'n' is the length, and the range is 1 to 65535 (note 3).
STRING	No	"abc", 'bcd', "alibaba", ' inc'	The string type. Maximum length: 8 MB (note 4)
BINARY	Yes	N/A	The binary data type. Maximum length: 8 MB
DATETIME	No	DATETIME '2017-11-11 00:00:00'	The date time type. Range: January 1, 0000 to December 31, 9999, accurate to milliseconds (note 6)
TIMESTAMP	Yes	TIMESTAMP '2017-11-11 00:00:00.123456789'	The timestamp type that is irrelevant to time zones. Range: January 1, 0000 to 23.59:59.999999999 December 31, 9999 Note: For some time zone-related functions, such as cast(<a timestamp> as string), timestamps that are irrelevant to the time zone must be displayed in accordance with the current time zone.

Type	New in MaxCompute 2.0?	Constant	Description
BOOLEAN	No	True, False	The Boolean type. Value: True, False

Note:
The data types listed in the preceding table can be NULL.

When you use new data types in MaxCompute, pay attention to the following information:

- Applicable scenarios of new data types:
  - MaxCompute SQL
  - The latest version of MapReduce
  - SDK 0.27.2 (public and later versions), and client 0.27.0 and later versions
- New data type flag

  Currently, new data types cannot be directly used by default. To use a new data type, run a flag command. Note that only lowercase letters are supported in the flag command.

  - Session level: To use new data types (such as TINYINT, SMALLINT, INT, FLOAT, VARCHAR, TIMESTAMP, and BINARY) in SQL or MapReduce (the latest version), add a set statement before the table statement `set odps . sql . type . system . odps2 = true ;` and submit the two statements. The SQL statements submitted through MaxCompute Studio are performed automatically. For more information, see #unique_4.
  - Project level: New data types at the project level can be used. To use the new data types at the project level, the project owner must run the following command:

    ```
    setproject  odps . sql . type . system . odps2 = true ;
    ```

    For more information about the setproject command, see #unique_5.

- Impact of using the new data type odps.sql.type.system.odps2 :
  - Note 1:

    If the new data type flag is enabled, INT in the SQL statement indicates a 32-bit integer. For example, if you run the `cast ( a as INT )` command, type a is converted to a 32-bit integer. If the new data type flag is not enabled, type a is converted to BIGINT (64-bit).

    For example, the `cast ( a as INT )` command is equivalent to `cast ( a as BIGINT )`, `create table t ( a INT )`, and `create table a ( BIGINT )`. If you do not set odps.sql.type.system.odps2 to true, you can also convert data types in MaxCompute. However, a warning will be prompted, indicating that INT is processed as BIGINT. Therefore, we recommend that you write BIGINT in your scripts.
  - The syntax of an integer constant changes.

    In `SELECT 1 + a ;`, the integer constant is 1.

    - If the new data type flag is not enabled, the integer constant is processed as BIGINT. If the constant length (such as 1000000000000000000000000) exceeds the value range of BIGINT, the integer constant is processed as DOUBLE.
    - If the new data type flag is enabled, the integer constant is expressed as 1 (a 32-digit integer). If the constant value is greater than the maximum INT value but smaller than the maximum BIGINT value, the integer is converted to BIGINT. If the constant value is greater than the maximum BIGINT value, the integer is converted to DOUBLE.
    - 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 jobs might be changed by new type tables generated after data is written to disk.
  - The rules for converting implicit data types change.

    If the new data type flag is enabled, some implicit types may not be converted. For example, the precision of conversions from STRING to BIGINT, STRING to DATETIME, DOUBLE to BIGINT, DECIMAL to DOUBLE, and DECIMAL to BIGINT might be reduced. In this case, you can use the CAST function to convert the data type.

Converting implicit data types affects insert and the calling of functions. You can run the SQL statements that meet the requirements before enabling the new data type flag. However, an error might be displayed after the new data type flag is enabled.

- The supported operations, built-in functions, and UDFs are different.

  If the new type flag is not enabled, some operations and built-in functions that use new types as parameters and response values are not available.

  1. Some built-in functions can be performed only after the new type flag is enabled, for example, most of the functions that use INT as parameters have BIGINT overloading. Functions such as YEAR, QUARTER, MONTH, DAY, HOUR, MINUTE, SECOND, MILLISECOND, NANOSECOND, DAYOFMONTH, and WEEKOFYEAR can be implemented by using DATEPART built-in functions.
  2. The UDF resolutions are different. For example, a UDF contains both BIGINT and INT. Before the new type flag is enabled, the resolution is BIGINT. After the new type flag is enabled, the resolution is INT.
- The BIGINT resolutions are different.

  An integer constant, such as 123, is of the BIGINT type before a new data type is used. The integer constant becomes INT type after a new data type is used.

  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 jobs might be changed by new type tables generated after data is written to disk.
- Types of supported partition columns are different.
  - Before the new type flag is enabled, only STRING is supported by partition columns.
  - After the new type flag is enabled, data types such as STRING, VARCHAR, CHAR, TINYINT, SMALLINT, INT, and BIGINT are supported by partition columns.
  - If the new type flag is not enabled, partition fields in INSERT operations must be processed as STRING. For example, you can enter `insert overwrite`

`table t partition ( pt = 045 ) select ...`. Note that 045 is not enclosed by quotation marks ("") and is resolved as an integer (45).

- Action of the LIMIT statement changes.

  Take the `SELECT * FROM t1 UNION ALL SELECT * FROM t2 limit 10 ;` statement as an example:

  - Before the new type flag is enabled, the statement is `SELECT * FROM t1 UNION ALL SELECT * FROM ( SELECT * FROM t2 limit 10 ) t2 ;`.
  - After the new type flag is enabled, the statement is `SELECT * FROM ( SELECT * FROM t1 UNION ALL SELECT * FROM t2 ) t limit 10 ;`.

  Actions of the #unique_8, INTERSECT, EXCEPT, LIMIT, ORDER BY, DISTRIBUTE BY, SORT BY, and CLUSTER BY statements are also changed if the new type flag is enabled.

- The resolutions of the IN expression are different.

  Take the IN expression, such as a in (1, 2, 3), as an example:

  - Before the new type flag is enabled, all the values in the parentheses () must be of the same type.
  - After the new type flag is enabled, all the values in the parentheses () can be converted to the same implicit type.

- Note 2: If a constant value is greater than the maximum INT value but smaller than the maximum BIGINT value, the integer is converted to BIGINT. If the constant value is greater than the maximum BIGINT value, the integer is converted to DOUBLE. In MaxCompute versions earlier than 2.0, all INT types in SQL scripts are converted to BIGINT. The following is an example:

```
create table a_bigint_t able ( a int ); -- Here INT is
  processed as BIGINT .
select cast ( id as int ) from mytable ; -- Here INT
is processed as BIGINT .
```

- Note 3: VARCHAR constants can be expressed through implicit transformation of STRING constants.
- Note 4: STRING constants can be connected to different strings, for example, `abc` and `xyz` are resolved as `abcxyz`, and can be written into different row.

- Note 5:: When you insert a constant to the DECIMAL field, ensure that the constant is in the same format as that in the constant definition, for example, 3.5BD in the following command:

```
insert into test_tb ( a ) values ( 3 . 5BD )
```

- Note 6: The displayed time value does not contain milliseconds. You can use the tunnel command and `- dfp` to specify the time format, for example, `tunnel upload - dfp ' yyyy - MM - dd HH : mm : ss . SSS '`. For more information about tunnel commands, see #unique_9.

Complex data types

The following table lists the complex data types that are supported by MaxCompute 2 .0.

Type	Definition method	Construction method
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))

Note:
Complex data types are nestable. For the related built-in functions, see #unique_10/unique_10_Connect_42_section_zcz_4lb_wdb, #unique_10/unique_10_Connect_42_section_bzn_hcb_wdb, #unique_10/unique_10_Connect_42_section_ifb_2nb_wdb.

2 Common commands

2.1 List of common commands

This module explains how to use the relevant commands through the client to help you quickly understand MaxCompute.

The latest MaxCompute service adjusts the usual commands, the new command style is more closely used by hive, which is convenient for original Hadoop/HIVE users.

MaxCompute offers many operations for projects, tables, resources, instances, and other objects. You can perform operations on these objects using the console commands and SDK.

Note:

- The common commands introduced in this module are mainly targeted at latest version of theClient .
- If you want to learn how to install and configure clients, see Install and configure a clientQuick Start.
- For more information about the SDK, see MaxCompute SDK introductionMaxCompute SDK introduction.

List of common commands

addaliasalter

costcreate

dropdescdescribedownload/get

extended

flag/flagsfunctions

get

helphistory

jar/mapreduce

kill

lifecyclelist

odpscmd

partition

q/quit

resource

setshowstatus

tunnel

upload

weitwho

Use limits

- When you perform resource operations, please note that the size of each resource file should not exceed 500 MB, and the total size of resources referenced by a single SQL or MapReduce task should not exceed 2048 MB. For more restrictions, seeMR limits。

2.2 Project operations

This article introduces you to command operations for entering the project and setting space properties (permissions and whitelist functions, etc.).

Enter the workspce

Command format:

```
use  < project_na  me >;
```

Action:

- Enter the specified workspce. After entering the workspce, all objects in this workspce can be operated by the user.
- If the workspce does not exist or the current user is not in this workspce, an exception is returned.

Example:

```
odps : my_project > use   my_project ; -- my_project   is   a
workspce   the   user   has   privilege   to   access .
```

Note:

The preceding examples uses the MaxCompute client. All MaxCompute command keywords, workspce names, table names, column names are case insensitive.

Creating a project is creating a MaxCompute project

After running the command, you can access the objects of this workspce. In the following example, assume that test_src exists in the project 'my_project' . Run the following command:

```
odps : my_project > select  *  from   test_src ;
```

MaxCompute automatically searches the table in my_project. If the table exists, it returns the data of this table. If the table does not exist, an exception is thrown. To access the table test_src in another workspce, such as 'my_project2' , through the project 'my_project' , you must first specify the workspce name as follows:

```
odps : my_project > select  *  from   my_project  2 . test_src ;
```

The returned data is the data in my_project2, not the initial data of test_src in my_project.

MaxCompute does not support commands to create or delete workspce. You can use the MaxCompute console for additional configurations and operations as needed.For details, see project list

Query workspace

Command format:

```
list   projects ;
```

Features:

Used to view the list of items created by the primary account.

Note:
This command is supported from odpscmd 0.30.2.

SetProject

Command format:

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

Action:

- Use `setproject` command to set workspce attributes.

  The following example sets the method that allows a full table scan.

```
setproject  odps . sql . allow . fullscan  =  true ;
```

- If the value of <KEY>=<VALUE> is not specified, the current workspce attribute configuration is displayed. Command format:

```
setproject ;  -- Display  the  parameters  set  by  the
setproject  command .
```

Parameters

Property name	Configured permission	Description	Value range
odps.sql.allow.fullscan	ProjectOwner	Determines whether to allow a full table scan.	True (permitted) /false (prohibited)
odps.table.drop.ignorenonexistent	All users	Whether to report an error when deleting a table that does not exist. When the value is true, no error is reported.	True (no error reported)/false
odps.security.ip.whitelist	ProjectOwner	Specify an IP whitelist to access the workspce.	IP list separated by commas (,)
odps.instance.remain.days	ProjectOwner	Determines the duration of the retention of the instance information.	[3- 30]
READ_TABLE_MAX_ROW	ProjectOwner	The number of data entries returned by running the Select statement in the client.	[1-10000]

Examples for odps.security.ip.whitelist

MaxCompute supports a workspce level IP whitelist.

Note:

- If the IP whitelist is configured, only the IP (console IP or IP of exit where SDK is located) in the whitelist can access this workspce.

- After setting the IP white list, wait for at least five minutes to let the changes take effect.
- For further assistance, open a ticket to contact Alibaba Cloud technical support team.

The following are the three formats for an IP list in the whitelist, which can appear in the same command. Use commas (,) to separate these commands.

- IP address: For example, 101.132.236.134.
- Subnet mask: For example, 100.116.0.0/16.
- Network segment: For example, 101.132.236.134-101.132.236.144.

Example of the command line tool set the IP white list:

```
setproject   odps . security . ip . whitelist = 101 . 132 . 236 . 134
, 100 . 116 . 0 . 0 / 16 , 101 . 132 . 236 . 134 - 101 . 132 . 236 .
144 ;
```

If no IP address is added in the whitelist, then the whitelist function is disabled.

```
setproject   odps . security . ip . whitelist =;
```

2.3 Table operations

This article will show you how to create, delete and view tables using common commands through the MaxCompute client.

If you want to operate a table, use common commands in the client. Moreover it is more convenient to collect tables, apply permissions, and view partitions using the visible data table manager in DataWorks. For more information, see Table Details.

Create tables

Command format:

```
CREATE   TABLE  [ IF   NOT   EXISTS ]  table_name
[( col_name   data_type  [ COMMENT   col_commen  t ], ...)]
[ COMMENT   table_comm  ent ]
[ PARTITIONE  D   BY  ( col_name   data_type  [ COMMENT   col_commen
t ], ...)]
[ LIFECYCLE   days ]
[ As   select_sta  tement ]
CREATE   TABLE  [ IF   NOT   EXISTS ]  table_name
 LIKE   existing_t  able_name
```

Action:

Create a table.

Note:

- Both the table name and column name are case insensitive and follow the same naming conventions. The name can be up to 128 bytes in length and can contain letters, numbers, and underscores (_).
- The comment content is an effective string, and it can be up to 1,024 bytes in length.
- [LIFECYCLE days]: The parameter 'days' refers to the time required to complete a 'Table Operation' lifecycle. It must be a positive integer. The unit is 'day'.
- Suppose that the 'table_name' is no-partition table. If calculated from the last updated date, the data is still not modified after N (days), then MaxCompute automatically recycles the table without user intervention (similar to 'drop table' operation).
- Suppose that the 'table_name' is a partition table. MaxCompute determines whether to recycle the table according to LastDataModifiedTime of each partition. Unlike non-partitioned tables, a partitioned table is not deleted after all its partitions are reclaimed. The lifecycle can only be created for tables and not for the specified partitions.

Example:

```
CREATE   TABLE   IF   NOT   EXISTS   sale_detai  l (
 shop_name   STRING ,
 customer_i  d   STRING ,
 total_pric  e   DOUBLE )
PARTITIONE  D   BY  ( sale_date   STRING , region   STRING ); --
Create   a   partition   table   sale_detai  l .
```

Drop Table

Command format:

```
DROP   TABLE  [ IF   EXISTS ]  table_name ; --  Table   name   to
be   deleted .
```

Action:

- Delete a table.
- If the option [IF EXISTS] is specified, regardless of whether the table exists or not, the return is successful. If the option [IF EXISTS] is not specified, and the table does not exist, an exception is returned.

Example:

```
DROP   TABLE   sale_detai  l ; --  If   the   table   exists ,
success   returns .
DROP   TABLE   IF   EXISTS   sale_detai  l ; --  No   matter
whether   the   table   sale_detai  l   exists   or   not ,  success
  returns .
```

Describe Table

Command format:

```
DESC  < table_name >; --  Table   name   or   view   name .
DESC   extended  < table_name >; --  View   the   extended   table
informatio  n .
```

Action:

Return information of a specified table, includes:

- Owner: The owner of the table.
- Project: The project to which a table belongs.
- CreateTime: The creation time of the table.
- LastDDLTime: The last DDL operation.
- LastModifiedTime: The last time of table modification.
- InternalTable: Indicates the object to be described is table. The value is 'YES' by default.
- Size: Storage size occupied by table data, usually the compression ratio is 5. The unit is Byte.
- Native Columns: Non-partition column information, including column name, type, comment.
- Partition Columns: Partition column information, including partition name, type, and comment.
- Extended Info: The information of extended table, such as StorageHandler and Location.

Example:

```
odps @  project_na  me > DESC   sale_detai  l ; --  Describe   a
partition   table .
+------------------------------------------------------------------------------------
+
|  Owner :  ALIYUN $ odpsuser @ aliyun . com  |  Project :
test_proje  ct  |
|  TableComme  nt : |
+------------------------------------------------------------------------------------
+
```

```
| CreateTime : 2014 - 01 - 01 17 : 32 : 13 |
| LastDDLTim e : 2014 - 01 - 01 17 : 57 : 38 |
| LastModifi edTime : 1970 - 01 - 01 08 : 00 : 00 |
+------------------------------------------------------------------------------------
+
| Internalta ble : Yes | size : 0 |
+------------------------------------------------------------------------------------
+
| Native Columns : |
+------------------------------------------------------------------------------------
+
| Field | Type | Comment |
+------------------------------------------------------------------------------------
+
| shop_name | string | |
| customer_i d | string |
| total_pric e | double | |
+------------------------------------------------------------------------------------
+
| Partition Columns : |
+------------------------------------------------------------------------------------
+
| sale_date | string | |
| region | string | |
+------------------------------------------------------------------------------------
+
```

Note:

- The preceding example is executed using the MaxCompute client.
- If the table has no partition, the information of Partition Columns is not displayed.
- To describe a 'View', the option ‘InternalTable’ cannot be displayed but the option ‘VirtualView’ can be displayed and its value is ‘YES’ by default. Similarly, the 'Size' option is replaced by the 'View Text' option, which represents the definition of the view, for example: `select * from src`. For more information, see#unique_32.

View partition table

Command format:

```
desc table_name partition ( pt_spec
```

Action:

View the specific partition information of a partition table.

Example:

```
odps @ project_na me > desc meta . m_security _users partition
 ( ds =' 20151010 ');
+------------------------------------------------------------------------------------
+
| PartitionS ize : 2109112 |
```

```
+------------------------------------------------------------------------------
+
| CreateTime : 2015 - 10 - 10 08 : 48 : 48 |
| LastDDLTim e : 2015 - 10 - 10 08 : 48 : 48 |
| LastModifi edTime : 2015 - 10 - 11 01 : 33 : 35 |
+------------------------------------------------------------------------------
+
 OK
```

Show Tables/Show Tables like

Command format:

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

Action:

- SHOW TABLES: List all tables of current project.
- SHOW TABLES like 'chart': Lists the tables on which the following table names of the current project match the 'chart'. Regular expressions are supported.

Example:

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

Note:

- The preceding example is executed using the MaxCompute client.
- ALIYUN is a system prompt, indicating the you are an Alibaba Cloud user.
- In this example,odps_user@aliyun.com is the creator of the table in this example.
- In this example,table_name is the name of the table.

Show Partitions

Command format:

```
SHOW PARTITIONS table_name ; -- table_name : Specify the
table to be queried . If the table does not exist
or it is not a partition table , an exception is
thrown .
```

Action:

List all partitions of a table.

Example:

```
odps @  project_na  me > SHOW   PARTITIONS   table_name ;
partition_  col1 = col1_value  1 / partition_  col2 = col2_value  1
partition_  col1 = col1_value  2 / partition_  col2 = col2_value  2
…
```

Note:

- The preceding example is executed using the MaxCompute client.
- Partition_col1 and partition_col2 are the partition columns of the table.
- Col1_value1, col2_value1, col1_value2, and col2_value2 are corresponding values of the partition columns.

2.4 Instances operations

Show instances/Show P

Command format:

```
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 >;
```

Action:

Displays the information about the instances created by the current users.

Parameters:

- `startdate` 、 `enddate` : Returns the instance information during the specified period (from startdate to enddate) in the yyyy-mm-dd format and the unit is ‘day’ . The parameters are optional. If the parameters are not specified, instances submitted within three days are returned by default.
- `number` : Specifies the number of instances to be displayed. Based on the scheduled time, return N (number) instances nearest to the current time. If not specified, all instances that meet the requirements are shown.
- `- all` : The information of all instances that meet requirements is returned. To execute the command, you must have the 'list' permission for the project. This command can only return 50 records by default. You can `- limit   number` to show more record. For example, use `show   p  - all  - limit   100` to show 100 instance records in the project.

- The output items: Include StartTime (the time accurate to seconds), RunTime (s) and Status (including Waiting, Success, Failed, Running, Cancelled, and Suspended).

InstanceID and corresponding SQL are as follows:

```
 StartTime   RunTime   Status   InstanceID   Query
 2015 - 04 - 28   13 : 57 : 55   1s   Success   20150428xx
 xxxxxxxxxx  xxxxxx   ALIYUN $ xxxxx @ aliyun - inner . com   select
 *  from   tab_pack_p  riv   limit   20 ;
...    ...    ...    ...    ...    ...
...    ...    ...    ...    ...    ......
```

The probable status of an instance is as follows:

- Running
- Success
- Waiting
- Failed (job failed but data in the target table is modified)
- Suspended
- Canceled

Note:
The commands from the preceding example run in MaxCompute client.

Status Instance

Command format:

```
status  < instance_i  d >; --  instance_i  d :  the   unique
identifier   of   an   instance ,  to   specify   which   instance
to   be   queried .
```

Action:

- Query the status of specified instance, such as Success, Failed, Running, and Cancelled.
- If this instance is not created by the current user, exception is returned.

Example:

```
odps @ $ project_na  me > status   2013122512  3xxxxxxxxx  xxxxxx ;
Success
```

Query the status of an instance which ID is 20131225123xxxxxxxxxxxxxxx, and the result is Success.

Note:
The commands from the preceding example run in MaxCompute client.

Top Instance

Command format:

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

Action:

Permission requirements: The user must be a project owner or administrator.

`top instance` : Displays the job information of the current account that is running in the project. It is displayed, includesding ISNTANCEID , Owner, Type, StartTime, Progress, Status, Priority, RuntimeUsage (CPU/MEM), TotalUsage (CPU/MEM), QueueingInfo (POS/LEN) and so on.

`top instance - all` : Returns all jobs that are currently being executed in the current project. This command can only return 50 records by default. You can user `- limit number` to show more record.

Example:

```
odps @ $ project_na me > top instance ;
```

Note:
The commands from the preceding example run in MaxCompute client (version 0.29.0 or later).

Kill Instance

Command format:

```
kill < instance_i d >; -- instance_i d : The unique
identifier of an instance , which must be ID of
an instance whose status is ' Running ', otherwise , an
error is returned .
```

Action:

Stop specified instance. The instance must be in the Running status.

Example:

```
odps @ $ project_na me > kill 2013122512 3xxxxxxxxx xxxxxx ;
```

Stop the instance which ID is 20131225123xxxxxxxxxxxxxxx.

Note:

- The commands from the preceding example run in MaxCompute client.
- This is an asynchronous process. It does not mean that the distributed task has stopped after the system accepts the request and returns the result. You can check whether the instance is deleted by using the `status` command.

Desc Instance

Command format:

```
desc instance < instance_i d >; -- instance_i d : The unique
  identifier of an instance .
```

Action:

Get the job information according to instance ID, including SQL, owner, startime, endtime, status.

Example:

```
odps @ $ project_na me > desc instance 20150715xx xxxxxxxxxx
xxx ;
ID  20150715xx xxxxxxxxxx xxx
Owner  ALIYUN $ XXXXXX @ alibaba - inc . com
StartTime  2015 - 07 - 15  18 : 34 : 41
EndTime  2015 - 07 - 15  18 : 34 : 42
Status  Terminated
console_se lect_query _task_1436 956481295  Success
Query  select * from  mj_test ;
```

Query all the job information related to the instance whose ID is 20150715xxxxxxxxxxxxxxx.

Note:

The commands from the preceding example run in MaxCompute client.

Wait instance

Command format:

```
wait  < instance_i  d >;  --  instance_i  d :  The   unique
identifier   of   an   instance .
```

Action:

Get running task information, including logs based on the instance ID and a logview link. View task details by accessing the logview link.

Example:

```
wait   2017092516  11xxxxxxxx  xxxxxx ;
ID  =  2017092516  11xxxxxxxx  xxxxxx
Log   view :
http :// logview . odps . aliyun . com / logview /? h = http ://
service . odps . aliyun . com / xxxxxxxxxx
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_tab  le :  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 :
                StreamLine  Write_REL5  213305 :  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 :
                StreamLine  Read_REL52  13306 :  8  ( min :  8 ,  max
:  8 ,  avg :  8 )
        output   records :
```

```
                TableSink_  REL5213309 :  8  ( min :  8 ,  max :  8
 ,  avg :  8 )
```

2.5 Resources operations

This article explains how to use common commands to operate resources in the MaxCompute client.

You can also search and upload resources using the visualized online data development tools in DataWorks. For more information, see Resource management.

Add a resource

Command format:

```
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 ];
```

Parameters

- `file / archive / table / jar` : Indicates the resource type. For more information, see Resources.
- `local_file` : Indicates path of the local file, and uses this file name as the resource name. Resource name also acts as a unique identifier of a resource.
- `table_name` : Indicates table name in MaxCompute. Currently, external tables cannot be added into resource.
- `[ PARTITION  ( spec )]`: When the resource to be added is a partition table, MaxCompute only supports taking a partition as a resource, not the entire partition table.
- `alias` : Specifies a resource name. If this parameter is not specified, the file name is used as a resource name by default. Jar and Python resources do not support this function.
- `[ comment  ‘ cmt ’]`: Adds a comment for the resource.
- `[- f ]`: If a name is duplicated, this parameter can be added as a substitute to the original resource. If this parameter is not specified and the duplicate resource name exists, the operation fails.

Example

```
odps @  odps_publi  c_dev > add   table   sale_detai  l   partition
( ds =' 20150602 ')  as   sale . res   comment  ' sale   detail   on
  20150602 ' - f ;
OK :  Resource  ' sale . res '  have   been   updated .
--- Add   a   resource   named   sale . res   in   MaxCompute .
```

> **Note:**
> Each resource file size cannot exceed 500 MB. The resource size referenced by a single SQL or MapReduce task cannot exceed 2048 MB. For more information about, see MR Restrictions .

Delete a resource

Command format:

```
DROP   RESOURCE  < resource_n  ame >; -- resource_n  ame :  a
specified   resource   name .
```

View the resource list

Command format:

```
LIST   RESOURCES ;
```

Action:

View all resources in the current project.

Example:

```
odps @ $ project_na  me > 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 resources

Use the following command format to download resources:

```
GET   RESOURCE  < resource_n  ame > < path >;
```

Action:

Download resources to your local device. The resource type must be file, jar, archive, or py.

Example:

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

2.6 Functions operations

This article explains how to use common commands to operate functions in the MaxCompute client.

You can also operate functions using the visualized online data development tools in DataWorks. For more information, see Function Management.

Create a Function

Command format:

```
CREATE FUNCTION < function_n ame > AS < package_to _class >
USING < resource_l ist >;
```

Parameters

- `function_n ame` : An UDF name referenced in SQL.
- `package_to _class` : For Java UDF, this name is a fully qualified class name (from top-level package name to UDF class name). This parameter must be in double quotation marks. And, for Python UDF, this name is a python script name. classname. For both Java UDF and python script, use double quotation (" ") marks to indicate this parameter. And for the name, use quotation marks.
- `resource_l ist` : Provides resource list used by UDF.
  - Resources that contain UDF code must be included in the list.
  - If the code reads the resource file by the distributed cache interface, this list also contains the list of resource files read by the UDF.
  - The resource list is composed of multiple resource names, separated by a comma (,). The resource list must be in double quotation ("") marks.
  - Specify the project in which the resource is located as follows: `< project_na me >/ resources /< resource_n ame >`.

Example:

- Suppose a Java UDF class org.alidata.odps.udf.examples.Lower is in my_lower.jar, create function my_lower as follows:

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

- Suppose a Python UDF MyLower is used in project pyudf_test.py,create function my_lower as follows:

```
create   function   my_lower   as  ' pyudf_test . MyLower '  using
' test_proje  ct / resources / pyudf_test . py ';
```

- Suppose a Java UDF class com.aliyun.odps.examples.udf.UDTFResource is in udtfexample1.jar, and it depends on file resource file_resource.txt and table resource table_resource1,create function test_udtf as follows:

```
create   function   test_udtf   as  ' com . aliyun . odps .
examples . udf . UDTFResour  ce '  using  ' udtfexampl  e1 . jar ,
file_resou  rce . txt ,  table_reso  urce1 , test_archi  ve . zip
';
```

Note:

- Similar to the resource files, the UDF duplicate name can be registered only once.
- Generally UDF cannot overwrite system built-in functions. Only the project owner has right to overwrite the built-in functions. If you are using a UDF which overwrites the built-in function, the warning is triggered in Summary after SQL execution.

Drop a Function

Command format:

```
DROP   FUNCTION  < function_n  ame >;
```

Example:

```
DROP   FUNCTION   test_lower ;
```

List Functions

Command format:

```
list   functions ; -- View   all   user - defined   functions   in
current   project .
```

```
list functions - p my_project ; -- View all user - defined
functions in the project ' my_project '.
```

2.7 Set operations

This topic describes how to use the set command to set MaxCompute or user-defined system variables and how to clear the settings.

set command

Format

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

Action

You can use the `set` command to configure operations in MaxCompute.

The following table lists the system variables that are supported by MaxCompute.

System variable	Description	Value
odps.sql.allow.fullscan	Specifies whether to allow a partitioned table to be fully scanned.	· `True` : The partitioned table is allowed to be fully scanned. · `False` : The partitioned table is not allowed to be fully scanned.
odps.stage.mapper.mem	Sets the memory size of each map worker.	Default value: 1024 MB
odps.stage.reducer.mem	Sets the memory size of each reduce worker.	Default value: 1024 MB
odps.stage.joiner.mem	Sets the memory size of each join worker.	Default value: 1024 MB
odps.stage.mem	Sets the memory size of all workers in specified MaxCompute jobs. This set key has lower priority than that of the preceding three ones.	This set key does not have a default value.

System variable	Description	Value
odps.stage.mapper.split.size	Modifies the input data quantity of each map worker (the input file shard size) to manage the number of workers at each map stage.	Default value: 256 MB
odps.stage.reducer.num	Modifies the number of workers at each reduce stage.	This variable does not have a default value.
odps.stage.joiner.num	Modifies the number of workers at each join stage.	This variable does not have a default value.
odps.stage.num	Modifies the worker concurrency at all stages in specified MaxCompute jobs. This set key has lower priority than that of the preceding three ones.	This variable does not have a default value.
odps.sql.reshuffle.dynamicpt	Sets dynamic partitions to avoid generating excessive small files.	· True · False Default value: True Note: If a small number of dynamic partitions are generated, we recommend that you set the value of this variable to `False` to avoid data skew.
odps.sql.type.system.odps2	Sets the value to `True` if the SQL statement contains new data types such as TINYINT, SMALLINT, INT, FLOAT, VARCHAR, and TIMESTAMP BINARY.	· True · False Default value: False

System variable	Description	Value
odps.sql.hive.compatible	Specifies whether to enable the Hive compatibility mode. MaxCompute supports various syntaxes specified by Hive, such as inputRecordReader, outputRecordReader, and Serde only after the Hive compatibility mode is enabled.	· True · False Default value: False

Note:
Only lowercase letters can be used in the set command. For settings about project operations, see #unique_41.

Example

```
set odps . sql . executione ngine . coldata . deep . buffer . size .
max
```

- The preceding SQL statement is used to adjust the buffer size of a complex type column in a table that is written in MaxCompute.
- Application scenarios
  1. An output table contains many complex data types.
  2. The size of a single complex variable contained in the output table exceeds the specified size.
- Description
  - The default buffer size is 67,108,864 byte (64 MB).
  - If an output table has 3 columns whose schema is of a complex type, such as string, map, struct, array, and binary, MaxCompute reserves 64 MB for each column by default. The buffer that is applied for each column is used to store data for the corresponding `batch row count` row.
  - We recommend that you set a proper value according to the estimated size of the complex variables in a table. For example, if the size of each complex variable

does not exceed 1,024 byte and the `batch row count` value is 1024 (the default value), you can set the flag to 1024 × 1024. The following is an example:

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

- If the value of each complex variable is between 7 MB and 8 MB, and the value of `batch row count` is 32, you can set this value to 8 MB × 32.
- If the output of a task has a complex type, or if the `mapjoin` table of a task has a complex type, adjusting the value affects the memory during task running. An excessive large value might cause out of memory (OOM).

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

- Similar to `set odps . stage . mapper . split . size`, the `set odps . stage . mapper . split . size` command can also be used to adjust the quantity of data (in MB) read by each `mapper` worker. The following is an example:

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

show flags

Format

```
show flags ; -- Display parameters set by using the set
  command .
```

> **Note:**
> You can run the `use project` command to clear the settings.

2.8 Other operations

Alias command

The ALIAS command reads different resources (data) using a fixed resource name in MapReduce or UDF without modifying the code.

Command format:

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

Action:

Create alias for a resource.

Example:

```
ADD   TABLE   src_part   PARTITION  ( ds =' 20121208 ')  AS
res_201212  08 ;
ADD   TABLE   src_part   PARTITION  ( ds =' 20121209 ')  AS
res_201212  09 ;
ALIAS   resName = res_201212  08 ;
jar  - resources   resName  - libjars   work . jar  - classpath  ./
work . jar   com . company . MainClass   args  ... ;// job   1
ALIAS   resName = res_201212  09 ;
jar  - resources   resName  - libjars   work . jar  - classpath  ./
work . jar   com . company . MainClass   args  ... ;// job   2
```

In the preceding example, resource alias resName refers to different resource tables in two jobs. Different data can be read without modifying the code.

Cost SQL

Command format:

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

Action:

Estimate an SQL measurement message, including the size of the input data, the number of UDFs, and the SQL complexity level.

Note:
Use the following information for reference purpose only. Refrain from using it as an actual charging standard.

Example:

```
odps @ $ odps_proje  ct  > cost   sql   select   distinct
project_na  me ,  user_name   from   meta . m_security  _users
distribute   by   project_na  me   sort   by   project_na  me ;
ID  =  2015071511  3033121xxx  xxxxx
Input : 65727592   Bytes
UDF : 0
Complexity : 1 . 0
```

3 Data upload and download

3.1 Data upload and download overview

This topic provides an overview of the upload and download processes of MaxCompute system data, including service connection information, SDKs, tools, and how to migrate data to the cloud.

DataHub provides a real-time data tunnel, and Tunnel provides a batch data tunnel . Both of these tunnels can access MaxCompute and provide their own SDKs and derivative data upload and download tools. Specifically, the tools include DataWorks , DTS, OGG plugin, Sqoop, Flume plugin, LogStash plugin, Fluentd plugin, Kettle plugin, and MaxCompute client.

The underlying data tunnels used by these tools include:

- DataHub tools
  - OGG
  - Flume
  - LogStash
  - Fluentd
- Tunnel tools
  - DataWorks
  - DTS
  - Sqoop
  - Kettle
  - MaxCompute client

A wide range of data upload and download tools are applicable to most cloud data migration scenarios. The subsequent topics introduce the tools,Hadoop data migration, database data synchronization, log collection, and other cloud migration scenarios. We recommend that you refer to the relevant topics describing these scenarios.

Note:

For information about how to synchronize data in offline mode, we recommend that you readData integration overview.

Limits

Limits to uploading data while using Tunnel

- Your upload speed is dependent on your network bandwidth and server performance.
- The number of retransmission attempts has an upper limit. When this upper limit is exceeded, the system still continues to upload the next data block. However, your data may be lost as a result. Therefore, we recommend that you run the `select count (*)` command after the data upload is completed to check whether any data is lost.
- Tunnel commands cannot be used to upload or download the data types ARRAY, MAP, and STRUCT.
- By default, each project supports up to 2,000 concurrent Tunnel connections.
- On the server, the lifecycle for the session of each tunnel spans 24 hours. Each session can be shared among processes and threads on the server. During these sessions, you must ensure that each `BlockId` is unique.

Limits to uploading data while using DataHub

- The size of each field cannot exceed its upper limit. For information about the limits of each field, see Data types.

  Note:
  The length of a STRING-type field cannot exceed 8 MB.
- Multiple data entries are packetized into one package before they are uploaded.

Limits of TableTunnel SDK interfaces

- The value of `BlockId` 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 your session times out due to large volume data uploads, you must split your data into multiple sessions.
- The lifecycle of an HTTP request of the `RecordWriter` class is 120s. If no data flows over an HTTP connection within 120 seconds, the server closes the connection.

3.2 Connection to data tunnel service

In different network environments, you need to choose different service addresses (Endpoints) to connect services, otherwise you will not be able to initiate requests to services.

Both DataHub and Tunnel use different endpoints in different network environments. Depending on the network environment, select the appropriate service address or endpoint, to connect to the service. Select the appropriate address or endpoint for your network to be able to send requests to the service.

Note:

Different network connections may affect your Billing.

For detailed endpoints information for different network environments, see Endpoints and Data Centers Access Domains and Data Centers.

3.3 Cloud data migration

Data upload and data download tools of the MaxCompute platform can be used for a wide range of cloud data migration scenarios. This article introduces some typical scenarios.

Hadoop data migration

For Hadoop data migration, either use Sqoop or DataWorks.

- Sqoop runs an MR job on the original Hadoop cluster for the distributed data transmission to MaxCompute and is highly efficient. For more information, see Sqoop tool introduction.
- DataWorks can be combined with DataX for Hadoop data migration.

Database synchronization

To synchronize the data of a database to MaxCompute, select an appropriate tool based on the database type and synchronization rule.

- For offline batch data synchronization, use DataWorks. It supports a wide range of database types, including MySQL, SQL Server, and PostgreSQL. For more information, see #unique_54. For instance operation instructions, see #unique_55.
- For real-time Oracle data synchronization, use OGG plug-in tools.

- For real-time RDS data synchronization, use DTS.

Log collection

For log collection, use Flume, Fluentd, and Logstash tools.

3.4 Data upload and download tools

The MaxCompute platform supports a wide range of data upload and download tools. The source code for most of the tools can be found on GitHub, the open-source community to upload and download the data. You can select the tool according to the scenario. The tools are divided into two types: Alibaba Cloud DTplus products and open-source products. This article helps you learn more about these tools.

Alibaba Cloud DTplus products

- Data integration of DataWorks

  Data Integration, or data synchronization, 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 types: MaxCompute, RDS (MySQL, SQL Server, and PostgreSQL), Oracle, FTP, AnalyticDB (ADS), OSS, Memcache, and DRDS. For more information, see #unique_48.
- MaxCompute console
  - For information about console installation and basic use, see Client introduction.
  - Based on the Batch data tunnel SDK, the client provides built-in Tunnel commands for data upload and download. For more information, see Basic Tunnel command usage.

  > **Note:**
  > This is an open-source aliyun-odps-console.
- DTS

  Data Transmission (DTS) is a data service provided by Alibaba Cloud that supports data exchanges between RDBMS, NoSQL, OLAP, and other data sources. It provides data migration, real-time data subscription, real-time data synchronization, and other data transmission features.

DTS supports data synchronization from ApsaraDB for RDS and MySQL instances to MaxCompute tables. Currently, other data source types are not supported.

Open-source products

- Sqoop

  As a tool developed based on the Sqoop 1.4.6 community, Sqoop provides enhanced MaxCompute support with the ability to import and export data from MySQL and other relational databases to MaxCompute tables. Data in HDFS/Hive can also be imported to MaxCompute tables.

  Note:
  This is an open-source aliyun-maxcompute-data-collectors.

- Kettle

  Kettle is an open-source ETL tool based on Java which can run on Windows, Unix, or Linux. It provides graphic interfaces for you to easily define data transmission topology using drag-and-drop components.

  Note:
  This is an open-source aliyun-maxcompute-data-collectors.

- Flume

  Apache Flume is a distributed and reliable system, which efficiently collects, aggregates, and moves massive volumes of log data from different data sources to a centralized data storage system. It supports multiple Source and Sink plugins.

  The DataHub Sink plug-in of Apache Flume allows you to upload log data to DataHub in real time and archive the data in the MaxCompute tables.

  Note:
  This is an open-source aliyun-maxcompute-data-collectors.

- Fluentd

  Fluentd is an open-source software product that collects logs, including Applicatio n Logs, System Logs, and Access Logs, from various sources. It allows you to select plug-ins to filter and store log data to different data processors, including MySQL, Oracle, MongoDB, Hadoop, and Treasure Data.

The DataHub plug-in of Fluentd allows you to upload data to DataHub in real time and archive the data in MaxCompute tables.

- LogStash

  Logstash is an open-source log collection and processing framework. The logstash -output-datahub plugin allows you to import data to DataHub. This tool can be easily configured to collect and transmit data. When used together with MaxCompute or StreamCompute, it allows you to easily create an all-in-one streaming data solution right from data collection to analysis.

  The DataHub plug-in of Logstash allows you to upload data to DataHub in real time and archive the data in MaxCompute tables.

- OGG

  The DataHub plug-in of OGG allows you to incrementally synchronize the Oracle database data to DataHub in real time and archive the data in MaxCompute tables.

> Note:
> This is an open-source aliyun-maxcompute-data-collectors.

3.5 Tunnel commands

This topic introduces you to the instructions for the use of Upload, Show, Resume and other Tunnel upload and download commands.

Features

The Client provides Tunnel commands for you to use the functions of the original Dship tool.

Tunnel commands are mainly used to upload or download data.

- `Upload` : Supports file or directory (level-one) uploading. Data can only be uploaded to a single table or table partition each time. For partitioned tables, the destination partition must be specified.

```
tunnel upload log . txt test_proje ct . test_table / p1 ="
b1 ", p2 =" b2 ";
-- Uploads data in log . txt to the test_proje ct
project ' s test_table table , partitions : p1 =" b1 ", p2 ="
b2 ".
```

```
tunnel upload log . txt test_table -- scan = only ;
-- Uploads data from log . txt to the test_table
table .-- The scan parameter indicates that the data
in log . txt must be scanned to determine if it
complies with the test_table definition s . If it does
 not , the system reports an error and the upload
is stopped .
```

- `Download` : You can only download data to a single file. Only data in one table or partition can be downloaded to one file each time. For partitioned tables, the source partition must be specified.

```
tunnel download test_proje ct . test_table / p1 =" b1 ", p2 ="
b2 " test_table . txt ;
-- Download data from the table to the test_table .
txt file .
```

- `Resume` : If an error occurs because of network or the Tunnel service, you can resume transmission of the file or directory after interruption. This command allows you to resume the previous data upload operation, but does not support download operations.

```
tunnel resume ;
```

- `Show` : Displays the history of the commands used.

```
tunnel show history - n 5 ;
-- Displays details for the last five data upload /
download commands .
tunnel show log ;
-- Displays the log for the last data upload /
download .
```

- `Purge` : Clears the session directory. Use this command to clear history for last three days.

```
tunnel purge 5 ;
-- Clears logs from the previous five days .
```

Tunnel upload and download limits

Tunnel command does not support uploading and downloading data of the ARRAY, MAP, and STRUCT types.

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.

Use of Tunnel commands

Tunnel commands allow you to obtain help information using the Help sub-command on the client. Each command and selection supports short command format.

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

Parameters

- `upload` : Uploads the data to a MaxCompute table.
- `download` : Downloads the data from a MaxCompute table.
- `resume` : If data fails to be uploaded, use the Resume command to resume the upload from where it was interrupted. Do not use this command for download operations. Each data upload or download operation is called as a session. Run the Resume command and specify the session ID to be resumed.
- `show` : Displays the history of the commands used.
- `purge` : Clears the session directory. Use this command to clear history for last three days.
- `help` : Provides 'help' information regarding questions related to Tunnel.

Upload

Import data of local files to MaxCompute tables in the append mode. The sub-commands are used as follows:

```
odps @  project_na  me > tunnel   help   upload ;
usage :  tunnel   upload  [ options ] < path > <[ project .] table [/
partition ]>
              upload   data   from   local   file
- acp ,- auto - create - partition  < ARG >  auto   create   target
partition   if   not
                                     exists ,  default   false
- 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  "\ r \ n "
- s ,- scan  < ARG >  specify   scan   file
                                     action ( true | false | only ),
default   true
- sd ,- session - dir  < ARG >  set   session   dir ,  default
                                     D :\ software \ odpscmd_pu  blic
\ plugins \ ds
                                     hip
- ss ,- strict - schema  < ARG >  specify   strict   schema   mode .
If   false ,
                                     extra   data   will   be
abandoned   and
                                     insufficie  nt   field   will
be   filled
                                     with   null .  Default   true
- te ,- tunnel_end  point  < ARG >  tunnel   endpoint
   - threads  < ARG >  number   of   threads ,  default   1
- tz ,- time - zone  < ARG >  time   zone ,  default   local
timezone :
                                     Asia / Shanghai
For   example :
    tunnel   upload   log . txt   test_proje  ct . test_table / p1 ="
b1 ", p2 =" b2 "
```

Parameters

- `- acp` : Determines if the operation automatically creates the destination partition if it does not exist. This one is disabled by default.
- `- bs` : Specifies the size of each data block uploaded using Tunnel. Default value: 100MiB (1MiB=1024*1024B) .
- `- c` : Specifies the local data file encoding. Default value: I. When not set, the encoding of the downloaded source data is used by default.
- `- cp` : Determines whether the local file is compressed before being uploaded, reducing traffic usage. It is enabled by default.

- `-dbr` : Determines whether to ignore corrupted data (including extra, missing columns or mismatched column data types).
  - If this value is true, all the data that does not satisfy table definitions is ignored.
  - When the parameter is set to false, the system displays error messages in case of corrupted data, but the raw data in the destination table remains unaffected.
- `-dfp` : Specifies the format of DateTime data. Default value: yyyy-MM-dd HH:mm:ss. If you want to specify the time format to the level of milliseconds, use `tunnel upload -dfp 'yyyy-MM-dd HH:mm:ss.SSS'`, for more information, see Data types.
- `-fd` : Specifies the column delimiter of the local data file. The default value is comma (,).
- `-h` : Determines whether the data file contains the header. If it is set to true, Dship skips the header and starts uploading from the next row.
- `-mbr` : By default, if more than 1,000 rows of corrupted data is uploaded, the upload is terminated. This parameter allows you to adjust the tolerated volume of the corrupted data.
- `-ni` : Specifies the NULL data identifier. Default value: " "(blank string).
- `-rd` : Specifies the row delimiter of the local data file. Default value: \r\n.
- `-s` : Determines whether to scan the local data file. Default value: false.
  - If set to true, the system scans the data first, and then imports the data if the format is correct.
  - If set to false, the system imports the data directly without scanning.
  - If the value is 'only', then only the local data is scanned. No data is imported after scanning.
- `-sd` : Sets the session directory.
- `-te` : Specifies the tunnel endpoint.
- `-threads` : Specifies the number of threads. Default value: 1.
- `-tz` : Specifies the time zone. The default value is the local time zone: Asia/Shanghai.

Example

- Create a destination table:

```
CREATE TABLE IF NOT EXISTS sale_detail (
```

```
       shop_name   STRING ,
       customer_i  d   STRING ,
       total_pric  e   DOUBLE )
 PARTITIONE  D   BY  ( sale_date   STRING , region   STRING );
```

- Add a partition:

```
alter   table   sale_detai  l   add   partition  ( sale_date ='
201312 ',  region =' hangzhou ');
```

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

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

The data of the third row of this file is not consistent with the definition in Table sale_detail. The three columns are defined by sale_detail, but this row only has two .

- Import data:

```
odps @  project_na  me > tunnel   u   d :\ data . txt   sale_detai
l / sale_date = 201312 , region = hangzhou  - s   false
Upload   session :  20150610 ************************ 60c
Start   upload : d :\ data . txt
Total   bytes : 41   Split   input   to   1   blocks
2015 - 06 - 10   16 : 39 : 22   upload   block : ' 1 '
ERROR :  column   mismatch  -, expected   3   columns ,  2
columns   found ,  please   check   data   or   delimiter
```

Because data.txt contains corrupted data, data import fails. The system displays the session ID and error message.

- Verify data:

```
 odps @  odpstest_a  y52c_ay52 >  select  *  from   sale_detai  l
 where   sale_date =' 201312 ';
 ID  =  2015061008  4135370gyv  c61z5
+-----------+------------+------------+-----------+--------+
|  shop_name  |  customer_i  d  |  total_pric  e  |  sale_date  |
 region  |
+-----------+------------+------------+-----------+--------+
+-----------+------------+------------+-----------+--------+
```

The data import failed because of dirty data and hence the table is empty.

Show

Displays historical records. The sub-commands are used as follows:

```
odps @  project_na  me > tunnel   help   show ;
usage :  tunnel   show   history  [ options ]
              show   session   informatio  n
- n ,- number  < ARG >  lines
For   example :
    tunnel   show   history  - n   5
```

```
    tunnel  show  log
```

Parameter

- n : Specifies the number of rows to be displayed.

Example

```
odps @  project_na  me > tunnel  show  history ;
20150610 *********************** 60c  failed  ' u  -- config -
file  / D :/ console / conf / odps_confi  g . ini  -- project
odpstest_a  y52c_ay52  -- endpoint  http :// service . odps . aliyun
. com / api  -- id  Ul ******* rI1  -- key  2m ************* R
  d :\ data . txt  sale_detai  l / sale_date = 201312 , region =
hangzhou  - s  false '
```

Note:

With reference to the preceding example, `20150610 ***********************` `60c` is the session ID of the failed data importing in the previous section.

Resume

Repairs and re-executes historical records (only valid for data uploads). The sub-commands are used as follows:

```
odps @  project_na  me > tunnel  help  resume ;
usage :  tunnel  resume  [ session_id ] [- force ]
              resume  an  upload  session
- f ,- force  force  resume
For  example :
    tunnel  resume
```

Example

Modify the data.txt file as follows:

```
shopx , x_id , 100
shopy , y_id , 200
```

Re-upload the repaired data:

```
odps @  project_na  me > tunnel  resume  20150610
*********************** 60c  -- force ;
start  resume
20150610 *********************** 60c
Upload  session :  20150610 *********************** 60c
Start  upload : d :\ data . txt
Resume  1  blocks
2015 - 06 - 10  16 : 46 : 42  upload  block : ' 1 '
2015 - 06 - 10  16 : 46 : 42  upload  block  complete ,  blockid
= 1
upload  complete ,  average  speed  is  0  KB / s
```

```
OK
```

Note:

With reference to the preceding example, `20150610 ************************ 60c` is session ID.

Verify data:

```
odps @  project_na  me > select  *  from   sale_detai  l   where
sale_date =' 201312 ';
 ID  =  20150610xx  xxxxxxxxxa  741z5
+-----------+------------+------------+-----------+--------+
|  shop_name  |  customer_i  d  |  total_pric  e  |  sale_date  |
region  |
+-----------+------------+------------+-----------+--------+
|  shopx      |  x_id          |  100 . 0          |  201312     |
hangzhou |
|  shopy      |  y_id          |  200 . 0          |  201312     |
hangzhou |
+-----------+------------+------------+-----------+--------+
```

Download

The sub-commands are used as follows:

```
odps @  project_na  me > 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
- ci ,- columns - index  < ARG >  specify   the   columns   index (
starts   from
                                   0 )  to   download ,  use   comma
  to   split   each
                                   index
- cn ,- columns - name  < ARG >  specify   the   columns   name   to
  download ,
                                   use   comma   to   split   each
name
- cp ,- compress  < ARG >  compress ,  default   true
- dfp ,- date - format - pattern  < ARG >  specify   date   format
pattern ,  default
                                   yyyy - MM - dd   HH : mm : ss
- e ,- exponentia  l  < ARG >  When  download  double   values ,
use
                                   exponentia  l   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
"\ r \ n "
- sd ,- session - dir  < ARG >  set   session   dir ,  default
                                   D :\ software \ odpscmd_pu  blic \
plugins \ dshi
                                   p
- te ,- tunnel_end  point  < ARG >  tunnel   endpoint
   - threads  < ARG >  number   of   threads ,  default   1
- tz ,- time - zone  < ARG >  time   zone ,  default   local
timezone :
                                   Asia / Shanghai
usage :  tunnel   download  [ options ]  instance ://<[ project /]
instance_i  d > < path >
              download   instance   result   to   local   file
- c ,- charset  < ARG >  specify   file   charset ,  default   ignore
.
                                   set   ignore   to   download   raw
  data
- ci ,- columns - index  < ARG >  specify   the   columns   index (
starts   from
                                   0 )  to   download ,  use   comma
  to   split   each
                                   index
- cn ,- columns - name  < ARG >  specify   the   columns   name   to
  download ,
                                   use   comma   to   split   each
name
- cp ,- compress  < ARG >  compress ,  default   true
- dfp ,- date - format - pattern  < ARG >  specify   date   format
pattern ,  default
                                   yyyy - MM - dd   HH : mm : ss
- e ,- exponentia  l  < ARG >  When   download   double   values ,
use
                                   exponentia  l   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
"\ r \ n "
```

```
- sd ,- session - dir  < ARG >  set   session   dir ,  default
                                   D :\ software \ odpscmd_pu  blic \
plugins \ dshi
                                   p
- te ,- tunnel_end  point  < ARG >  tunnel   endpoint
   - threads  < ARG >  number   of   threads ,  default   1
- tz ,- time - zone  < ARG >  time   zone ,  default   local
timezone :
                                   Asia / Shanghai
For   example :
    tunnel   download   test_proje  ct . test_table / p1 =" b1 ", p2
=" b2 "  log . txt
    tunnel   download   instance :// test_proje  ct / test_insta  nce
  log . txt
```

Parameters

- `- c` : Specifies the local data file encoding. Default value: Ignore.
- `- ci` : Specifies the column index (starts from 0) for downloading. Separate multiple entries with commas (,).
- `- cn` : Specifies the names of the columns to download. Separate multiple entries with commas (,).
- `- cp ,- compress` : Determines whether the data is compressed before it is downloaded, reducing traffic usage. It is enabled by default.
- `- dfp` : Specifies the format of DateTime data. Default value: yyyy-MM-dd HH:mm:ss.
- `- e` : When downloading Double type data, use this parameter to express the values as exponential functions. Otherwise, a maximum of 20 digits can be retained.
- `- fd` : Specifies the column delimiter of the local data file. The default value is comma (,).
- `- h` : Determines whether the data file contains the header. If set to 'true', Dship skips the header and starts downloading from the second row.

  Note:

  `- h = true` and `threads > 1` cannot be used together.
- `- limit` : Specifies the number of files to be downloaded.
- `- ni` : Specifies the NULL data identifier. Default value: " "(blank string).
- `- rd` : Specifies the row delimiter of the local data file. Default value: \r\n.
- `- sd` : Sets the session directory.
- `- te` : Specifies the tunnel endpoint.

- `- threads` : Specifies the number of threads. Default value: 1.
- `- tz` : Specifies the time zone. The default value is the local time zone: Asia/Shanghai.

Example

Download data to the *result . txt* :

```
$ ./ tunnel   download   sale_detai  l / sale_date = 201312 , region =
 hangzhou   result . txt ;
     Download   session :  2015061016  5824528387  0a002ed0b9
     Total   records :  2
     2015 - 06 - 10   16 : 58 : 24   download   records :  2
     2015 - 06 - 10   16 : 58 : 24   file   size :  30   bytes
     OK
```

Verify the content of the *result . txt* :

```
 shop9 , 97 , 100 . 0
 shop10 , 10 , 200 . 0
```

Download the data of an instance

Method 1

Run the `tunnel   download` command to download the query result of a specified instance to your computer.

```
 tunnel   download   instance ://<[ project_na  me /] instance_i  d >
 < path >
```

Parameters

- `project_na  me` : the name of the project where the instance resides.
- `instance_i  d` : the ID of the instance whose data is to be downloaded.

Example

1. Run a `SELECT` statement to query the data of a specified instance:

   ```
    odps @  odps_test_  project > select  *  from   wc_in ;
    ID  =  2017072407  1705393ge3  csfb8
   ... ...
   ```

2. Use InstanceTunnel to download the query result to your computer:

   ```
    odps @  odps_test_  project > tunnel   download   instance ://
    2017072407  1705393ge3  csfb8   result ;
    2017 - 07 - 24   15 : 18 : 47   -   new   session :  2017072415
    184785b651  6400090ca8      total   lines :  8
    2017 - 07 - 24   15 : 18 : 47   -   file  [ 0 ]: [ 0 ,  8 ),
    result
   ```

```
downloadin g 8 records into 1 file
2017 - 07 - 24 15 : 18 : 47 - file [ 0 ] start
2017 - 07 - 24 15 : 18 : 48 - file [ 0 ] OK . total : 44
  bytes
download OK
```

3. View the query result:

```
cat result
slkdfj
hellp
apple
tea
peach
apple
tea
teaa
```

Method 2

Set the `use_instan ce_tunnel` parameter to `true` .

After you set this parameter to `true` on the MaxCompute console, SQL uses InstanceTunnel to download the query results that are returned by `SELECT` statements. This helps to ensure that the query results can be properly downloaded in the case that your session times out or the data to be downloaded exceeds the maximum size that is permitted. You can use one of the following two methods to enable this function:

- Log on to the latest version of Console. Find the *odps_confi g . ini* file. Then set the `use_instan ce_tunnel` parameter to `true` and the `instance_t unnel_max_ record` parameter to `10000` .

```
# download sql results by instance tunnel
 use_instan ce_tunnel = true
# the max records when download sql results by
 instance tunnel
 instance_t unnel_max_ record = 10000
```

Note:
The `instance_t unnel_max_ record` parameter specifies the maximum number of query result records that SQL can download by using InstanceTunnel. If this parameter is unspecified, the number of query result records that can be downloaded is not limited by this parameter.

- Run the following command to set the `console . sql . result . instancetu nnel` parameter to `true :`

```
odps @  odps_test_  tunnel_pro  ject > set   console . sql . result
. instancetu  nnel = true ;
OK
```

You can run a `SELECT` statement to query the data of a specified instance:

```
odps @  odps_test_  tunnel_pro  ject > select  *  from   wc_in ;
ID  =  2017072408  1946458g14  csfb8
Log   view :
http :// logview / xxxxx .....
+------------+
|  key        |
+------------+
|  slkdfj     |
|  hellp      |
|  apple      |
|  tea        |
|  peach      |
|  apple      |
|  tea        |
|  teaa       |
+------------+
A   total   of   8   records   fetched   by   instance   tunnel .
```

Note:
When InstanceTunnel is enabled, a message is displayed that states that a total of eight records is returned, after you run a `SELECT` statement to query the data of an instance. You can run the `set   console . sql . result . instancetu nnel` command to disable InstanceTunnel.

Purge

Purge the session directory. By default, sessions for last three days are purged. The sub-commands are used as follows:

```
odps @  project_na  me > tunnel   help   purge ;
usage :  tunnel   purge  [ n ]
              force   session   history   to   be   purged .([ n ]
days   before ,  default
              3   days )
For   example :
    tunnel   purge   5
```

Data types:

Type	Required
STRING	String type data. The length cannot exceed 8MB.

Type	Required
BOOLEN	Upload values only support true, false, 0, and 1. Only the values true or false (not case-sensitive) are supported for downloading.
BIGINT	Value range: [-9223372036854775807, 9223372036854775807].
DOUBLE	· 16-bit valid. · Uploads support expression in scientific notation. · Supports only numerical expression for downloading. · Max value: 1.7976931348623157E308. · Min value: 4.9E-324. · Positive infinity: Infinity. · Negative infinity: -Infinity.
DATETIME	By default, Datetime data supports the UTC+8 time zone for data upload. Use the command to specify the format pattern for the date in your data.

If you upload DATETIME type data, specify the time and date format. For more information about specific formats, see SimpleDateFormat.

```
" yyyyMMddHH  mmss ":  data   format  " 2014020910  1000 "
" yyyy - MM - dd   HH : mm : ss " ( default ):  data   format  " 2014
 - 02 - 09   10 : 10 : 00 "
" MM / dd / yyyy ":  data   format  " 09 / 01 / 2014 "
```

Example

```
tunnel   upload   log . txt   test_table  - dfp  " yyyy - MM - dd
HH : mm : ss "
```

Null: All data types can be Null.

- By default, a blank string indicates a Null value.

- The parameter `- null - indicator` can be used in the command line to specify a Null string.

```
tunnel upload log . txt test_table - ni " NULL "
```

Character encoding: You can specify the character encoding of the file. Default value: UTF-8.

```
tunnel upload log . txt test_table - c " gbk "
```

Delimiter: The Tunnel commands support custom file delimiters. The row delimiter is '-record-delimiter', and the column delimiter is -field-delimiter.

Description:

- Row and column delimiters of multiple characters are supported.
- A column delimiter cannot contain a row delimiter.
- Only the follow escape character delimiters are supported in the command line: \r, \n, and \t.

Example

```
tunnel upload log . txt test_table - fd "||" - rd "\ r \ n "
```

3.6 Tunnel SDK

3.6.1 Tunnel overview

This topic provides an overview of MaxCompute Tunnel, which is a data tunnel that is used to upload and download data to MaxCompute.

MaxCompute is based on Tunnel SDK and offers data upload and download tools. For more information, see Client.

When using Maven, you can search for `odps - sdk - core` in the Maven database to find different versions of Java SDK. The configuration is as follows:

```
< dependency >
    < groupId > com . aliyun . odps </ groupId >
    < artifactId > odps - sdk - core </ artifactId >
    < version > 0 . 24 . 0 - public </ version >
</ dependency >
```

The following table describes the interfaces of Tunnel SDK, which may differ according to the SDK version. For more information, see SDK Java Doc.

Interface	Description
TableTunnel	The ingress-class interface that is used to access the MaxCompute Tunnel service. You can access MaxCompute and Tunnel through the Internet or an intranet network on Alibaba Cloud. Data downloaded through an intranet network is free of charge.
TableTunnel.UploadSession	A session that is for uploading data to a MaxCompute table.
TableTunnel.DownloadSession	A session that is for downloading data from a MaxCompute table.
InstanceTunnel	The ingress-class interface that is used to access the MaxCompute Tunnel service. You can access MaxCompute and Tunnel through the Internet or an intranet network on Alibaba Cloud. Data downloaded through an intranet network is free of charge.
InstanceTunnel.DownloadSession	A session that is for downloading data to a MaxCompute SQL instance. The SQL instance must start with the `SELECT` keyword and is used for querying data.

Note:

- For information about Tunnel SDK, see SDK Java Doc.
- For information about service connections, see Configure Endpoint.

3.6.2 TableTunnel

This topic provides a definition and describes the processes and limits of TableTunnel, which itself provides an ingress class for you to use the MaxCompute Tunnel service to upload and download tables.

Definition

The TableTunnel interface is defined as follows:

```
public   class   TableTunne  l  {
 public   DownloadSe  ssion   createDown  loadSessio  n ( String
projectNam  e ,  String   tableName );
```

```
 public DownloadSession createDownloadSession(String projectName, String tableName, PartitionSpec partitionSpec);
 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);
}
```

For more information, see Java-sdk-doc.

Parameter description:

- `lifecycle`: the period of time that starts when a TableTunnel instance is created and ends when the service process is completed.
- `UploadSession` and `DownloadSession`: the objects that you can create by using TableTunnel. After creating an `UploadSession` or `DownloadSession` object, you can call a session, `TableTunnel.UploadSession` or `TableTunnel.DownloadSession`, to upload or download data.
- `Session`: the period of time in which a table or partition is uploaded or downloaded. A session consists of one or more HTTP requests to the Tunnel RESTful API actions that you call.
- `TableTunnel.UploadSession`: This session offers the same capabilities as the `INSERT INTO` statement. You can create multiple sessions to upload the same table or partition, and these sessions do not affect each another. The data uploaded by each session is stored to a unique directory.
- `RecordWriter`: In `TableTunnel.UploadSession`, each `RecordWriter` class corresponds to an HTTP request and is uniquely identified by its block ID. The block ID is the name of the file corresponding to the `RecordWriter` class.
- `blockId`: If you use the same block ID to open a `RecordWriter` class multiple times in the same session, the data uploaded by the `RecordWriter` class that is the last to call the `close()` function overwrites all previous data.

This is helpful in retransmitting data of a block in case that the block data fails to be transmitted.

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 accordingly. In this way, data moved into a table by the current task can be visible to the other MaxCompute tasks such as SQL and MapReduce.

Limits

- The number used for the 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 ID. The lifecycle of a session is 24 hours. If your session times out due to large data uploads, you will need to split your data into multiple sessions to mitigate the chance of session timeouts.
- The lifecycle of an HTTP request of a `RecordWriter` class is 120s. If there is no inbound traffic over an HTTP connection within 120 seconds, the server closes the connection.

  Note:
  HTTP provides an 8-KB buffer. When you call the `RecordWriter.write()` function, your data can be saved to the buffer with no inbound traffic over the corresponding HTTP connection. In such a case, you can call the `TunnelRecordWriter.flush()` function to make this data stored in the buffer into inbound traffic over the HTTP connection.
- When you create `RecordWriter` classes to write logs to MaxCompute, the `RecordWriter` classes are likely to time out due to unexpected traffic fluctuations. Therefore, we recommend that you:
  - Do not create a `RecordWriter` class for each of your data records because each `RecordWriter` class corresponds to a file. If you create a `RecordWrit`

`er` class for every data record, a large number of small files are produced, degrading the overall performance of MaxCompute.

  - Do not create a `RecordWrit er` class to write data in batches until the size of cached code reaches 65 MB.
- The lifecycle of a `RecordRead er` class is 300s.

3.6.3 InstanceTunnel

This topic describes the interface, parameters, and limits of InstanceTunnel. You can use InstanceTunnel to call an SQL instance that starts with the `SELECT` keyword and is used for querying data.

The InstanceTunnel interface is defined as follows:

```
public   class   InstanceTu  nnel {
 public   DownloadSe  ssion   createDown  loadSessio  n ( String
projectNam  e ,  String   instanceID );
 public   DownloadSe  ssion   createDown  loadSessio  n ( String
projectNam  e ,  String   instanceID ,  boolean   limitEnabl  ed );
 public   DownloadSe  ssion   getDownloa  dSession ( String
projectNam  e ,  String   id );
}
```

For more information, see Java-sdk-doc.

Parameter description:

- `projectNam e` : the name of the project where the specified instance resides.
- `instanceID` : the ID of the specified instance.

Limits:

- If the number of records does not exceed 10,000, all users who have the permission s to read the specified instance can call this instance. This is the same for when calling a RESTful API to query data.
- If the number of records exceeds 10,000, only users who have the permissions to read all the source tables from which the specified instance queries data can call this instance.

3.6.4 UploadSession

This paper introduces the UploadSession interface.

`UploadSession` interface defination

The UploadSession interface is defined as follows:

```
public   class   UploadSess  ion  {
        UploadSess  ion ( Configurat  ion   conf ,  String
projectNam  e ,  String   tableName ,
            String   partitionS  pec )  throws   TunnelExce  ption ;
        UploadSess  ion ( Configurat  ion   conf ,  String
projectNam  e ,  String   tableName ,
            String   partitionS  pec ,  String   uploadId )  throws
TunnelExce  ption ;
        public   void   commit ( Long []  blocks );
        public   Long []  getBlockLi  st ();
        public   String   getId ();
        public   TableSchem  a   getSchema ();
        public   UploadSess  ion . Status   getStatus ();
        public   Record   newRecord ();
        public   RecordWrit  er   openRecord  Writer ( long   blockId
);
        public   RecordWrit  er   openRecord  Writer ( long   blockId
,  boolean   compress );
        public   RecordWrit  er   openBuffer  edWriter ();
        public   RecordWrit  er   openBuffer  edWriter ( boolean
compress );
   }
```

Upload Objects description

- *Life cycle*: Begins with the creation of the Upload instance and ends with the completion of an upload process.
- Create Upload instance: An instance can be created either by Calling the Constructor or using the `TableTunnel`.
  - Request mode: Synchronous.
  - The server creates a session for this upload instance and a unique `UploadId` is generated. Obtain this ID using the `getId` on the client.
- Upload data:
  - Request mode: Synchronous.
  - Call the `openRecordWriter` method to generate a `RecordWriter` instance. The blockId identifies the data to be uploaded and indicates its location in the table within the value range [0, 20000]. If the data upload fails, use BlockId to re-upload it.

- View upload:
  - Request mode: Synchronous.
  - Call `getStatus` to obtain the current upload status.
  - Call `getBlockList` to obtain the successfully uploaded `blockId` list. Compare the result with the upload `blockId` list to find and re-upload failed `blockIds`.
- End upload:
  - Request mode: Synchronous.
  - Call the `commit (Long[] blocks)` method. The blocks list shows successfully uploaded blocks. The server verifies this list.
  - This function enhances data verification. If the provided block list does not match the block list on the server, an error occurs.
  - If Commit fails, try again.
- Six kinds of status are described as follows:
  1. UNKNOWN: The initial value when the server creates a session.
  2. NORMAL: The upload object is created successfully.
  3. CLOSING: The server changes the status to CLOSING when `complete` is called.
  4. CLOSED: The upload is now complete. Precisely, moving the data to the directory where the result table is located.
  5. EXPIRED: The upload session is timed out.
  6. CRITICAL: A service error has occurred.

Note:

- The `blockIds` in the same `UploadSession` must be unique. In a single `UploadSession`, when you use a `blockId` to open `RecordWriter`, write a batch of data, call `close`, and then call commit. Do not use the same `blockID` to open another `RecordWriter` to write data.
- The maximum size of a block is 100 GB, preferably more than 64 MB.
- The threshold of each session on the server is 24 hours.
- When data is being uploaded, each 8 KB of data written by the Writer triggers a network action. If no network actions are triggered within 120 seconds, the

server closes the connection. In this case, open a new connection when the Writer becomes unavailable.

- We recommend that you use the `openBufferedWriter` interface to upload data. This interface does not show `blockId` details and contains an internal data cache for automatic retry upon failures. For more information, see the introductions and examples of `TunnelBufferedWriter`.

3.6.5 DownloadSession

This DownloadSession interface is defined as follows:

```
public   class   DownloadSe  ssion  {
        DownloadSe  ssion ( Configurat  ion   conf ,  String
projectNam  e ,  String   tableName ,
            String   partitionS  pec )  throws   TunnelExce  ption
        DownloadSe  ssion ( Configurat  ion   conf ,  String
projectNam  e ,  String   tableName ,
            String   partitionS  pec ,  String   downloadId )  throws
  TunnelExce  ption
        public   String   getId ()
        public   long   getRecordC  ount ()
        public   TableSchem  a   getSchema ()
        public   TableTunne  l . DownloadSt  atus   getStatus ()
        public   RecordRead  er   openRecord  Reader ( long   start
,  long   count )
        public   RecordRead  er   openRecord  Reader ( long   start
,  long   count ,  boolean   compress )
   }
```

Parameters:

- Life cycle: Begins with the creation of the Download instance and ends with the completion of a download process.
- Create Download instance: An instance can be created either by Calling the Constructor or by using the TableTunnel.
  - Request mode: Synchronous.
  - The server creates a session for this download instance and a unique DownloadId is generated. Obtain this ID using the getId on the client.
  - This operation incurs high costs. The server creates an index for the data files. Large files generally take longer time to download.
  - Simultaneously, the server returns the total number of Records and starts multiple concurrent downloads based on this value.

- Download data:
  - Request mode: Asynchronous.
  - Call the `openRecordReader` method to generate a RecordReader instance. “start” identifies the start position of downloading this record, which cannot be less than zero. “count” specifies the number of records for this download which must be greater than zero.
- View download:
  - Request mode: Synchronous.
  - Call `getStatus` to obtain the current download status.
- Following is the list of 4 states:
  - UNKNOWN: The initial value when the server creates a session.
  - NORMAL: The download object is successfully created.
  - CLOSED: The download is now complete.
  - EXPIRED: The download session is timed out.

3.6.6 TunnelBufferedWriter

To complete the uploading process, follow these steps:

1. Divide the data.
2. Specify a block ID for each data block by calling the `openRecordWriter (id)`.
3. Use one or more threads to upload the blocks. Even if a single block upload fails, you must re-upload all the blocks.
4. After uploading all blocks, provide the uploaded blockID list to the server for verification. Call `session.commit([1,2,3,…])` to complete this action.

   The connection time-out and other limits on the server block manager complicate the upload process logic. So, to simplify the process, SDK provides an enhanced RecordWriter—TunnelBufferWriter interface.

This interface is defined as follows:

```
public   class   TunnelBuff  eredWriter   implements   RecordWrit  er
 {
        public   TunnelBuff  eredWriter ( TableTunne  l . UploadSess
ion   session ,  CompressOp  tion   option )  throws   IOExceptio  n
;
        public   long   getTotalBy  tes ();
        public   void   setBufferS  ize ( long   bufferSize );
        public   void   setRetrySt  rategy ( RetryStrat  egy
strategy );
```

```
        public   void   write ( Record   r )  throws   IOExceptio  n
 ;
        public   void   close ()  throws   IOExceptio  n ;
    }
```

Parameters:

- Life cycle: Begins with a RecordWriter creation and ends with the completion of data upload.
- Create TunnelBufferedWriter instance: Call `openBufferedWriter` interface ofUploadSession to create an instance.
- Data upload: Call the Write interface. Data is first written to the local cache. Once the cache is full, the data is submitted to the server in batches to avoid connection time-out. Automatic retries are supported if the upload fails.
- End upload: Call the `close` interface, and then call the Commit interface of UploadSession to complete the upload process.
- Buffer control: Use the `setBufferSize` interface to modify the size of memory (bytes), occupied by the buffer preferably greater than 64 MB(default) to prevent the server from generating numerous small files that may critically impact the performance. The default value is generally used for this parameter without additional settings.
- Retry policy setting: You have three retry avoidance policies to choose from: EXPONENTIAL_BACKOFF, LINEAR_BACKOFF, and CONSTANT_BACKOFF. For example: The following code segment sets the number of Write retries to 6. To avoid unnecessary retries, each retry is performed only after exponentially ascending intervals of 4s, 8s, 16s, 32s, 64s, and 128s. This is the default configuration and generally cannot be changed.

```
RetryStrat  egy   retry
 =  new   RetryStrat  egy ( 6 ,  4 ,  RetryStrat  egy . BackoffStr
ategy . EXPONENTIA  L_BACKOFF )
writer  = ( TunnelBuff  eredWriter )  uploadSess  ion . openBuffer
edWriter ();
```

```
writer . setRetrySt  rategy ( retry );
```

3.7 Bulk data channel SDK example

3.7.1 Example

This article recommends using Tunnel service address and Tunnel Buffered Writer to upload data.

- MaxCompute provides two service addresses for you to choose from. If you select the Tunnel service address, it may directly affect your data upload efficiency and billing. For more information, see Tunnel SDK overview.
- We recommend that you use the TunnelBufferedWriter interface when uploading data. For more information, see the sample codes in BufferedWriter.
- Operations may vary based on SDK versions. This example is provided only for your reference. Consider variances between different versions before you proceed.

3.7.2 Simple upload

```
 import   java . io . IOExceptio  n ;
 import   java . util . Date ;
 import   com . aliyun . odps . Column ;
 import   com . aliyun . odps . Odps ;
 import   com . aliyun . odps . PartitionS  pec ;
 import   com . aliyun . odps . TableSchem  a ;
 import   com . aliyun . odps . account . Account ;
 import   com . aliyun . odps . account . AliyunAcco  unt ;
 import   com . aliyun . odps . data . Record ;
 import   com . aliyun . odps . data . RecordWrit  er ;
 import   com . aliyun . odps . tunnel . TableTunne  l ;
 import   com . aliyun . odps . tunnel . TunnelExce  ption ;
 import   com . aliyun . odps . tunnel . TableTunne  l . UploadSess
ion ;
 public   class   UploadSamp  le  {
          private   static   String   accessId  = "< your   access
id >";
          private   static   String   accessKey  = "< your   access
Key >";
          private   static   String   odpsUrl  = " http :// service .
odps . aliyun . com / api ";
          private   static   String   tunnelUrl  = " http :// dt . cn
- shanghai . maxcompute . aliyun - inc . com ";
                        // The   tunnelURL   must   be   set   if
you   need   to   connect   internal  network ,  otherwise ,  the
  system   uses   public   network   as   default .  The   example
  shows   the   Tunnel   Endpoint   of   classical   network   in
HuaDong   2 ,  for   other   regions ,  see   Access   domain   and
data   centers .
          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   AliyunAcco  unt (
accessId ,  accessKey );
                Odps   odps  =  new   Odps ( account );
                odps . setEndpoin  t ( odpsUrl );
                odps . setDefault  Project ( project );
                try  {
                        TableTunne  l   tunnel  =  new   TableTunne
l ( odps );
                        tunnel . setEndpoin  t ( tunnelUrl );  //
set   tunnelUrl
                        PartitionS  pec   partitionS  pec  =  new
PartitionS  pec ( partition );
                        UploadSess  ion   uploadSess  ion  =  tunnel
. createUplo  adSession ( project ,
                                        table ,  partitionS  pec );
                        System . out . println (" Session   Status
is  : "
                                       +  uploadSess  ion .
getStatus (). toString ());
                        TableSchem  a   schema  =  uploadSess  ion .
getSchema ();
                        //  After   preparing   data ,  open   a
Writer   to   start   writing   data .  The   prepared   data   is
written   to   one   block .
                        //  When   the   data   written   to
individual   blocks   is   too   small ,  the   system   will
produce   a   large   number   of   small   files ,  seriously
degrading   computing   performanc  e .  We   strongly   recommend
over   64   MB   of   data   be   written   each   time   ( up   to
100   GB   of   data   can   be   written   to   the   same   block
).
                        //  You   can   use   the   average   data
volume   and   record   count   to   estimate   the   total   value
.  For   example :  64MB  <  Average   data   size   x   Record
count  <  100GB .
                        RecordWrit  er   recordWrit  er  =
uploadSess  ion . openRecord  Writer ( 0 );
                        Record   record  =  uploadSess  ion .
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 ;
                                case   DATETIME :
                                        record . setDatetim  e ( i
,  new   Date ());
                                        break ;
                                case   DOUBLE :
                                        record . setDouble ( i ,  0
. 0 );
                                        break ;
                                case   STRING :
                                        record . setString ( i , "
sample ");
```

```
                                        break ;
                                default :
                                        throw   new   RuntimeExc
eption (" Unknown   column   type : "
                                                       +  column .
getType ());
                               }
                        }
                         for  ( int   i  =  0 ;  i  <  10 ;  i ++) {
                                 //  Writes   data   to   the
server .  Each   8   KB   of   data   written   triggers   a
network   transmissi  on .
                                 //  If   no   network   transmissi
on   occurs   for   120   seconds ,  the   server   closes
the   connection .  At   this   time ,  the   Writer   becomes
unavailabl  e   and   you   must   write   data   again .
                                 recordWrit  er . write ( record );
                        }
                         recordWrit  er . close ();
                         uploadSess  ion . commit ( new   Long []{ 0L
});
                         System . out . println (" upload   success
!") ;
                } catch  ( TunnelExce  ption   e ) {
                         e . printStack  Trace ();
                } catch  ( IOExceptio  n   e ) {
                         e . printStack  Trace ();
                }
        }
}
```

Constructor:

PartitionSpec(String spec): Uses a string to construct this class of object.

Parameters

spec: The partition definition string, such as pt=’ 1’ ,ds=’ 2’ .

In this program, the configuration must be as follows:

```
private   static   String   partition  = “ pt =’ XXX ’, ds =’ XXX ’”;
```

Note:

This paper gives the Tunnel Endpoint of East China 2 classical network. The Tunnel Endpoint settings of other regions can be referred to Configure Endpoint.

3.7.3 Simple download

This topic describes how to use MaxCompute Java SDK to download data.

Download data by using the DownloadSession interface of TableTunnel

```
import   java . io . IOExceptio  n ;
 import   java . util . Date ;
 import   com . aliyun . odps . Column ;
 import   com . aliyun . odps . Odps ;
```

```
 import   com . aliyun . odps . PartitionS  pec ;
 import   com . aliyun . odps . TableSchem  a ;
 import   com . aliyun . odps . account . Account ;
 import   com . aliyun . odps . account . AliyunAcco  unt ;
 import   com . aliyun . odps . data . Record ;
 import   com . aliyun . odps . data . RecordRead  er ;
 import   com . aliyun . odps . tunnel . TableTunne  l ;
 import   com . aliyun . odps . tunnel . TableTunne  l . DownloadSe
ssion ;
 import   com . aliyun . odps . tunnel . TunnelExce  ption ;
 public   class   DownloadSa  mple  {
     private   static   String   accessId  = "< your   access   id
>";
     private   static   String   accessKey  = "< your   access   Key
>";
     private   static   String   odpsUrl  = " http :// service . odps
. aliyun . com / api ";
     private   static   String   tunnelUrl  = " http :// dt . cn -
shanghai . maxcompute . aliyun - inc . com ";
    // tunnelUrl   specifies   the   tunnel   URL .  This   parameter
  is   mandatory   when   you   download   data   over   your
intranet .  If   this   parameter   is   set   to   null ,  your
data   is   downloaded   via   the   Internet .
     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   AliyunAcco  unt ( accessId ,
accessKey );
         Odps   odps  =  new   Odps ( account );
         odps . setEndpoin  t ( odpsUrl );
         odps . setDefault  Project ( project );
         TableTunne  l   tunnel  =  new   TableTunne  l ( odps );
         tunnel . setEndpoin  t ( tunnelUrl );// Set   tunnelUrl .
         PartitionS  pec   partitionS  pec  =  new   PartitionS  pec
( partition );
           try  {
                 DownloadSe  ssion   downloadSe  ssion  =  tunnel .
createDown  loadSessio  n ( project ,  table ,
                                     partitionS  pec );
                 System . out . println (" Session   Status   is  :
"
                                    +  downloadSe  ssion . getStatus
(). toString ());
                 long   count  =  downloadSe  ssion . getRecordC
ount ();
                 System . out . println (" RecordCoun  t   is : " +
count );
                 RecordRead  er   recordRead  er  =  downloadSe
ssion . openRecord  Reader ( 0 ,
                                        count );
                        Record   record ;
                        while  (( record  =  recordRead  er . read
()) !=  null ) {
                                consumeRec  ord ( record ,
downloadSe  ssion . getSchema ());
                       }
                        recordRead  er . close ();
               }  catch  ( TunnelExce  ption   e ) {
                        e . printStack  Trace ();
               }  catch  ( IOExceptio  n   e1 ) {
                        e1 . printStack  Trace ();
               }
```

```
        }
         private   static   void   consumeRec  ord ( Record   record
,  TableSchem  a   schema ) {
                for  ( int   i  =  0 ;  i  <  schema . getColumns
(). 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 . getDatetim  e
( 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   RuntimeExc  eption ("
Unknown   column   type : "
                                              +  column . getType
());
                        }
                        System . out . print ( colValue  ==  null  ?
" null " :  colValue );
                        if  ( i  !=  schema . getColumns (). size
())
                                System . out . print ("\ t ");
                }
                System . out . println ();
        }
}
```

Note:

- In the preceding command, a tunnel endpoint on the classic network in the China East 2 (Shanghai) region is used as an example. For more information about how to configure tunnel endpoints in the other regions, see Access domains and data centers.
- To make the test easier, we use `System . out . printl` to output data. You can choose to output data as a file in TXT format.

Download data by using the DownloadSession interface of InstanceTunnel

```
Odps   odps  =  OdpsUtils . newDefault  Odps (); // Initialize   Open
  Data   Processing   Service  ( ODPS )  objects .
    Instance   i  =  SQLTask . run ( odps , " select  *  from   wc_in
;");
    i . waitForSuc  cess ();

   // Create   an   instance   tunnel .
    InstanceTu  nnel   tunnel  =  new   InstanceTu  nnel ( odps );
   // Create   a   download   session   based   on   the   specified
  instance   ID .
    InstanceTu  nnel . DownloadSe  ssion   session  =  tunnel .
createDown  loadSessio  n ( odps . getDefault  Project (),  i . getId
());

    long   count  =  session . getRecordC  ount ();
    // Specify   the   number   of   records   that   will   be
presented .
    System . out . println ( count );

   // Obtain   data   by   using   the   same   method   as   you
do   with   TableTunne  l .
    TunnelReco  rdReader   reader  =  session . openRecord  Reader (
0 ,  count );
    Record   record ;
    while  (( record  =  reader . read ()) !=  null ) {
      for  ( int   col  =  0 ;  col  <  session . getSchema ().
getColumns (). size (); ++ col ) {
       // Specify   that   all   the   fields   in   the   wc_in
table   are   strings   and   will   be   directly   printed .
        System . out . println ( record . get ( col ));
     }
   }
    reader . close ();
```

Download data by using SQLTask.getResultSet()

```
Odps   odps  =  OdpsUtils . newDefault  Odps (); // Initialize   ODPS
  objects .
    Instance   i  =  SQLTask . run ( odps , " select  *  from   wc_in
;");
    i . waitForSuc  cess ();

   // Obtain   the   result   iterator   based   on   the   specified
  instance   object .
    ResultSet   rs  =  SQLTask . getResultS  et ( i );
    for  ( Record   r  :  rs ) {
     // Specify   the   number   of   records   that   will   be
presented .
```

```
      System . out . println ( rs . getRecordC  ount ());

      for  ( int   col  =  0 ;  col  <  rs . getTableSc  hema ().
getColumns (). size (); ++ col ) {
       // Specify   that   all   the   fields   in   the   wc_in
table   are   strings   and   will   be   directly   printed .
        System . out . println ( r . get ( col ));
     }
   }
```

3.7.4 Example for multi-thread uploading

```
import   java . io . IOExceptio  n ;
 import   java . util . ArrayList ;
 import   java . util . Date ;
 import   java . util . concurrent . Callable ;
 import   java . util . concurrent . ExecutorSe  rvice ;
 import   java . util . concurrent . Executors ;
 import   com . aliyun . odps . Column ;
 import   com . aliyun . odps . Odps ;
 import   com . aliyun . odps . PartitionS  pec ;
 import   com . aliyun . odps . TableSchem  a ;
 import   com . aliyun . odps . account . Account ;
 import   com . aliyun . odps . account . AliyunAcco  unt ;
 import   com . aliyun . odps . data . Record ;
 import   com . aliyun . odps . data . RecordWrit  er ;
 import   com . aliyun . odps . tunnel . TableTunne  l ;
 import   com . aliyun . odps . tunnel . TunnelExce  ption ;
 import   com . aliyun . odps . tunnel . TableTunne  l . UploadSess
ion ;
 class   UploadThre  ad   implements   Callable < Boolean > {
         private   long   id ;
         private   RecordWrit  er   recordWrit  er ;
         private   Record   record ;
         private   TableSchem  a   tableSchem  a ;
         public   UploadThre  ad ( long   id ,  RecordWrit  er
recordWrit  er ,  Record   record ,
                        TableSchem  a   tableSchem  a ) {
                 this . id  =  id ;
                 this . recordWrit  er  =  recordWrit  er ;
                 this . record  =  record ;
                 this . tableSchem  a  =  tableSchem  a ;
        }
        @ Override
         public   Boolean   call () {
                 for  ( int   i  =  0 ;  i  <  tableSchem  a .
getColumns (). size ();  i ++) {
                        Column   column  =  tableSchem  a .
getColumn ( i );
                        switch  ( column . getType ()) {
                        Case   bigint :
                                record . setBigint ( i ,  1L );
                                Break ;
                        Case   Boolean :
                                record . setBoolean ( i ,  true );
                                break ;
                        case   DATETIME :
                                record . setDatetim  e ( i ,  new
Date ());
                                break ;
                        case   DOUBLE :
                                record . setDouble ( i ,  0 . 0 );
```

```
                                break ;
                        case   STRING :
                                record . setString ( i , " sample
");
                                break ;
                        default :
                                throw   new   RuntimeExc  eption ("
Unknown   column   type : "
                                                + column . getType
());
                        }
                }
                for  ( int   i  =  0 ;  i  <  10 ;  i ++) {
                        try  {
                                recordWrit  er . write ( record );
                        }  catch  ( IOExceptio  n   e ) {
                                recordWrit  er . close ();
                                e . printStack  Trace ();
                                return   false ;
                        }
                }
                recordWrit  er . close ();
                return   true ;
        }
}
 public   class   UploadThre  adSample  {
         private   static   String   accessId  = "< your   access
id >";
         private   static   String   accessKey  = "< your   access
Key >";
         private   static   String   odpsUrl  = "< http :// service .
odps . aliyun . com / api >";
         private   static   String   tunnelUrl  = "< http :// dt . cn
- shanghai . maxcompute . aliyun - inc . com >";
                         // The   tunnelURL   must   be   set   if
you   need   to   connect   internal   network ,  otherwise ,  the
  system   uses   public   network   as   default .  The   example
  shows   the   Tunnel   Endpoint   of   classical   network   in
HuaDong   2 ,  for   other   regions ,  see   Access   domain   and
data   centers .
         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   AliyunAcco  unt (
accessId ,  accessKey );
                 Odps   odps  =  new   Odps ( account );
                 odps . setEndpoin  t ( odpsUrl );
                 odps . setDefault  Project ( project );
                 try  {
                         TableTunne  l   tunnel  =  new   TableTunne
l ( odps );
                         tunnel . setEndpoin  t ( tunnelUrl );  //
set   tunnelUrl
                         PartitionS  pec   partitionS  pec  =  new
PartitionS  pec ( partition );
                         UploadSess  ion   uploadSess  ion  =  tunnel
. createUplo  adSession ( project ,
                                         table ,  partitionS  pec );
                         System . out . println (" Session   Status
is  : "
```

```
                                         +  uploadSess  ion .
getStatus (). toString ());
                         ExecutorSe  rvice   pool  =  Executors .
newFixedTh  readPool ( threadNum );
                         ArrayList < Callable < Boolean >>  callers
=  new   ArrayList < Callable < Boolean >>();
                         for  ( int   i  =  0 ;  i  <  threadNum ;  i
++) {
                                 RecordWrit  er   recordWrit  er  =
uploadSess  ion . openRecord  Writer ( i );
                                 Record   record  =  uploadSess  ion
. newRecord ();
                                 callers . add ( new   UploadThre  ad
( i ,  recordWrit  er ,  record ,
                                                 uploadSess  ion .
getSchema ()));
                        }
                         pool . invokeAll ( callers );
                         pool . shutdown ();
                         Long []  blockList  =  new   Long [
threadNum ];
                         for  ( int   i  =  0 ;  i  <  threadNum ;  i
++)
                                 blockList [ i ] =  Long . valueOf (
i );
                         uploadSess  ion . commit ( blockList );
                         System . out . println (" upload   success
!") ;
                } catch  ( TunnelExce  ption   e ) {
                         e . printStack  Trace ();
                } catch  ( IOExceptio  n   e ) {
                         e . printStack  Trace ();
                } catch  ( Interrupte  dException   e ) {
                         e . printStack  Trace ();
                }
        }
}
```

The Tunnel Endpoint can be specified or left blank.

- If specified, the uploading data goes through the specified Endpoint.
- If not specified, the uploading data goes through public network.
- This paper gives the Tunnel Endpoint of East China 2 classical network. The Tunnel Endpoint settings of other regions can be referred to Configure Endpoint.

3.7.5 Example for multi-thread downloading

This article shows you how to use the TableTunnel interface to achieve multithreaded download through code examples.

```
import   java . io . IOExceptio  n ;
 import   java . util . ArrayList ;
 import   java . util . Date ;
 import   java . util . List ;
 import   java . util . concurrent . Callable ;
 import   java . util . concurrent . ExecutionE  xception ;
 import   java . util . concurrent . ExecutorSe  rvice ;
 import   java . util . concurrent . Executors ;
```

```
 import   java . util . concurrent . Future ;
 import   com . aliyun . odps . Column ;
 import   com . aliyun . odps . Odps ;
 import   com . aliyun . odps . PartitionS  pec ;
 import   com . aliyun . odps . TableSchem  a ;
 import   com . aliyun . odps . account . Account ;
 import   com . aliyun . odps . account . AliyunAcco  unt ;
 import   com . aliyun . odps . data . Record ;
 import   com . aliyun . odps . data . RecordRead  er ;
 import   com . aliyun . odps . tunnel . TableTunne  l ;
 import   com . aliyun . odps . tunnel . TableTunne  l . DownloadSe
ssion ;
 import   com . aliyun . odps . tunnel . TunnelExce  ption ;
 class   DownloadTh  read   implements   Callable < Long > {
         private   long   id ;
         private   RecordRead  er   recordRead  er ;
         private   TableSchem  a   tableSchem  a ;
         public   DownloadTh  read ( int   id ,
                         RecordRead  er   recordRead  er ,
TableSchem  a   tableSchem  a ) {
                 this . id  =  id ;
                 this . recordRead  er  =  recordRead  er ;
                 this . tableSchem  a  =  tableSchem  a ;
        }
        @ Override
         public   Long   call () {
                 Long   recordNum  =  0L ;
                 try  {
                         Record   record ;
                         while  (( record  =  recordRead  er . read
()) ! =  null ) {
                                 recordNum ++;
                                 System . out . print (" Thread  " +
id  + "\ t ");
                                 consumeRec  ord ( record ,
tableSchem  a );
                        }
                         recordRead  er . close ();
                } catch  ( IOExceptio  n   e ) {
                         e . printStack  Trace ();
                }
                 return   recordNum ;
        }
         private   static   void   consumeRec  ord ( Record   record
,  TableSchem  a   schema ) {
                 for  ( int   i  =  0 ;  i  <  schema . getColumns
(). 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 . getDatetim  e
( 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   RuntimeExc  eption ("
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   DownloadTh  readSample  {
         private   static   String   accessId  = "< your   access
id >";
         private   static   String   accessKey  = "< your   access
Key >";
         private   static   String   odpsUrl  = " http :// service .
odps . aliyun . com / api ";
         private   static   String   tunnelUrl  = " http :// dt . cn
- shanghai . maxcompute . aliyun - inc . com ";
                        // The   tunnelURL   must   be   set   if
you   need   to   connect   internal   network ,  otherwise ,  the
  system   uses   public   network   as   default .  The   example
  shows   the   Tunnel   Endpoint   of   classical   network   in
HuaDong   2 ,  for   other   regions ,  see   Access   domain   and
data   centers .
         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   AliyunAcco  unt (
accessId ,  accessKey );
                 Odps   odps  =  new   Odps ( account );
                 odps . setEndpoin  t ( odpsUrl );
                 odps . setDefault  Project ( project );
```

```
                 TableTunne  l   tunnel  =  new   TableTunne  l (
odps );
                 tunnel . setEndpoin  t ( tunnelUrl );  // set
tunnelUrl
                 PartitionS  pec   partitionS  pec  =  new
PartitionS  pec ( partition );
                 DownloadSe  ssion   downloadSe  ssion ;
                 try  {
                         downloadSe  ssion  =  tunnel . createDown
loadSessio  n ( project ,  table ,
                                         partitionS  pec );
                         System . out . println (" Session   Status
is  : "
                                        +  downloadSe  ssion .
getStatus (). toString ());
                         long   count  =  downloadSe  ssion .
getRecordC  ount ();
                         System . out . println (" RecordCoun  t   is
: " +  count );
                         ExecutorSe  rvice   pool  =  Executors .
newFixedTh  readPool ( threadNum );
                         ArrayList < Callable < Long >>  callers  =
new   ArrayList < Callable < Long >>();
                         long   start  =  0 ;
                         long   step  =  count  /  threadNum ;
                         for  ( int   i  =  0 ;  i  <  threadNum  -
1 ;  i ++) {
                                 RecordRead  er   recordRead  er  =
downloadSe  ssion . openRecord  Reader (
                                                 step  *  i ,  step
);
                                 callers . add ( new   DownloadTh
read (  i ,  recordRead  er ,  downloadSe  ssion . getSchema ()));
                        }
                         RecordRead  er   recordRead  er  =
downloadSe  ssion . openRecord  Reader ( step  * ( threadNum  -  1
),  count
                                        - (( threadNum  -  1 ) *
step ));
                         callers . add ( new   DownloadTh  read (
threadNum  -  1 ,  recordRead  er ,  downloadSe  ssion . getSchema
()));
                         Long   downloadNu  m  =  0L ;
                         List < Future < Long >>  recordNum  =  pool
. invokeAll ( callers );
                         for  ( Future < Long >  num  :  recordNum )
                                 downloadNu  m  +=  num . get ();
                         System . out . println (" Record   Count
is : " +  downloadNu  m );
                         pool . shutdown ();
                }  catch  ( TunnelExce  ption   e ) {
                         e . printStack  Trace ();
                }  catch  ( IOExceptio  n   e ) {
                         e . printStack  Trace ();
                }  catch  ( Interrupte  dException   e ) {
                         e . printStack  Trace ();
                }  catch  ( ExecutionE  xception   e ) {
                         e . printStack  Trace ();
                }
        }
```

```
}
```

Note:

The Tunnel Endpoint can be specified or left blank.

- If specified, the downloading data goes through the specified Endpoint.
- If not specified, the downloading data goes through public network Endpoint.
- This paper gives the Tunnel Endpoint of East China 2 classical network. The Tunnel Endpoint settings of other regions can be referred to Configure Endpoint.

3.7.6 Example for BufferedWriter uploading

This article shows you how to use the BufferedWriter interface to upload data through code examples.

```
// Initialize s MaxCompute and Tunnel code
 RecordWrit er writer = null ;
 TableTunne l . UploadSess ion uploadSess ion = tunnel .
 createUplo adSession ( projectNam e , tableName );
 try {
   int i = 0 ;
  // Generates TunnelBuff eredWriter instance
   writer = uploadSess ion . openBuffer edWriter ();
   Record product = uploadSess ion . newRecord ();
   for ( String item : items ) {
     product . setString (" name ", item );
     product . setBigint (" id ", i );
    // Calls the Write interface to write data
     writer . write ( product );
     i += 1 ;

} finally {
   if ( writer ! = null ) {
    // Closes TunnelBuff eredWriter
     writer . close ();


// Submits data via uploadSess ion to end the upload
 process
 uploadSess ion . commit ();
```

3.7.7 Example for BufferedWriter multi-thread uploading

This article shows you how to use BufferedWriter interface to realize multithreaded upload through code examples.

```
 class UploadThre ad extends Thread {
   private UploadSess ion session ;
   private static int RECORD_COU NT = 1200 ;
   public UploadThre ad ( UploadSess ion session ) {
     this . session = session ;
  }
  @ Override
   Public void run (){
```

```
      RecordWrit  er   writer  =  up . openBuffer  edWriter ();
      Record   r  =  up . newRecord ();
      for  ( int   i  =  0 ;  i  <  RECORD_COU  NT ;  i ++) {
        r . setBigint ( 0 ,  i );
        writer . write ( r );
     }
      writer . close ();
    }
  };
  public   class   Example  {
    public   static   void   main ( String   args []) {
    //  Initialize  s   MaxCompute   and   Tunnel   code
     TableTunne  l . UploadSess  ion   uploadSess  ion  =  tunnel .
  createUplo  adSession ( projectNam  e ,  tableName );
     UploadThre  ad   t1  =  new   UploadThre  ad ( up );
     UploadThre  ad   t2  =  new   UploadThre  ad ( up );
     t1 . start ();
     t2 . start ();
     t1 . join ();
     t2 . join ();
     uploadSess  ion . commit ();
  }
```

3.8 Import or export data using the Data Integration

Use #unique_48 function of DataWorks to create data synchronization tasks and import and export MaxCompute data.

Prerequisites

Before importing or exporting data, complete the required operations first. For more information, see Prepare an Alibaba Cloud account and Purchase and create a project.

Add MaxCompute data source

> **Note:**
>
> - Only the project administrator can create a data source. Other roles can only view the data source.
> - If the data source you want to add is a current MaxCompute project, skip this operation. After this project is created and appears as a Data Integration data source, this project is added as a MaxCompute data source named odps_first by default.

Procedure

1. Log on to the DataWorks console as an administrator and click Enter Workspace from the Actions column of the relevant project in the Project List.

2. Select Data Integration from the upper navigation pane. Click Data Source from the left-side navigation pane.
3. Click New Source.Select MaxCompute (ODPS) from the Large Data Storage section.
4. Enter required configurations in the data dialog box.

   Parameters

   - `Name` : Contains letters, numbers, and underscores (_). It must begin with a letter or an underscore (_) , and cannot exceed 60 characters.
   - `Data source descriptio n` : Provides a brief description of the data source, and cannot exceed 80 characters.
   - `Data source type` : Currently, it is ODPS.
   - `ODPS Endpoint` : Read-only by default. The value is automatically read from the system configuration.
   - `ODPS Item name` : Name of the project, helps to identify the corresponding MaxCompute project.
   - `Access ID` : The Access ID associated with the account of the MaxCompute project owner.
   - `AccessKey` : The AccessKey associated with the account of the MaxCompute project owner, used in pairs with the Access ID.
5. (Optional). Click Test Connectivity to test the connectivity after entering all the required information in the relevant fields.
6. If the connectivity test is successful, click Save.

> Note:
> For more information about the other data sources configurations, see #unique_82.

Import data through Data Integration

Take importing MySQL data to MaxCompute as an example, you can configure a synchronization task using Wizard Mode or Script Mode.

Configure a synchronization task in Wizard mode

1. Create a Wizard Mode synchronization task.
2. Select the source.

   Select the MySQL data source and the source table "mytest" . The data browsing area is collapsed by default. Click Next.

3. Select a Target.

   The target must be a previously created MaxCompute table. You can also create a new table by clicking Quick Table Creation.

   Parameters

   - `Partition information`: Specify every level of partition. When writing data to a table with three levels of partitions, you must configure the last partition level, for example, pt=20150101, type=1, biz=2. This item is unavailable for non-partitioned tables.
   - `Data clearing rules`:
     - `Clear existing data before writing`: Before data is imported to a table or partition, all data in the table or partition is cleared, which is equivalent to Insert Overwrite.
     - `Retain existing data before writing`: Existing data is not cleared before new data is imported. Each operation appends new data, which is equivalent to Insert Into.
4. Map the fields.

   Select the mapping between fields. Configure the field mapping relationships. The Source Table Fields on the left correspond one to one with the Target Table Fields on the right.

5. Control the channel.

Click Next to configure the maximum job rate and dirty data check rules.

Parameters

- `Maximum job rate` : Determines the highest rate possible for data synchronization jobs. The actual rate of the job may vary with the network environment, database configuration, and other factors.
- `Concurrent job count` : For a single synchronization job, Concurrent job count * Individual job transmission rate = Total job transmission rate.

When a maximum job rate is specified, how do you select the concurrent job count ?

- If your data source is an online business database, we recommend that you refrain from setting a large value for the concurrent job count to avoid interference with the online database.
- If you require a high data synchronization rate, we recommend that you select the highest job rate and a large concurrent job count.

6. Preview and store.

Make sure the configuration of the task is correct, and click Save.

Run a synchronization task

Run a synchronization task directly

If system variable parameters are set in the synchronization task, the variable parameter configuration window is displayed during task operation.

After saving the task, click Run to run the task immediately. Click Submit and the synchronization task will be submitted to the scheduling system of the DataWorks. The scheduling system automatically and periodically runs the task from the second day according to the configuration attributes. For more information on scheduling configurations, see Scheduling configuration description.

Configure a synchronization task in Script mode

Use the following script to configure synchronization tasks. Other configurations and job operation are the same as Wizard Mode.

```
{
  " type ": " job ",
  " version ": " 1 . 0 ",
```

```
  " configurat  ion ": {
    " reader ": {
      " plugin ": " mysql ",
      " parameter ": {
        " datasource ": " mysql ",
        " where ": "",
        " splitPk ": " id ",
        " connection ": [
          {
            " table ": [
              " person "
            ],
            " datasource ": " mysql "
          }
        ],
        " connection  Table ": " person ",
        " Column  ":[
          " id ",
          " name "
        ]
      }
    },
    " writer ": {
      " plugin ": " odps ",
      " parameter ": {
        " datasource ": " odps_first ",
        " table ": " a1 ",
        " truncate ":  true ,
        " partition ": " pt =${ bdp . system . bizdate }",
        " Column  ":[
          " id ",
          " col1 "
        ]
      }
    },
    " Setting  ":{
      " speed ": {
        " mbps ": " 1 ",
        " concurrent ": " 1 "
      }
    }
  }
}
```

Referenes

- For the Reader configurations about different types of data sources, see Configure Reader Plug-ins.
- For the Writer configurations about different types of data sources, see Configure Writer Plug-ins.

4 SQL

4.1 SQL summary

This article introduces you to MaxCompute SQL keywords, type conversion instructions, partition tables, UNION ALL operations and use restrictions.

SQL summary

MaxCompute SQL is suitable for various scenarios. The massive data (GB, TB, or EB level) must be processed based on an offline batch calculation. It takes several seconds or even minutes to schedule after a job is submitted. Therefore, MaxCompute SQL is preferred for services that process tens of thousands of transactions per second.

The MaxCompute SQL syntax is similar to SQL and can be considered as a subset of standard SQL. However, the MaxCompute SQL must not be confused with a database . It does not have database characteristics including transactions, primary key constraints, indexes, and so on. The maximum size of SQL in MaxCompute is 3 MB.

Reserved words

MaxCompute SQL considers the keywords of SQL statement as reserved words. If you use keywords for name tables, columns, or partitions, you must escape the keywords with the `` symbol, otherwise an error is occurred. Reserved words are case insensitive and the most common words used are as follows: (For a complete reserved word list, see MaxCompute SQL Reserved Word).

```
% & && ( ) * +
 - . / ; < <= <>
 =     >     >=     ?      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
```

Type conversion

MaxCompute SQL allows conversion between data types. The conversion methods include explicit type conversion and implicit type conversion. For more information, see Type Conversion.

- Explicit conversions: Uses CAST to convert a value type.
- Implicit conversions: MaxCompute automatically performs implicit conversions while running based on the context environment and conversion rules. Implicit conversion scope includes various operators, built-in functions, and so on.

Partitioned table

MaxCompute SQL supports partitioned tables. Specify the partition as it simplifies the operation. For example, improve SQL running efficiency, reduce the cost, and so on. For more information, see Basic concept>Partition.

UNION ALL

To be involved in a UNION ALL operation, the data type of columns, column numbers , and column names must be consistent, otherwise an error occurs.

4.2 Operators

Operators are used to perform program code operations. This article introduces four types of operators: relational operator, arithmetic operator, bit operator and logical operator.

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.
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 not greater than B, TRUE is returned; otherwise FALSE is returned.

Operator	Description
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 not less than 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 NULL, TRUE is returned; otherwise FALSE is returned.

A LIKE B	If A or B is NULL, NULL is returned. If String A matches the SQL simple regular B TRUE is returned; otherwise FALSE is returned. The (%) character in B matches an arbitrary number of characters and the (_) character in B matches any character in A. To match (%) or(_), use by the escape characters ('%')'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	A is a string, and B is a string constant regular expression. If any substring of A matches the Java regular expression B, TRUE is returned; otherwise FALSE is returned. If expression B is empty , report an error and exit. If expression A or B is NULL, NULL is returned.
A IN B	B is a set. If expression A is NULL, NULL is returned. If expression A is in expression B, TRUE is returned; otherwise FALSE is returned . If expression B has only one element NULL, that is, A IN (NULL), return NULL. If expression B contains NULL element, take NULL as the type of other elements in B set. B must be a constant and at least has one element; all types must be consistent.
BETWEEN AND	The expression is `A [ NOT ] BETWEEN B AND C`. Empty if A, B, or C is empty. TRUE if A is larger than or equal to B and less than or equal to C; otherwise FALSE is returned.

The common use:

```
select  *  from   user   where   user_id  = ' 0001 ';
select  *  from   user   where   user_name  <> ' maggie ';
select  *  from   user   where   age  > ‘ 50 ’;
select  *  from   user   where   birth_day  >= ' 1980 - 01 - 01   00
: 00 : 00 ';
select  *  from   user   where   is_female   is   null ;
select  *  from   user   where   is_female   is   not   null ;
select  *  from   user   where   user_id   in  ( 0001 , 0010 );
```

```
select * from user where user_name like ' M %';
```

The Double values in MaxCompute are different in precision. For this reason, we do not recommend using the equal sign for comparison between two Double data. You can subtract two Double types, and then take the absolute value into consideration. When the absolute value is small enough, the two double values are considered equal.

Example:

```
abs ( 0 . 9999999999 - 1 . 0000000000 ) < 0 . 000000001
-- 0 . 9999999999 and 1 . 0000000000 have the precision
 of 10 decimal digits , while 0 . 000000001 has the
precision of 9 decimal digits .
-- It is considered that 0 . 9999999999 is equal to
1 . 0000000000 .
```

Note:

- ABS is a built-in function provided by MaxCompute to take absolute value. For more information, see ABS.
- In general, the DOUBLE type in MaxCompute can retain 14-bit decimal.

Arithmetic operators

Operator	Description
A + B	If expression A or B is NULL, NULL is returned; otherwise the result of A+B is returned.
A – B	If expression A or B is NULL, NULL is returned; otherwise the result of A – B is returned.
A * B	If expression A or B is NULL, NULL is returned; otherwise result of A * B is returned.
A / B	If expression A or B is NULL, NULL is returned; otherwise the result of A / B is returned. If Expression A and B are BIGINT types, the result is DOUBLE type.
A % B	If expression A or B is NULL, NULL is returned; otherwise the reminder result from dividing A by B is returned.
+A	Result A is returned.
-A	If expression A is NULL, NULL is returned; otherwise –A is returned.

The common use:

```
select  age + 10 , age - 10 , age % 10 , - age , age * age , age
/ 10  from  user ;
```

Note:

- You can only use STRING, BIGINT, and DOUBLE to perform arithmetic operations. (Using Datetime type and Boolean type is restricted.)
- Before you begin these operations, the type STRING is converted into DOUBLE by implicit type conversion.
- If BIGINT and DOUBLE both are involved in arithmetic operation, the type BIGINT is converted into DOUBLE by implicit type conversion.
- When A and B are BIGINT types, the return result of A/B will be a DOUBLE type. For other arithmetic operations, the return value is also a BIGINT type.

Bitwise operators

Operator	Description
A & B	Return the result of bitwise AND of A and B. For example: 1&2, return 0 ; 1&3, return 1; Bitwise AND of NULL and other values, all return NULL . Expression A and B must be BIGINT .
A | B	Return the result of bitwise OR of A and B. For example: 1|2, return3. 1|3, return 3. Bitwise OR of NULL and other values, all return NULL. Expression A and B must be BIGINT type.

Note:
Bitwise operator does not support implicit conversions, only supports the type BIGINT.

Logical operators

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

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

Note:

Only the type Boolean can be involved in logic operations and the implicit type conversion is not supported.

4.3 Type conversions

MaxCompute SQL allows for conversion between data types. The two conversion methods are explicit type conversion and implicit type conversion.

Explicit conversion

Explicit conversions use CAST to convert a value type to another. The following table lists the types that can be explicitly converted in MaxCompute SQL.

From/ To	BIGINT	DOUBLE	STRING	DATETIM	BOOLEA	DECIMA	FLOAT
BIGINT	N/A	Yes	Yes	No	Yes	Yes	Yes
DOUBLE	Yes	N/A	Yes	No	Yes	Yes	Yes
STRING	Yes	Yes	N/A	Yes	Yes	Yes	Yes
DATETIME	No	No	Yes	N/A	No	No	No

From/ To	BIGINT	DOUBLE	STRING	DATETIM	BOOLEA	DECIMA	FLOAT
BOOLEAN	Yes	Yes	Yes	No	N/A	Yes	Yes
DECIMAL	Yes	Yes	Yes	No	Yes	N/A	Yes
FLOAT	Yes	Yes	Yes	No	Yes	Yes	N/A

Y means can be converted. N means cannot be converted. – means conversion is not required.

Example:

```
select   cast ( user_id   as   double )  as   new_id   from   user ;
select   cast (' 2015 - 10 - 01   00 : 00 : 00 '  as   datetime )  as
  new_date   from   user ;
```

Note:

- To convert the Double type to the Bigint type, digits after the decimal point are dropped. For example, `cast ( 1 . 6   as   bigint ) =  1` .
- To convert the STRING type that meets the Double format to the Bigint type, it is converted to the Double type, and then to the Bigint type. The digits after the decimal point are dropped. For example, `cast (“ 1 . 6 ”  as   bigint ) = 1` .
- The STRING type that meets the Bigint format can be converted to the Double type, and must keep one digit after the decimal point. For example, `cast (“ 1 ”  as   double ) =  1 . 0` .
- Explicit conversions of unsupported types may return an exception.
- If a conversion fails during execution, the conversion is aborted with an exception .
- To convert the DATETIME type, use the default format yyyy-mm-dd hh:mi:ss. For more information, see Conversions between the STRING type and the DATETIME type.
- 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 values of the BOOLEAN type to the STRING type. For more information, see TO_CHAR. The `to_date` function can be used to convert values of the STRING type to the DATETIME type. For more information, see TO_DATE.

- For more information, see CAST.
- If a DECIMAL value exceeds the value range, MSB overflow error or LSB overflow truncation may occur for CAST STRING TO DECIMAL.
- MaxCompute supports conversion of complex data types. However, there are several conditions for conversions of complex data types. For the implicit conversion of complex data types, data subtypes must be supported. In Struct-type conversion, field names can be inconsistent, but the number of fields must be consistent, and the specified fields must be able to be converted implicitly or explicitly. The following are examples of complex data types and explanations as to whether they can be converted based on the preceding conditions:
  - `array < bigINT >` can be implicitly or explicitly converted into `array < STRING >`.
  - `array < bigINT >` can be explicitly converted into `array < INT >`, but cannot be implicitly converted.
  - `array < bigINT >` cannot be implicitly or explicitly converted into `array < datetime >`.
  - `struct < a : bigINT , b : INT >` can be implicitly converted into `struct < col1 : STRING , col2 : bigINT >`, but cannot be implicitly or explicitly converted into `struct < a : STRING >`.

Implicit conversion and scope

Implicit type conversion is an automatic type conversion performed by MaxCompute according to the usage context and type conversion rules. The following table lists the types that can be implicitly converted using MaxCompute.

	BOO	TINY	SMA	INT	BIGI	FLOA	double	Decimal	strin	varcl	time	binary
boolean to	Yes	No	No	No	No	No	No	No	No	No	No	No
tinyint to	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
smallint to	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
int to	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	N/A
bigint to	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No

	BOO	TINY	SMA	INT	BIGI	FLOA	double	Decimal	strin	varcl	time	binary
float to	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	No	N/A
double to	No	No	No	No	No	No	Yes	Yes	Yes	Yes	No	No
decimal to	No	No	No	No	No	No	No	Yes	Yes	Yes	No	No
string to	No	No	No	No	No	No	Yes	Yes	Yes	Yes	No	No
varchar to	No	No	No	No	Yes	Yes	Yes	Yes	No	No	N/A	N/A
timestamp to	No	No	No	No	No	No	No	No	Yes	Yes	Yes	No
binary to	No	No	No	No	No	No	No	No	No	No	No	Yes

Y means can be converted. N means cannot be converted.

Note:

- The DECIMAL type and DATETIME constant definition mode are added to MaxCompute2.0. 100BD indicates a DECIMAL, the value is 100. DATETIME `2017 - 11 - 11 00 : 00 : 00` indicates a constant of the DATETIME type. The constant definition is convenient because it can be directly used in values clauses and tables.
- In the earlier version of MaxCompute, values of the DOUBLE type can be implicitly converted to the BIGINT type. Owing to some reasons, such conversions may lead to data loss, which is not allowed by common database systems.

Common use:

```
select   user_id + age +' 12345 ',
           concat ( user_name , user_id , age )
  from   user ;
```

Note:

- Implicit conversions of unsupported types may cause an error.
- If a conversion fails during execution, an exception occurs.

- MaxCompute automatically performs implicit conversions based on the context environment. We recommend that you use CAST to perform an explicit conversion when the types do not match.
- Implicit conversion rules are applicable to a specific range of scopes. In some scopes, only some rules can take effect. For more information, see the scopes of implicit conversions.

- Implicit conversions under 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. For the particularities, implicit conversion rules of LIKE, RLIKE, and IN are discussed separately. The following descriptions do not contain these three special operators.

  The following table describes implicit conversion rules when different types of data is involved in relational operations.

From/To	BIGINT	DOUBLE	STRING	DATETIME	BOOLEAN	DECIMAL
BIGINT	N/A	DOUBLE	DOUBLE	No	No	DECIMAL
DOUBLE	DOUBLE	N/A	DOUBLE	No	No	DECIMAL
STRING	DOUBLE	DOUBLE	N/A	DATETIME	No	Decimal
DATETIME	No	No	DATETIME	N/A	No	No
BOOLEAN	No	No	No	No	N/A	No
DECIMAL	DECIMAL	DECIMAL	DECIMAL	No	No	N/A

Note:

- If two types cannot be implicitly converted, the relational operation is aborted by an error.
- For more information about the relational operators, see Relational Operators.

- Implicit conversions under special relational operators

  Special relational operators include LIKE, RLIKE, and IN.

  - The usage of LIKE and RLIKE is as follows:

```
source  like  pattern ;
```

```
source   rlike   pattern ;
```

The following illustrates the notes for LIKE and RLIKE in implicit conversions:

■ The source and pattern parameters of LIKE and RLIKE can only be of the STRING type.

■ Other types can neither be involved in the operations nor be implicitly converted to the STRING type.

- The usage of IN is as follows:

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

Implicit conversion rules of IN:

■ Data in the value column must be consistent.

■ To compare keys and values, if BIGINT, DOUBLE, and STRING types are compared, convert them to DOUBLE type. If the DATETIME and STRING types are compared, convert them to DATETIME type. Conversions between other types are not allowed.

· Implicit conversions under arithmetic operators

Arithmetic operators include addition (+), subtraction (-), multiplication (*), division (/), modulo (%), unary plus (+), and unary minus (-). Their implicit conversion rules are described as follows:

- Only the STRING, BIGINT, DOUBLE, and DECIMAL types can be involved in the operation.
- The STRING type are implicitly converted to the DOUBLE type before the operation.
- When the BIGINT and DOUBLE types are involved in the operation, the BIGINT type is implicitly converted to the DOUBLE type.
- The DATETIME and BOOLEAN types are not allowed in the arithmetic operation.

· Implicit conversions under logical operators

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

- Only the BOOLEAN type can be involved in the logical operation.
- Other types are not allowed in the logical operation, and cannot be implicitly converted to other types.

Implicit conversions for Built-in functions

MaxCompute SQL provides numerous system functions. You can calculate one or multiple columns of any row and output data of any type. Their implicit conversion rules are described as follows:

- To call a function, if the data type of an input parameter is different from that defined in the function, convert the data type of the input parameter to that defined in the function.
- Parameters of different built-in functions of MaxCompute SQL have different requirements on implicit conversions. For more information, see Built-in Functions.

Implicit conversions under CASE WHEN

For more information about CASE WHEN, see CASE WHEN Expressions. Its implicit conversion rules are listed as follows:

- If the types of the returned values are BIGINT and DOUBLE, convert all to the DOUBLE type.
- If a STRING type exists in return types, convert all to the STRING type. If the conversion fails (such as BOOLEAN type conversion), an error is returned.
- Conversions between other types are not allowed.

Conversions between the STRING Type and DATETIME Type

MaxCompute supports conversions between the STRING type and DATETIME type. The conversion format is `yyyy - mm - dd  hh : mi : ss`.

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

Note:

- In the value range of each unit, if the first digit is 0, it cannot be ignored. For example, `2014 - 1 - 9  12 : 12 : 12` is an invalid DATETIME format and it cannot be converted from the STRING type to the DATETIME type. It must be written as `2014 - 01 - 09  12 : 12 : 12`.
- Only the STRING type that meets the preceding format requirements can be converted to the DATETIME type. For example, `cast (“ 2013 - 12 - 31  02 : 34 : 34 ” as datetime )` converts `2013 - 12 - 31  02 : 34 : 34` of the STRING type to the DATETIME type. Similarly, when the DATETIME type is converted to the STRING type, the default conversion format is yyyy-mm-dd hh:mi:ss.

For example, the following conversions return an exception:

```
cast (" 2013 / 12 / 31  02 / 34 / 34 "  as  datetime )
cast (" 2013123102  3434 "  as  datetime )
cast (" 2013 - 12 - 31  2 : 34 : 34 "  as  datetime )
```

The threshold of dd depends on the actual days of a month. If the value exceeds the actual days of the month, the conversion is aborted with an error.

Example:

```
cast (" 2013 - 02 - 29  12 : 12 : 12 "  as  datetime ) --  Returns
  an  error  because  February  29 ,  2013  does  not  exist .

cast (" 2013 - 11 - 31  12 : 12 : 12 "  as  datetime ) --  Returns
  an  exception  because  November  31 ,  2013  does  not
exist .
```

MaxCompute provides the TO_DATE function to convert the STRING type that does not meet the DateDATETIME ime format to the DATETIME type. For more information, see TO_DATE.

4.4 SQL limits

Some users may fail to notice specific limits and find the service has stopped. The limits for MaxCompute SQL include the following:

Boundary name	Maximum value/ Limit	Class	Description
Length of table name	128 bytes	Length limit	Table names and column names cannot contain special characters. It must start with a letter and can contain only English letters (a-z, A-Z), numbers, and underscores (_).
Annotation length	1,024 bytes	Length limit	The annotation can contain valid strings for up to 1,024 bytes.
Column definitions	1,200	Quantity limit	One table can contain a maximum of 1,200 column definitions.
Partitions	60,000	Quantity limit	One table can contain a maximum of 60,000 partitions.
Partition levels of a table	6 levels	Quantity limit	A table can contain a maximum of six levels of partition.
Statistical definitions	100	Quantity limit	One table can contain a maximum of 100 statistical definitions.
Statistical definitions	64,000	Length limit	A statistical definition can contain a maximum of 64, 000 bytes.
Screen display	10,000 rows	Quantity limit	The screen display of a SELECT statement outputs a maximum of 10,000 rows.
INSERT targets	256	Quantity limit	A multiins operation can insert a maximum of 256 targets at a time.
UNION ALL	256	Quantity limit	The UNION ALL operation can be performed on a maximum of 256 tables.
MAPJOIN	Eight small tables	Quantity limit	A MAPJOIN operation can be performed on a maximum of eight small tables.

Boundary name	Maximum value/ Limit	Class	Description
MAPJOIN memory restriction	512 MB	Quantity limit	The memory size of all small tables on which MAPJOIN operation is performed cannot exceed 512 MB.
Window functions	Five	Quantity limit	A SELECT statement can contain a maximum of five window functions.
ptinsubq	1,000 rows	Quantity limit	The results returned by PT IN SUBQUERY cannot exceed 1,000 rows.
SQL statement	2 MB	Length limit	The maximum length of an SQL statement is 2 MB.
Number of conditions for a where clause	256	Quantity limit	A where clause can use a maximum of 256 conditions.
Length of column records	8 MB	Quantity limit	The maximum length of a cell in tables is 8 MB.
Number of parameters of an in statement	1,024	Quantity limit	Specifies the maximum number of parameters of an in statement, for example, in (1,2,3….,1024). An excess of parameters of in(…) results in compilation pressure. 1,024 is a recommended value, not a limit value.
jobconf.json	1 MB	Length limit	The size of 'jobconf.json' is 1 MB. Including too many partitions in a table may cause 'jobconf.json' to exceed 1 MB.
View	Not writable	Operation restriction	A view cannot be written or operated by using an `INSERT` statement.
Column data type	Not allowed	Operation limit	The data type and position of a column cannot be modified.

Boundary name	Maximum value/ Limit	Class	Description
java udf function	Cannot be abstract or static	Operation limit	A Java UDF cannot be abstract or static.
A maximum of 10,000 partitions can be queried.	10,000	Quantity limit	A maximum of 10,000 partitions can be queried.

Note:

The limits of MaxCompute SQL cannot be modified.

4.5 Insert Operation

4.5.1 INSERT OVERWRITE/INTO

Function definition:

```
INSERT   OVERWRITE | INTO   TABLE   tablename  [ PARTITION  (
partcol1 = val1 ,  partcol2 = val2  ...)] [( col1 , col2  ...)]
select_sta  tement
FROM   from_state  ment ;
```

Note:

- Insert syntax of MaxCompute is different from MySQL or Oracle Insert syntax. The keyword table must be added following `insert overwrite | into`, instead of using tablename directly.
- When the target table for Insert is a partitioned table, expressions such as functions are not allowed in `[ PARTITION ( partcol1 = val1 , partcol2 = val2 …)]`.
- Currently, INSERT OVERWRITE does not support inserting columns. You can use INSERT INTO instead.

Insert overwrite/into saves calculation results into a destination table.

The difference between `insert into` and `insert overwrite` is that `insert into` inserts added data into the table or partition, while `insert overwrite` clears source data from the table or partition before inserting the data in it.

Note:

The partition size in the MaxComputer partition table gets different data partition sizes when the same partition is repeatedly INSERT OVERWRITEd with the value described. This is because the file splitting logic changes when you select from the same partition on the same table and insert overwrite back to the same partition on the same table, thus causing the size of the data to change. But the total length of the data is constant around INSERT OVERWRITE, so users don't have to worry about billing for storage.

While processing data through MaxCompute SQL, `insert overwrite / into` is the most common statement. It can save the calculation result into a table, needed for the subsequent calculation. For example, use the following statements to calculate the sale detail of different regions from the table sale_detail:

```
create table sale_detai l_insert like sale_detai l ;
alter table sale_detai l_insert add partition ( sale_date ='
2013 ', region =' china ');
insert overwrite table sale_detai l_insert partition (
sale_date =' 2013 ', region =' china ')
select shop_name , customer_i d , total_pric e from
sale_detai l ;
```

Note:

The correspondence between source table and destination table depends on the column sequence in select clause, not the column name correspondence between the two tables. The following statement is still valid:

```
insert overwrite table sale_detai l_insert partition (
sale_date =' 2013 ', region =' china ')
select customer_i d , shop_name , total_pric e from
sale_detai l ;
-- When the sale_detai l_insert table is created , the
column sequence is as below :
-- shop_name string , customer_i d string , total_pric e
bigint
-- When data is inserted from sale_detai l to
  sale_detai l_insert , the insertion sequence of
sale_detai l is as below :
-- customer_i d , shop_name , total_pric e
-- Inserts data in sale_detai l . customer_i d into
sale_detai l_insert . shop_name .
-- Inserts data in sale_detai l . shop_name into
sale_detai l_insert . customer_i d .
```

To insert data into a partition, the partition column cannot appear in the Select list.

```
insert overwrite table sale_detai l_insert partition (
sale_date =' 2013 ', region =' china ')
select shop_name , customer_i d , total_pric e , sale_date ,
region from sale_detai l ;
```

```
-- Returns an error . The items sale_date and region
  are partition columns , which cannot appear in the
 INSERT statement of static partitions .
```

Simultaneously, the value of the partition can only be a constant and expressions cannot appear. The following statements are invalid:

```
insert overwrite table sale_detai l_insert partition (
sale_date = datepart (' 2016 - 09 - 18  01 : 10 : 00 ', ' yyyy ') ,
region =' china ')
select shop_name , customer_i d , total_pric e from
sale_detai l ;
```

4.5.2 MULTI INSERT

MaxCompute SQL supports inserting different result tables or partitions in a single SQL statement.

Statement format:

```
FROM from_state ment
INSERT OVERWRITE | INTO TABLE tablename1 [ PARTITION (
partcol1 = val1 , partcol2 = val2 ...)]
select_sta tement1 [ FROM from_state ment ]
[ INSERT OVERWRITE | INTO TABLE tablename2 [ PARTITION (
partcol1 = val3 , partcol2 = val4 ...)]
select_sta tement2 [ FROM from_state ment ]]
```

Note:

- Generally, up to 256 ways of output can be written in a single SQL statement. A syntax error occurs, if the output exceeds 256 ways.
- In a multi insert statement:
  - For a partitioned table, a target partition cannot appear multiple times.
  - For an unpartitioned table, this table cannot appear multiple times.
- Different partitions within a partitioned table cannot have an Insert overwrite operation and an Insert into operation at the same time; otherwise, an error is returned.

For an unpartitioned table, this table cannot appear multiple times.

```
create table sale_detai l_multi like sale_detai l ;
from sale_detai l
insert overwrite table sale_detai l_multi partition (
sale_date =' 2010 ', region =' china ' )
select shop_name , customer_i d , total_pric e where .....
insert overwrite table sale_detai l_multi partition (
sale_date =' 2011 ', region =' china ' )
select shop_name , customer_i d , total_pric e where .....
```

```
-- Return result successful ly . Insert the data of
 sale_detai l into the 2010 sales records and 2011
 sales records in China region .
 from sale_detai l
 insert overwrite table sale_detai l_multi partition (
 sale_date =' 2010 ', region =' china ' )
 select shop_name , customer_i d , total_pric e
 insert overwrite table sale_detai l_multi partition (
 sale_date =' 2010 ', region =' china ' )
 select shop_name , customer_i d , total_pric e ;
-- An error is thrown . The same partition appears
 for multiple times .
 from sale_detai l
 insert overwrite table sale_detai l_multi partition (
 sale_date =' 2010 ', region =' china ' )
 select shop_name , customer_i d , total_pric e
 insert into table sale_detai l_multi partition ( sale_date
 =' 2011 ', region =' china ' )
 select shop_name , customer_i d , total_pric e ;
-- An error is thrown . Different partitions within a
 partition table cannot have both an ‘ insert overwrite
 ’ operation and an ‘ insert into ’ operation .
```

4.5.3 DYNAMIC PARTITION

To ‘insert overwrite’ into a partition table, specify the partition value in the statement. It can also be realized in a more flexible way, to specify a partition column in a partition table but not give the value.

OverView

Correspondingly, the columns in Select clause are used to specify these partition values.

Statement format:

```
insert overwrite table tablename partition ( partcol1 ,
partcol2 ...) select_sta tement from from_state ment ;
```

Note:

- In the ‘select_statement’ field, the following field provides a dynamic partition value for the target table. If the target table has only one-level dynamic partition, the last field value of select_statement is the dynamic partition value of the target table.
- Currently, a single worker can only output up to 512 dynamic partitions in a distributed environment, otherwise it leads to abnormality.
- Currently, any dynamic partition SQL cannot generate more than 2,000 dynamic partitions; otherwise it causes abnormality.

- The value of dynamic partition cannot be NULL, and also does not support special or Chinese characters, otherwise an exception is thrown. The exception is as follows:

```
FAILED :  ODPS - 0123031 : Partition   exception  -  invalid
dynamic   partition   value :
               province = xxx
```

- If the destination table has multi-level partitions, it is allowed to specify parts of partitions to be static partitions through 'Insert' statement, but the static partitions must be advanced partitions.

Examples

A simple example to explain dynamic partition is as follows:

```
create   table   total_reve  nues  ( revenue   bigint )  partitione
d   by  ( region   string );
    insert   overwrite   table   total_reve  nues   partition (
region )
        select   total_pric  e   as   revenue ,  region
            from   sale_detai  l ;
```

As mentioned in the preceding example, user is unable to know which partitions are generated before running SQL. Only after the Select statement running ends, user can confirm which partitions have been generated using 'region' as the value. This is why the partition is called as the Dynamic Partition.

Other Examples:

```
create   table   sale_detai  l_dypart   like   sale_detai  l ; --
Create   target   table .
```

- --Example 1:

```
insert   overwrite   table   sale_detai  l_dypart   partition  (
sale_date ,  region )
select   shop_name , customer_i  d , total_pric  e , sale_date ,
region   from   sale_detai  l ;
```

```
  -- Return   successful  ly .
```

- In ‘sales_detail’ table, the value of the sale_date determines the sales_date partition value of the target table, and the value of the region determines the region partition value of the target table.
- In a dynamic partition, the correspondence between the select_statement field and the dynamic partition of the target table is determined by the order of the fields. In this example, if the Select statement is written as the following:

```
select   shop_name , customer_i  d , total_pric  e , region ,
sale_date   from
          sale_detai  l ;
```

  the region value determines the sale_date partition value of the target table, and the value of sale_date determines the region partition value of the target table.

· --Example 2:

```
insert   overwrite   table   sale_detai  l_dypart   partition  (
sale_date =' 2013 ',  region )
        select   shop_name , customer_i  d , total_pric  e , region
  from   sale_detai  l ;
   --  Return   successful  ly ;  multiple   partitions ;  specify
  a   secondary   partition .
```

· --Example 3:

```
insert   overwrite   table   sale_detai  l_dypart   partition  (
sale_date =' 2013 ',  region )
        select   shop_name , customer_i  d , total_pric  e   from
sale_detai  l ;
   --  Return   failure   informatio  n .  When   inserting   a
dynamic   partition ,  the   dynamic   partition   column   must
appear   in   Select   list .
```

· --Example 4:

```
insert   overwrite   table   sales   partition   ( region =' china
',  sale_date )
select   shop_name , customer_i  d , total_pric  e , sale_date
from   sale_detai  l ;
   --  Return   failure   informatio  n .  User   cannot   specify
  the   lowsubpart  ition   only ,  but   needs   to   insert
advanced   partition   dynamicall  y .
```

When the old version of MaxCompute performs dynamic partitioning, if the partition column type is not exactly the same as the column type in the corresponding select list, an error is reported. MaxCompute 2.0 supports implicit conversion, as shown in the following :

```
create   table   parttable ( a   int ,  b   double )  partitione  d
by  ( p   string );
```

```
insert into parttable partition ( p ) select key , value ,
current_ti mestmap () from src ;
select * from parttable ;
```

The result is as follows:

a	b	c
0	NULL	2017-01-23 22:30:47.130406621
0	NULL	2017-01-23 22:30:47.130406621

4.6 DDL SQL

4.6.1 Table operations

This topic describes how to create, view, delete, rename, and modify table information through the client.

Create tables

Statement format:

```
CREATE [ EXTERNAL ] TABLE [ IF NOT EXISTS ] table_name
[( col_name data_type [ COMMENT col_commen t ], ...)]
[ COMMENT table_comm ent ]
[ PARTITIONE D BY ( col_name data_type [ COMMENT col_commen
t ], ...)]
[ CLUSTERED BY ( col_name [, col_name , ...]) [ SORTED BY (
col_name [ ASC | DESC ] [, col_name [ ASC | DESC ] ...])]
INTO number_of_ buckets BUCKETS ] - Sets the Shuffle and
  Sort attributes when you create hash cluster tables .
[ STORED BY StorageHan dler ] - Used only for external
tables .
[ WITH SERDEPROPE RTIES ( Options )] - Used only for
external tables .
[ LOCATION OSSLocatio n ];- Used only for external tables
.
[ LIFECYCLE days ]
[ AS select_sta tement ]
  CREATE TABLE [ IF NOT EXISTS ] table_name
  LIKE existing_t able_name
```

Consider the following points:

- When a table is created, an error is returned if another table has the same name, but the `if not exists` option is not specified. If the option is specified, no matter whether another table that has the same name exists or even if the source table structure and the target table structure are inconsistent, a success message is returned. The meta information of the existing table that has the same name remains unchanged.

- Both the table name and column name are not case sensitive. They can contain letters, numbers, and underscores (_), but must begin with a letter. Neither of them can exceed 128 bytes in length.
- Up to 1,200 column definitions are allowed in a table.
- Supported data types include bigint, double, boolean, datetime, decimal, and string.

> **Note:**
> If new data types (such as TINYINT, SMALLINT, INT, FLOAT, VARCHAR, TIMESTAMP, and BINARY) are used in a SQL statement, use the `set` statement to enable the new data type flag:
>
> - Session-level: Add a set statement `set odps . sql . type . system . odps2 = true ;` before the SQL statement and submit the two statements simultaneously.
> - Project-level: New data types at the project level can be used. To use the new data types at the project level, the project owner must run the following command:
>
> ```
> setproject odps . sql . type . system . odps2 = true ;
> ```
>
> For more information about the `setproject` command, see Other operations. For precautions on enabling new data types for a project, see #unique_40.

- Use `partitione d by` to specify the partition field, which supports the following data types: tinyint, smallint, int, bigint, varchar, and string.

  The value of `partition` cannot have a double-byte character and must begin with a letter, followed by a letter or number. The name cannot exceed 128 bytes in length. Special characters can be used, including spaces, colons (:), underscores (_), dollar signs ($), pound signs (#), periods (.), exclamation points (!), and at signs (@). Other characters, such as (\t), (\n), and (/) are considered undefined characters. If the `partition` field is used to partition a table, a full scan is not needed when you add a partition or update or read data in a partition. This makes table processing more efficient.
- Up to 60,000 partitions for up to six levels are allowed in a table.
- The content of a comment is a string whose length does not exceed 1024 bytes.

- `lifecycle` indicates the lifecycle of a table, the unit is 'days.' The statement `create table like` does not copy the lifecycle attribute from source table
- `clustered by` is used to specify hash keys. MaxCompute executes hash computation formulas on specified columns, and places computation results into buckets based the specified hash keys.
  - To prevent data skew and hotspots and better execute parallel statements, we recommend that you specify columns in `clustered by` in the case that the value range is large and a small number of duplicate key values exist. Also, to better execute `join` statements, we recommend that you select commonly used join or aggregation keys. Join and aggregation keys are similar to primary keys in conventional databases.
  - `sorted by` specifies how to sort fields in a bucket. We recommend that you keep the value of `sorted by` consistent with that of `clustered by` to make performance higher. After fields are specified in the `sorted by` clause, MaxCompute automatically generates indexes. It also executes the clause faster based on the indexes when you query data.
  - `INTO number_of_ buckets BUCKETS` specifies the number of hash buckets. The value of this field varies depending on the data size. By default, MaxCompute supports up to 1,111 reducers. Therefore, up to 1,111 hash buckets are allowed. You can run the `set odps . sql . reducer . instances = xxx ;` command to increase the maximum value of this field. However, the maximum value cannot exceed 4,000. If the maximum value exceeds 4,000, performance deteriorates as a result.

    We recommend that you follow the following points when you specify the number of hash buckets:

    - We recommend that the size of each bucket be around 500 MB. For example, if you want to add 1,000 buckets to a 500-GB partition, the size of each bucket is 500 MB on average. If a table contains a large amount of data, you can increase the size of each bucket from 500 MB to 2 or 3 GB. You can also run the `set odps . sql . reducer . instances = xxx` command to increase the maximum number of hash buckets that are allowed.
    - If two tables are joined frequently, specify the same number of hash buckets for them to better execute `join` statements and to skip `Shuffle` and

`Sort` . If the number of hash buckets for one table is different from that for the other table, we recommend that you use the greater number for both tables. This keeps statement concurrency and execution efficiency at proper levels.

- Hash cluster tables help optimize the following aspects:
  - Bucket pruning
  - Aggregation
  - Storage
- Hash cluster tables are subject to the following limits:
  - The `insert into` statement is not supported. You can add data only by using the `insert overwrite` statement.
  - A tunnel cannot be uploaded to a range cluster table because data uploaded over a tunnel is unordered.

· For more information about external tables, see #unique_103.

Assume that the table `sale_detail` is created to store sales records. The table uses `sale_date` and `region` as partition columns. Table creation statements are described as follows:

```
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 partition table sale_detail .
```

The statement `create table ... as select ...` can also be used to create a table. After creating a table, the data is copied to the new table, such as:

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

If the table `sale_detail` has data, the example mentioned preceding copies all data of `sale_detail` into the table `sale_detail_ctas1` .

Note:

`sale_detail` is a partitioned table, while the table created by the statement `create table ... as select ...` does not copy the partition attribute. The partition column of the source table becomes a general column of object table. In other words, `sale_detai l_ctas1` is a non-partitioned table with 5 columns.

In the statement `create table ... as select ...` if using a constant as a column value in `select` clause, it is suggested specify the column name, such as:

```
CREATE   TABLE   sale_detai  l_ctas2
AS
SELECT   shop_name ,  customer_i  d ,  total_pric  e , ' 2013 '  AS
sale_date , ' China '  AS   region
FROM   sale_detai  l ;
```

If the column name is not specified, the statement is as shown as follows:

```
CREATE   TABLE   sale_detai  l_ctas3
AS
SELECT   shop_name ,  customer_i  d ,  total_pric  e , ' 2013 ', '
China '
FROM   sale_detai  l ;
```

Then the forth column and fifth column of the created table `sale_detai l_ctas3` become system generated names, like `_c5` , `_c6` .

To allow the destination table to have the same structure as the source table, try to use `create table … like` ' statement, such as:

```
create   table   sale_detai  l_like   like   sale_detai  l ;
```

Now the table structure of `sale_detai l_like` is exactly the same as `sale_detai l` . Except the life cycle, attributes including the column name, column comment, and table comment, of the two tables are the same. But the data in `sale_detai l` cannot be copied into the table `sale_detai l_like` .

An example of creating a hash cluster table is as follows:

```
CREATE   TABLE   T1  ( a   string ,  b   string ,  c   bigint )
CLUSTERED   BY  ( c )  SORTED   by  ( c )  INTO   1024   BUCKETS ;
--  Creates   a   hash   cluster   non - partitione  d   table   with
  a   few   clicks .
CREATE   TABLE   T1  ( a   string ,  b   string ,  c   bigint )
PARTITIONE  D   BY  ( dt   string )  CLUSTERED   BY  ( c )  SORTED
by  ( c )  INTO   1024   BUCKETS ; -  Creates   a   hash   cluster
partitione  d   table .
```

View table information

Statement format:

```
desc  < table_name >;
```

```
desc   extended  < table_name >; -- View   external   table
informatio  n .
```

For example:

- **To view the info of the preceding table `sale_detai l`, run the following statement:**

  ```
  desc   sale_detai  l ;
  ```

  Return info:

  ```
  odps @ $ odps_proje  ct > desc   sale_detai  l ;
  +--------------------------------------------------------------------
  +
  |  Owner :  ALIYUN $ lili . ll @ alibaba - inc . com  |  Project : $
  odps_proje  ct
                     |
  |  TableComme  nt :
     |
  +--------------------------------------------------------------------
  +
  |  CreateTime :  2017 - 06 - 28   15 : 05 : 17
     |
  |  LastDDLTim  e :  2017 - 06 - 28   15 : 05 : 17
     |
  |  LastModifi  edTime :  2017 - 06 - 28   15 : 05 : 17
     |
  +--------------------------------------------------------------------
  +
  |  InternalTa  ble :  YES  |  Size :  0
     |
  +--------------------------------------------------------------------
  +
  |  Native   Columns :
     |
  +--------------------------------------------------------------------
  +
  |  Field  |  Type  |  Label  |  Comment
     |
  +--------------------------------------------------------------------
  +
  |  shop_name  |  string  | |
     |
  |  customer_i  d  |  string  | |
     |
  |  total_pric  e  |  double  | |
     |
  +--------------------------------------------------------------------
  +
  |  Partition   Columns :
     |
  +--------------------------------------------------------------------
  +
  |  sale_date  |  string  |
     |
  |  region  |  string  |
     |
  +--------------------------------------------------------------------
  +
  ```

```
OK
```

- **To view the information of the preceding table `sale_detai l_like`, run the following statement:**

```
desc   sale_detai  l_like
```

Return info:

```
odps @ $ odps_proje  ct > desc   sale_detai  l_like ;
+------------------------------------------------------------------
+
|  Owner :  ALIYUN $ lili . ll @ alibaba - inc . com  |  Project : $
odps_proje  ct
                    |
|  TableComme  nt :
   |
+------------------------------------------------------------------
+
|  CreateTime :  2017 - 06 - 28   15 : 42 : 17
   |
|  LastDDLTim  e :  2017 - 06 - 28   15 : 42 : 17
   |
|  LastModifi  edTime :  2017 - 06 - 28   15 : 42 : 17
   |
+------------------------------------------------------------------
+
|  InternalTa  ble :  YES  |  Size :  0
   |
+------------------------------------------------------------------
+
|  Native   Columns :
   |
+------------------------------------------------------------------
+
|  Field  |  Type  |  Label  |  Comment
   |
+------------------------------------------------------------------
+
|  shop_name  |  string  | |
   |
|  customer_i  d  |  string  | |
   |
|  total_pric  e  |  double  | |
   |
+------------------------------------------------------------------
+
|  Partition   Columns :
   |
+------------------------------------------------------------------
+
|  sale_date  |  string  |
   |
|  region  |  string  |
   |
+------------------------------------------------------------------
+
```

```
OK
```

In preceding example, we can see that the attributes of `sale_detai l_like` coincide with that of `sale_detai l`, except for the lifecycle. For more information, see #unique_14.

> Note:
> The data size you obtain by using the `describe table` command includes the size of data in the recycle bin. If you want to clear the recycle bin, run the command. Then, run the `describe table` command, and the returned data size no longer includes the size of data in the recycle bin. To obtain details about data in the recycle bin, run the `show recyclebin` command.

Check the information of `sale_detai l_ctas1`, you can find that `sale_date` and `region` are only normal columns and not partitions of the table.

- As more data types are being added to MaxCompute, the types of data returned by the `desc` command increase. For details, see Data types. If new data types are used in MaxCompute, you need to enable new data types when you execute SQL statements. However, you do not need to do so when you run the `desc` command.

  > Note:
  > If the output of SQL statements depends on the input of the `desc table` command, we recommend that you promptly update settings to parse new data types in MaxCompute.

  For example:

```
set  odps . sql . type . system . odps2 = true ;
CREATE  TABLE  test_newty pe  (
    c1  tinyint
   , c2  smallint
   , c3  int
   , c4  BIGINT
   , c5  float
   , c6  DOUBLE
   , c7  decimal
   , c8  binary
   , c9  timestamp
   , c10  ARRAY < map < BIGINT , BIGINT >>
   , c11  map < STRING , ARRAY < BIGINT >>
   , c12  STRUCT < s1 : STRING , s2 : BIGINT >
   , c13  varchar ( 20 ))
LIFECYCLE  1
```

```
;
```

Information returned by the `desc test_newty pe ;` command (some of the information is not presented):

```
| Native Columns :
                    |
+--------------------------------------------------------------------------------
+
| Field              | Type          | Label  | Comment
                                         |
+--------------------------------------------------------------------------------
+
| c1                 | tinyint       |        |
                     |
| c2                 | smallint      |        |
                     |
| c3                 | int           |        |
                     |
| c4                 | bigint        |        |
                     |
| c5                 | float         |        |
                     |
| c6                 | double        |        |
                     |
| c7                 | decimal       |        |
                     |
| c8                 | binary        |        |
                     |
| c9                 | timestamp     |        |
                     |
| c10                | array < map < bigint , bigint >> |        |
                           |
| c11                | map < string , array < bigint >> |        |
                           |
| c12                | struct < s1 : string , s2 : bigint > |
 |                              |
| c13                | varchar ( 20 ) |        |
                       |
+--------------------------------------------------------------------------------
+
```

You can run the `DESC EXTENDED table_name ;` command to view the `Clustering` attribute of a hash cluster table. In the following example, the `Clustering` attribute is displayed in `Extended Info` .

```
+--------------------------------------------------------------------------------
+
| Owner : ALIYUN $ xxxxxxx @ aliyun . com | Project : xxxxx |
| TableComme nt : |
+--------------------------------------------------------------------------------
+
| CreateTime : 2017 - 12 - 25 11 : 18 : 26 |
| LastDDLTim e : 2017 - 12 - 25 11 : 18 : 26 |
| LastModifi edTime : 2017 - 12 - 25 11 : 18 : 26 |
| Lifecycle : 2 |
+--------------------------------------------------------------------------------
+
```

```
| InternalTa ble : YES | Size : 0 |
+------------------------------------------------------------------------------
+
| Native Columns : |
+------------------------------------------------------------------------------
+
| Field | Type | Label | Comment |
+------------------------------------------------------------------------------
+
| a | string | | |
| b | string | | |
| c | bigint | | |
+------------------------------------------------------------------------------
+
| Partition Columns : |
+------------------------------------------------------------------------------
+
| dt | string | |
+------------------------------------------------------------------------------
+
| Extended Info : |
+------------------------------------------------------------------------------
+
| TableID : 91a3395d3e f64b4d9ee1 d285275528 64 |
| IsArchived : false |
| PhysicalSi ze : 0 |
| FileNum : 0 |
| ClusterTyp e : hash |
| BucketNum : 1024 |
| ClusterCol umns : [ c ] |
| SortColumn s : [ c ASC ] |
+------------------------------------------------------------------------------
+
```

If the table is a partitioned table that has the `Clustering` attribute, run the following command to view the partition attributes in addition to running the preceding command to view the table attributes:

```
DESC EXTENDED table_name partition ( pt_spec );
```

Use the `select` statement to view data in the table. For details, see Introduction to the SELECT Syntax.

View table creation statements

Run the following command to view the format of statements that are used for creating a table:

```
SHOW CREATE TABLE < table_name >;
```

Note:

DDL statements used for creating a table are generated after this command is executed, which helps you rebuild the database schema through SQL.

Drop a table

Statement format:

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

Note:

- If the option `if   exists` is not specified and the table does not exist, exception returns. If this option is specified, no matter whether the table exists or not, all return success.
- Data in OSS is not deleted when the external tables are deleted.

For example:

```
create   table   sale_detai  l_drop   like   sale_detai  l ;
    drop   table   sale_detai  l_drop ;
   -- If   the   table   exists ,  return   success ;  otherwise ,
return   exception .
    drop   table   if   exists   sale_detai  l_drop2 ;
   -- No   matter   whether   the   table   sale_detai  l_drop2
exists   or   not ,  all   return   success .
```

Rename a table

Statement format:

```
ALTER   TABLE   table_name   RENAME   TO   new_table_  name ;
```

Note:

- `Rename` operation is used to update the table name only and not the data in the table.
- If the `new_table_  name` is duplicated an error may occur.
- If the table `table_name` does not exist, error may occur.

For example:

```
create   table   sale_detai  l_rename1   like   sale_detai  l ;
alter   table   sale_detai  l_rename1   rename   to   sale_detai
l_rename2 ;
```

Change the owner of a table

MaxCompute SQL allows you to run the `changeowne   r` command to change the owner of a table.

Example:

```
alter table table_name changeowne r to ' ALIYUN $ xxx @
aliyun . com ';
```

Alter the comments of a table

Command format:

```
ALTER TABLE table_name SET COMMENT ' tbl comment ';
```

Note:

- The table `table_name` must exist.
- The comment length must not exceed 1024 bytes.

For example:

```
alter table sale_detai l set comment ' new comments for
  table sale_detai l ';
```

Use the command `desc` to view the comment modification in the table. For more information, see `describe table` in Common commands > Table operations.

Alter LastDataModifiedTime of a table

MaxCompute SQL supports `touch` operation to modify `LastDataMo difiedTime` of a table. The result is to modify `LastDataMo difiedTime` of a table to be current time.

Statement format:

```
ALTER TABLE table_name TOUCH ;
```

Note:

- If the table `table_name` does not exist, an error is returned.
- This operation changes the value of `LastDataMo difiedTime` of a table and this is when MaxCompute identifies change in the table data and then begins the corresponding lifecycle calculation.

Modify the Hash Clustering attribute of a table

You can execute the `alter table` statement to add or remove the `Hash Clustering` attribute of a partitioned table.

Add the `Hash Clustering` attribute:

```
ALTER TABLE table_name
[ CLUSTERED BY ( col_name [, col_name , ...]) [ SORTED BY (
col_name [ ASC | DESC ] [, col_name [ ASC | DESC ] ...])]
INTO number_of_ buckets BUCKETS ]
```

Remove the `Hash Clustering` attribute:

```
ALTER TABLE table_name NOT CLUSTERED ;
```

Note:

- The `alter table` statement cannot modify the `Clustering` attribute of a non-partitioned table because this attribute cannot be modified once it is specified for a non-partitioned table.
- The `alter table` statement takes effect only on the new partitions of a table. Therefore, you do not need to execute the `partition alter table` statement for the existing partitions. After the `Clustering` attribute is added, data is stored to the new partitions in compliance with hash clustering.

Empty data from a non-partitioned table

Empty data in specified non-partitioned table. This command does not support partitioned table. For the partitioned table, use `ALTER TABLE table_name DROP PARTITION` to clear the data in the partition.

Command format:

```
TRUNCATE TABLE table_name ;
```

4.6.2 Lifecycle of table

MaxCompute provides data life cycle management functions to facilitate you to release storage space and simplify the process of data recovery.

Modify lifecycle of table

Statement format:

```
ALTER TABLE table_name SET lifecycle days ;
```

Note:

- The parameter 'days' refers to the time required to complete the lifecycle. It must be a positive integer and its unit is 'day'.
- Suppose that the table 'table_name' is a no-partition table. Calculated from the last updated date, the data is still not modified after N (days) days, then MaxCompute automatically recycles the table without user intervention (similar to 'drop table' operation).
- In MaxCompute, once the data in the table is modified, the LastDataModifiedTime is updated. So MaxCompute judges whether to recycle this table based on the LastDataModifiedTime setting and lifecycle.
- · Suppose the table 'table_name' is a partition table. MaxCompute determines whether to recycle the table according to LastDataModifiedTime of each partition.
- · Unlike no-partition table, after the last partition of a partitioned table has been recycled, the table is not deleted.
- · The lifecycle can be set for a table, not for the partition.
- · It can be specified while creating a table.

Example:

```
create   table   test_lifec  ycle ( key   string )  lifecycle   100 ;
--  Create   a   new   table  test_lifec  ycle   and   the
lifecycle   is   100   days .
 alter   table   test_lifec  ycle   set   lifecycle   50 ;
--  Alter   the   lifecycle   for   the   table   test_lifec  ycle
and   set   it   to   be   50   days .
```

Disable lifecycle of table

In some cases, the data in specified partitions do not need to be recycled by the lifecycle function. For example, data in the beginning of the month, or the data during the Global Shopping Day period. You can disable the lifecycle function using some specific partitions.

Statement format:

```
ALTER TABLE table_name partition_ spec ENABLE | DISABLE
LIFECYCLE ;
```

An example is shown as follows.

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

4.6.3 Column and Partition operation

This article shows you how to add, delete, and modify table partition command operations.

Add partition

Statement format:

```
ALTER TABLE TABLE_NAME ADD [ IF NOT EXISTS ] PARTITION
partition_ spec
partition_ spec :( partition_ col1 = partition_ col_value1 ,
partition_ col2 = partiton_c ol_value2 , ...)
```

Note:

- The partition name must be lowercase.
- Only 'creating partitions' are supported wherein, 'creating partition columns' are not supported.
- If the same name partition has already existed and the option [if not exists] is not specified, an exception returns.
- Currently, the maximum number of partitions supported in a single MaxCompute table is 60,000.
- For tables that have multi-level partitions, to add a new partition, all partition values must be specified.

Example:

add a new partition for the table 'sale_detail'.

```
alter table sale_detai l add if not exists partition
( sale_date =' 201312 ', region =' hangzhou ');
-- Add partition successful ly , to store the sale
detail of hangzhou region in December of 2013 .
alter table sale_detai l add if not exists partition
( sale_date =' 201312 ', region =' shanghai ');
-- Add partition successful ly , to store the sale
detail of shanghai region in December of 2013 .
```

```
alter table sale_detai l add if not exists partition (
sale_date =' 20111011 ');
-- Only specify a partition sale_date , error occurs and
  return .
alter table sale_detai l add if not exists partition (
region =' shanghai ');
-- Only specify a partition region , error occurs and
return .
```

Drop partition

Delete the syntax format for the partition is as follows:

```
ALTER TABLE TABLE_NAME DROP [ IF EXISTS ] PARTITION
partition_ spec ;
partition_ spec :( partition_ col1 = partition_ col_value1 ,
partition_ col2 = partiton_c ol_value2 , ...)
```

Note:

If the partition does not exist and the option [if exists] is not specified, then an error returns.

Example:

delete a partition from the table sale_detail.

```
alter table sale_detai l drop if exists partition (
sale_date =' 201312 ', region =' hangzhou ');
-- - Delete the sale details of Hangzhou in December
of 2013 successful ly .
```

Add column

Statement format:

```
ALTER TABLE table_name ADD COLUMNS ( col_name1 type1 ,
col_name2 type2 ...)
```

```
ALTER TABLE table_name ADD COLUMNS ( col_name1 type1
comment ' XXX ', col_name2 type2 comment ' XXX ');
```

Note:

You cannot specify order for a new column. By default, a new column is placed in the last column.

Modify column name

Statement format:

```
ALTER TABLE table_name CHANGE COLUMN old_col_na me
RENAME TO new_col_na me ;
```

Note:

- Column 'old_col_name' refers to an existing column.
- A column named 'new_col_name' cannot exist in the table.

Alter Column/Partition Comment

Modify column/partition comment is as follows:

```
ALTER TABLE table_name CHANGE COLUMN col_name COMMENT
comment_st ring ;
```

Note:

The maximum comment content is 1024 bytes.

Modify column names and column notes simultaneously

Statement format:

```
ALTER TABLE table_name CHANGE COLUMN old_col_na me
new_col_na me column_typ e COMMENT column_com ment ;
```

Note:

- Column 'old_col_name' must be an existing column.
- A column named 'new_col_name' cannot exist in the table.
- The content of the comment cannot exceed 1024 bytes.

Modify LastDataModifiedTime of table/partition

MaxCompute MaxCompute SQL supports 'touch' operation to modify LastDataMo difiedTime of a partition. The result is to modify 'LastDataModifiedTime' of a partition to be current time.

Statement format:

```
ALTER   TABLE   table_name   TOUCH   PARTITION ( partition_  col ='
partition_  col_value ', ...)
```

Note:

- If 'table_name' or 'partition_col' does not exist, an error returns.
- If the specified partition_col_value does not exist, an error returns.
- This operation changes the value of 'LastDataModifiedTime' in the table and now MaxCompute determines whether the data of the table or partition has changed and the lifecycle calculation begins again.

Modify partition value

MaxCompute SQL supports to change the partition value for corresponding partition value through 'rename' operation.

Statement format:

```
ALTER   TABLE   table_name   PARTITION  ( partition_  col1  =
partition_  col_value1 ,  partition_  col2  =  partiton_c  ol_value2
, ...)
RENAME   TO   PARTITION  ( partition_  col1  =  partition_
col_newval  ue1 ,  partition_  col2  =  partiton_c  ol_newvalu  e2
, ...)
```

Note:

- The name of a partition column cannot be modified. Only the values in that column can be altered.
- To modify values in one or more partitions among multi-level partitions, users must write values for partitions at each level.

4.6.4 View operations

Create view

Statement format:

```
CREATE  [ OR   REPLACE ]  VIEW  [ IF   NOT   EXISTS ]  view_name
   [( col_name  [ COMMENT   col_commen  t ], ...)]
   [ COMMENT   view_comme  nt ]
   [ AS   select_sta  tement ]
```

Note:

- To create a view, you must have 'read' privilege on the table referenced by view.
- Views can only contain one valid 'select' statement.
- Other views can be referenced by a view, but this view cannot reference itself. Circular reference is not supported.
- Writing the data into a view is not allowed, such as, using `insert into` or `insert overwrite` to operate view
- After a view was created,it may be inaccessable if the referenced table is altered, such as deleting a referenced table. You must maintain corresponding relationsh ip between referenced tables and views.
- If the option 'if not exists' is not specified and the view has already existed, using `create view` causes abnormality. If this situation occurs, use `create or replace view` to recreate a view. After reconstruction, the privileges keep unchanged.

Example:

```
create view if not exists sale_detai l_view
( store_name , customer_i d , price , sale_date , region )
comment ' a view for table sale_detai l '
as select * from sale_detai l ;
```

Drop view

Statement format:

```
DROP VIEW [ IF EXISTS ] view_name ;
```

Note:
If the view does not exist and the option [if exists] is not specified, error occurs.

Example:

```
DROP VIEW IF EXISTS sale_detai l_view ;
```

Rename view

Statement format:

```
ALTER VIEW view_name RENAME TO new_view_n ame ;
```

Note:
If the same name view has already existed, error occurs.

Example:

```
create   view   if   not   exists   sale_detai  l_view
       ( store_name ,  customer_i  d ,  price ,  sale_date ,  region
)
        comment  ' a   view   for   table   sale_detai  l '
        as   select  *  from   sale_detai  l ;
    alter   view   sale_detai  l_view   rename   to   market ;
```

4.7 Lateral View

Lateral view is used in conjunction with UDTF such as split, explode, etc. It can split a row of data into multiple rows, and aggregate the split data on this basis.

Single Lateral View statement

Syntax:

```
lateralVie  w :  LATERAL   VIEW  [ OUTER ]  udtf ( expression )
tableAlias   AS   columnAlia  s  (',' columnAlia  s ) *  fromClause
:  FROM   baseTable  ( lateralVie  w )*
```

Notes:

- Lateral view outer: When the table function does not output any rows, the corresponding Input rows remain in the Lateral View results, and all table function output lists are null.

Example:

Suppose we have a table called "pageAds" which has two columns of data.The first column is "pageid string" and the second column is "adid_list", a comma-separated collection of AD IDs.

string pageid	Array<int> adid_list
“front_page”	[1, 2, 3]
“contact_page”	[3, 4, 5]

The requirement is to count the number of times all AD IDs have appeared. The implementation process is as follows.

1. Split the AD IDs as follows:

```
SELECT   pageid ,  adid
```

```
 FROM   pageAds   LATERAL   VIEW   explode ( adid_list )  adTable
AS   adid ;
```

The execution result is as follows:

string pageid	int adid
“front_page”	1
“front_page”	2
“front_page”	3
“contact_page”	3
“contact_page”	4
“contact_page”	5

2. The statistics for the aggregation:

```
SELECT   adid ,  count ( 1 )
    FROM   pageAds   LATERAL   VIEW   explode ( adid_list )
adTable   AS   adid
GROUP   BY   adid ;
```

Result:

int adid	count(1)
1	1
2	1
3	2
4.	1
50	1

Multiple Lateral View statements

A from statement can be followed by multiple Lateral View statements, the subsequent Lateral View statement can reference all the former tables and columns.

The following table is an example:

Array<int> col1	Array<string> col2
[1, 2]	[“a” , “b” , “c”]
[3, 4]	[“d” , “e” , “f”]

- Execute a single statement:

```
SELECT   myCol1 ,  col2   FROM   baseTable
```

```
    LATERAL   VIEW   explode ( col1 )  myTable1   AS   myCol1 ;
```

Result:

int mycol1	Array<string> col2
1	[“a” , “b” , “c”]
2	[“a” , “b” , “c”]
3	[d” , “e” , “f”]
4	[d” , “e” , “f”]

- **Add a Lateral View statement as follows:**

```
SELECT   myCol1 ,  myCol2   FROM   baseTable
    LATERAL   VIEW   explode ( col1 )  myTable1   AS   myCol1
    LATERAL   VIEW   explode ( col2 )  myTable2   AS   myCol2 ;
```

Result is as follows:

int myCol1	string myCol2
1	“a”
1	“b”
1	“c”
2	“a”
2	“b”
2	“c”
3	“d”
3	“e”
3	“f”
4	“d”
4	“e”
4	“f”

4.8 Differences with other SQL syntax

This article takes a SQL perspective. and introduces MaxCompute by comparing MaxCompute SQL with Hive, MySQL, Oracle, SQL Server Unsupported pant, and DML syntax.

DDL syntax not supported by MaxCompute

Syntax	MaxCompute	Hive	MySQL	Oracle	SQL Server
CREATE TABLE—PRIMARY KEY	N	N	Y	Y	Y
CREATE TABLE—NOT NULL	N	N	Y	Y	Y
CREATE TABLE—CLUSTER BY	Y	Y	N	Y	Y
CREATE TABLE—EXTERNAL TABLE	Y(OSS, OTS, TDDL)	Y	N	N	N
CREATE TABLE—TEMPORARY TABLE	N	Y	Y	Y	Y （with #prefix）
INDEX—CREATE INDEX	N	Y	Y	Y	Y
VIRTUAL COLUMN	N	N (only 2 predefined)	N	Y	Y

DML syntax not supported by MaxCompute

Syntax	MaxCompute	Hive	MySQL	Oracle	SQL Server
CTE	Y	Y	Y	Y	Y
SELECT—recursive CTE	N	N	N	Y	Y
SELECT—GROUP BY ROLL UP	Y	Y	Y	Y	Y
SELECT—GROUP BY CUBE	Y	Y	N	Y	Y
SELECT—GROUPING SET	Y	Y	N	Y	Y

Syntax	MaxCompute	Hive	MySQL	Oracle	SQL Server
SELECT—IMPLICT JOIN	Y	Y	N	Y	Y
SELECT—PIVOT	N	N	N	Y	Y
SEMI JOIN	Y	Y (corelated expression must be in WHERE , EXISTS must be corelated)	Y	N (has IN and EXISTS , but no SEMI JOIN grammer)	N (has IN and EXISTS, but no SEMI JOIN grammer)
SELEC TRANSFROM	Y	Y	N	N	N
SELECT—corelated subquery	Y	Y (corelated expression must be in WHERE , EXISTS must be corelated)	Y	Y	Y
ORDER BY NULLS FIRST/LAST	Y	Y	Y	Y	Y
LATERAL VIEW	Y	Y	N	Y (LATERAL keyword)	Y (CROSS APPLY keyword)
SET OPERATOR—UNION (disintct)	Y	Y	Y	Y	Y
SET OPERATOR—INTERSECT	Y	N	N	Y	Y
SET OPERATOR—MINUS/EXCEPT	Y	N	N	Y	Y（keyword EXCEPT）

Syntax	MaxCompute	Hive	MySQL	Oracle	SQL Server
INSERT INTO ... VALUES	Y	Y	Y	Y	Y
INSERT INTO (ColumnList)	Y	Y	Y	Y	Y
UPDATE … WHERE	N	Y	Y	Y	Y
UPDATE … ORDER BY LIMIT	N	N	Y	N	Y
DELETE … WHERE	N	Y	Y	Y	Y
DELETE … ORDER BY LIMIT	N	N	Y	N	N
ANALYTIC —reusable WINDOWING CLUSUE	Y	Y	N	N	N (can implement with join)
ANALYTIC— CURRENT ROW	Y	Y	N	Y	Y
ANALYTIC— UNBOUNDED	Y	N	Y	Y	Y
ANALYTIC—RANGE …	N	Y	N	Y	Y
WHILE DO	N	N	Y	Y	Y

SCRIPTING syntax not supported by MaxCompute

Syntax	MaxCompute	Hive	MySQL	Oracle	SQL Server
TABLE VARIABLE	Y	Y (TEMPORARY TABLE)	Y (TEMPORARY TABLE)	Y (TEMPLORARY TABLE)	Y
SCALER VARIABLE	Y	Y	Y (DECLARE x INT)	Y	Y
ERROR HANDLING —RAISE ERROR	N	N	Y	Y	Y

Syntax	MaxCompute	Hive	MySQL	Oracle	SQL Server
ERROR HANDLING —TRY CATCH	N	N	N	Y	Y
FLOW CONTROL— LOOP	N	N	Y	Y	Y
CURSOR	N	N	Y	Y	Y

4.9 Select Operation

4.9.1 SELECT syntax

This topic describes MaxCompute `SELECT` syntax and the precautions for executing nested queries, sorting operations, and grouping queries by using `SELECT` syntax.

SELECT statement format

The `SELECT` statement format is as follows:

```
 SELECT  [ ALL   |  DISTINCT ]  select_exp  r ,  select_exp  r , ...
 FROM   table_refe  rence
[ WHERE   where_cond  ition ]
[ GROUP   BY   col_list ]
[ ORDER   BY   order_cond  ition ]
[ DISTRIBUTE   BY   distribute  _condition  [ SORT   BY   sort_condi
 tion ] ]
```

```
[ LIMIT   number ]
```

Column expressions

When using the `SELECT` statement to read data from a table, specify the names of the columns to be read, or use an asterisk (*) wildcard to specify all columns. The following is an example `SELECT` statement:

```
select  *  from   sale_detai  l ;
```

To specify only the `shop_name` column in *the sale_detai l table*, use the following statement:

```
select   shop_name   from   sale_detai   l ;
```

Use a `WHERE` clause when you specify a filtering condition. For example:

```
select  *  from   sale_detai  l   where   shop_name   like  ' hang
%';
```

When you use a `SELECT` statement, up to 10,000 rows of results can be displayed. If the `SELECT` statement serves as a clause, all the results are returned to the upper-level query.

Note:

- Full table scans cannot be specified when `SELECT` statements are used on a partitioned table.

  For new projects created after January 10, 2018, full table scans cannot be specified for a partitioned table in a project. Instead, you must specify each partition condition to be scanned. This is to help reduce excessive resource usage and lower costs. If your instances are billed by the Pay-As-You-Go billing method, the total number of partition conditions to be scanned is regarded as one billable item.

  If the table definition is `t1 ( c1 , c2 )  partitione  d   by ( ds )`, you cannot run the following statement in a new project. Otherwise, an error may occur:

  ```
  Select  *  from   t1   where   c1 = 1 ;
  Select  *  from   t1   where  ( ds =‘ 20180202 ’  or   c2 = 3 );
  Select  *  from   t1   left   outer   join   t2   on   a . id  = b
  . id   and   a . ds = b . ds   and   b . ds =‘ 20180101 ’);
 -- When   Join   statement   is   running ,  if   the   partition
  clipping   condition   is   placed   in   where   clause ,  the
  partition   clipping   takes   effect .  If   you   put   it   in
    on   clause ,  the   partition   clipping   of   sub   table
  ```

```
takes effect , and the main table performs a full
table scan .
```

If you perform a full table scan on a partitioned table, you can add a set statement `set odps . sql . allow . fullscan = true ;` before the SQL statement that is used to scan the partitioned table. The set statement must be entered together with the SQL statement. In the case that the *sales_deta il* table is a partitioned table, submit the following simple query statements at the same time for a full table scan:

```
set odps . sql . allow . fullscan = true ;
select * from sale_detai l ;
```

- table_reference supports nested subqueries, for example:

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

Note:
When you use a `SELECT` statement, up to 10,000 rows of results can be displayed. If the `SELECT` statement serves as a clause, all the results are returned to the upper-level query.

Use DISTINCT to remove duplicates

`DISTINCT` : If duplicated data rows exist, you can use the Distinct option before the field to remove duplicates. In this case, only one value is returned. If you use the ALL option, or do not specify this option, all duplicated values in the fields are returned.

If you use the Distinct option, only one row of a record is returned, which is shown as follows:

```
select distinct region from sale_detai l ;
select distinct region , sale_date from sale_detai l ;
-- Performs the Distinct option on multiple columns .
The Distinct option has an effect on Select column
sets rather than a single column .
```

WHERE clause conditions

The filter conditions supported by `WHERE` clauses as shown in the following table:

Filter criteria	Description
> ,<, =, >=, <=, <>	Relational operators

Filter criteria	Description
like, rlike	The source and pattern parameters of like and rlike can only be of the String type.
in, not in	If a subquery is attached to the in or not in a condition, only the values of one column are returned for the subquery, and the returned values cannot exceed 1,000 entries.

You can specify a partition scope in the `WHERE` clause of a `SELECT` statement that is used to scan specified partitions of a table instead of a whole table, shown as follows:

```
SELECT   sale_detai  l . *  FROM   sale_detai  l   WHERE
sale_detai  l . sale_date  >= ' 2008 '  AND   sale_detai  l .
sale_date  <= ' 2014 ';
```

The `WHERE` clause of MaxCompute SQL supports query by using the between-and condition. The preceding SQL statement can be rewritten as follows:

```
SELECT   sale_detai  l . *  FROM   sale_detai  l   WHERE
sale_detai  l . sale_date   BETWEEN  ' 2008 '  AND  ' 2014 ';
```

Queries using GROUP BY

`GROUP BY`: Query by group. In most cases, `GROUP BY` is used in combination with an aggregation function. For a `SELECT` statement that contains an aggregate function to be used in combination with `GROUP BY`, it must comply with the following rules:

- Rule i: The key using `GROUP BY` is the name of a column in the input table.
- Rule ii: The key using `GROUP BY` is an expression consisting of columns of the input table. However, this expression cannot be the alias of an output column of the `SELECT` statement.

> Note:
> In the case that rules i and ii are in conflicting with each other, rule i takes priority over rule ii. Specifically, if the key using `GROUP BY` is a column or expression of the input table and an output column of `SELECT`, rule i takes priority over rule ii.

For example:

```
select   region   from   sale_detai  l   group   by   region ;
```

```
-- Runs successful ly with the name of a column in
   the input table directly used as the group by
 column
 select sum ( total_pric e ) from sale_detai l group by
 region ;
-- Runs successful ly with the table grouped by the
   region value and returns the total sales of each
 group
 Select region , sum ( total_pric e ) from sale_detai l
 group by region ;
-- Runs successful ly with the table grouped by the
 region value and returns the region value ( unique in
   the group ) and total sales of each group
 select region as r from sale_detai l group by r ;
 -- Runs with the alias of the Select column and
 returns an error
 select 2 + total_pric e as r from sale_detai l group
   by 2 + total_pric e ;
-- Requires a complete expression of the column
 Select region , total_pric e from sale_detai l group by
   region ;
-- Returns an error ; all columns not using an
 aggregate function in the Select statement must exist
 in group by
 select region , total_pric e from sale_detai l group by
   region , total_pric e ;
-- Runs successful ly
```

The preceding restrictions are imposed because `GROUP BY` operations come before `SELECT` operations during SQL parsing. Therefore, `GROUP BY` statements can only accept the columns or expressions of the input table as keys.

Note:

For more information, see Aggregate Functions.

Queries using ORDER BY, SORT BY, and DISTRIBUTE

- `ORDER BY` : Globally sorts all data based on certain columns. To sort records in descending order, use the DESC keyword. For global sorting, order by must be used together with limit. When `ORDER BY` is used for sorting, NULL is considered to be smaller than any other value. This action is the same as that in MySQL but different from that in Oracle.

  Unlike `GROUP BY`, `ORDER BY` must be followed by the alias of the `SELECT` column. 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.

```
 select * from sale_detai l order by region ;
-- Returns an error because order by is not used
 together with limit
 select * from sale_detai l order by region limit 100
 ;
```

```
select region as r from sale_detai l order by
region limit 100 ;
-- Returns an error because ORDER BY is not
followed by a column alias
select region as r from sale_detai l order by r
limit 100 ;
```

The number in `[ limit number ]` is a constant to limit the number of output rows. If you want to directly view the result of a `SELECT` statement without LIMIT from the screen output, you can view up to 10,000 rows. The upper limit of screen display varies by project. However, the upper limit can be controlled through the `setproject` console.

- `SORT BY`: For partial ordering, `DISTRIBUTE BY` must be added in front of the statement. `SORT BY` is used to partially sort the results of `DISTRIBUTE BY`. Aliases of `SELECT` output columns must be used.

```
select region from sale_detai l distribute by region
sort by region ;
select region as r from sale_detai l sort by
region ;
-- Returns an error and exits because no distribute
by exists .
```

- `DISTRIBUTE BY`: Performs hash-based sharding on data by values of certain columns. Aliases of `SELECT` output columns must be used.

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

`ORDER BY` and `GROUP BY` cannot be used together with `DISTRIBUTE BY` and `SORT BY`. Aliases of `SELECT` output columns must be used.

Note:

- The keys of `ORDER BY`, `SORT BY`, and `DISTRIBUTE BY` must be output columns (namely, column aliases) of `SELECT` statements.
- In MaxCompute SQL parsing, `ORDER BY`, `SORT BY`, and `DISTRIBUTE BY` come after `SELECT` operations. Therefore, they can only accept the output columns of `SELECT` statements as keys.

4.9.2 SELECT Sequence

The actual logic execution sequence of SELECT statements written in compliance with the preceding SELECT syntax are different from the standard writing sequence.

See the following example:

```
SELECT    key
       , MAX ( value )
FROM      src   t
WHERE     value  >  0
GROUP   BY   key
HAVING    SUM ( value ) >  100
ORDER   BY   key
LIMIT     100
;
```

The actual logic execution sequence is `FROM -> WHERE -> GROUP   BY -> HAVING -> SELECT -> ORDER   BY -> LIMIT`.

- ORDER BY can only reference columns generated in the SELECT list rather than accessing columns in the FROM source table.
- The HAVING operation can access GROUP BY keys and aggregate functions. When the SELECT operation is performed, SELECT can only access group keys and aggregate functions rather than columns in the FROM source table if GROUP BY exists.
- The columns generated in the select list can only be referenced in by, rather than accessing the columns in the source table of from.

To avoid confusion, MaxCompute allows users to write a query statement by the execution sequence. For example, the preceding statement can be written as follows:

```
FROM      src   t
WHERE     value  >  0
GROUP   BY   key
HAVING    SUM ( value ) >  100
SELECT    key
       , MAX ( value )
ORDER   BY   key
LIMIT     100
;
```

example2:

```
SELECT    shop_name
       , total_pric  e
       , region
FROM      sale_detai  l
WHERE     total_pric  e  >  150
DISTRIBUTE   BY   region
SORT   BY   region
```

```
;
```

In fact, the order of logical execution is `FROM -> WHERE -> SELECT -> DISTRIBUTE BY -> SORT BY`.

4.9.3 Subquery

Basic definition of a subquery

A normal SELECT operation reads data from several tables, for example, select `column_1 , column_2 … from table_name`. However, the query object can be another SELECT operation, which is shown as follows:

```
select * from ( select shop_name from sale_detai l ) a ;
```

Note:

The subquery must have an alias.

In a FROM clause, a subquery can be used as a table to perform JOIN operations with other tables or subqueries, which is shown as follows:

```
create table shop as select * from sale_detai l ;
select a . shop_name , a . customer_i d , a . total_pric e
from
( select * from shop ) a join sale_detai l on a .
shop_name = sale_detai l . shop_name ;
```

IN SUBQUERY / NOT IN SUBQUERY

IN SUBQUERY is similar to LEFT SEMI JOIN.

For example:

```
SELECT * from mytable1 where id in ( select id from
mytable2 );
-- is equivalent to
SELECT * from mytable1 a LEFT SEMI JOIN mytable2 b
on a . id = b . id ;
```

Currently, MaxCompute supports both IN SUBQUERY and CORRELATED conditions.

For example:

```
SELECT * from mytable1 where id in ( select id from
mytable2 where value = mytable1 . value );
```

`where value = mytable1 . value` in the subquery is a CORRELATED condition. MaxCompute of early versions reports errors for such expressions that reference source tables both in subqueries and in outer queries. MaxCompute supports such expressions now. In fact, such filtering conditions are a part of the ON condition in SEMI JOIN.

NOT IN SUBQUERY is similar to LEFT ANTI JOIN. However, they have one significant difference.

For example:

```
SELECT * from mytable1 where id not in ( select id
from mytable2 );
-- If none of the IDs in mytable2 are NULL , this
statement is equivalent to
SELECT * from mytable1 a LEFT ANTI JOIN mytable2 b
on a . id = b . id ;
```

If mytable2 contains any column whose ID is NULL, the NOT IN expression is NULL, so that the WHERE condition is invalid and no data is returned. This is different from LEFT ANTI JOIN.

MaxCompute 1.0 supports [NOT] IN SUBQUERY not serving as a JOIN condition, for example, in a non-WHERE statement, or failure in conversion to a JOIN condition even in a WHERE statement. MaxCompute 2.0 still supports this feature. However , [NOT] IN SUBQUERY cannot be converted to SEMI JOIN, and a separate job must be started to run subqueries. Therefore, [NOT] IN SUBQUERY does not support CORRELATED conditions.

For example:

```
SELECT * from mytable1 where id in ( select id from
mytable2 ) OR value > 0 ;
```

As the WHERE clause includes OR, [NOT] IN SUBQUERY cannot be converted to SEMI JOIN. A separate job must be started to run subqueries.

In addition, partition tables are specially processed:

```
SELECT * from sales_deta il where ds in ( select dt
from sales_date );
```

If ds is a partition column, `select dt from sales_date` separately starts a job to run subqueries, instead of converting to SEMI JOIN. After running, the results are compared with ds one by one. If a ds value in sales_detail is not in the returned results, the partition is not read to make sure that partition pruning is still valid.

EXISTS SUBQUERY/NOT EXISTS SUBQUERY

In an EXISTS SUBQUERY, when at least one data row exists in the subquery, TRUE is returned; otherwise, FALSE is returned. NOT EXISTS subquery is completely opposite of this.

Currently, MaxCompute supports only subqueries including the correlated WHERE conditions. EXISTS SUBQUERY/NOT EXISTS SUBQUERY is implemented by converting to LEFT SEMI JOIN or LEFT ANTI JOIN.

For example:

```
 SELECT  *  from   mytable1   where   exists  ( select  *  from
 mytable2   where   id  =  mytable1 . id );
--  is   equivalent   to
 Select  *  From   mytable1   a   left   semi   join   mytable2   B
 on   A .  ID  =  B .  ID ;
```

While

```
 SELECT  *  from   mytable1   where   not   exists  ( select  *  from
   mytable2   where   id  =  mytable1 . id );
--  is   equivalent   to
 SELECT  *  from   mytable1   a   LEFT   ANTI   JOIN   mytable2   b
 on   a . id = b . id ;
```

4.9.4 UNION, INTERSECT, and EXCEPT

This topic describes the syntax of UNION ALL, UNION DISTINCT, INTERSECT ALL, INTERSECT DISTINCT, EXCEPT ALL, and EXCEPT DISTINCT, and provides examples of query statements.

The following are example syntax statements:

```
 select_sta  tement   UNION   ALL   select_sta  tement ;
 select_sta  tement   UNION  [ DISTINCT ]  select_sta  tement ;
 select_sta  tement   INTERSECT   ALL   select_sta  tement ;
 select_sta  tement   INTERSECT  [ DISTINCT ]  select_sta  tement ;
 select_sta  tement   EXCEPT   ALL   select_sta  tement ;
 select_sta  tement   EXCEPT  [ DISTINCT ]  select_sta  tement ;
 select_sta  tement   MINUS   ALL   select_sta  tement ;
 select_sta  tement   MINUS  [ DISTINCT ]  select_sta  tement ;
```

- UNION: Returns the union of two data sets.
- INTERSECT: Returns the intersection of two data sets.
- EXCEPT: Returns the supplementary set of a data set in another set.
- MINUS: Means the same as EXCEPT.

Examples

- **UNOIN ALL**

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

Result: The two data sets are merged.

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

- **UNION DISTINCT**

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

Result: The result is the same as `SELECT DISTINCT * FROM (< Result of UNOIN ALL >) t ;`.

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

- **INTERSECT ALL**

```
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 );
```

Result: Repeated rows are not deleted. Each repeated row can be regarded as a unique row with a unique number.

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

```
+------------+------------+
```

- INTERSECT DISTINCT

```
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 );
```

Result: The result is the same as `SELECT DISTINCT * FROM (< Result of INTERSECT ALL >) t ;`.

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

- EXCEPT ALL

```
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 );
```

Result: Repeated rows are not deleted. Each repeated row can be regarded as a unique row with a unique number.

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

- EXCEPT DISTINCT

```
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 );
```

Result: The result is the same as `SELECT DISTINCT * FROM left_branch EXCEPT ALL SELECT DISTINCT * FROM right_branch ;`.

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

```
+------------+------------+
```

Note:

- The sequence of rows in the result set is not guaranteed to be in any specific order.
- The two data sets in one set operation must contain the same number of columns. If not, implicit type conversion is involved. Out of compatibility reasons, implicit type conversion of STRING and non-STRING data in set operations is disabled.
- Up to 256 tables can be contained in one set operation. If more than 256 tables are involved, an error is returned.
- If UNION is followed by CLUSTER BY, DISTRIBUTE BY, SORT BY, ORDER BY, or a LIMIT clause, when `set odps . sql . type . system . odps2 = false ;`, the clause applies to the last SELECT statement. When `set odps . sql . type . system . odps2 = true ;`, the clause applies to all the preceding UNION results. Consider the following 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 ;
```

Result:

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

4.9.5 JOIN

The JOIN operation of MaxCompute supports n-way join, but does not support Cartesian product, that is, a link without the ON condition.

Function definition.

```
join_table :
        table_refe  rence   join   table_fact  or  [ join_condi  tion
]
       |  table_refe  rence  { left   outer | right   outer | full
outer | inner }  join   table_refe  rence   join_condi  tion
    table_refe  rence :
        table_fact  or
```

```
        |  join_table
     table_fact  or :
         tbl_name  [ alias ]
        |  table_subq  uery   alias
        | (  table_refe  rences  )
     join_condi  tion :
         on   equality_e  xpression  (  and   equality_e  xpression
 )*
```

Note:

equality_expression is an equality expression.

`LEFT OUTER JOIN`: Returns all records from the left table (shop) even if no matching row exists in the right table (sale_detail).

```
select   a . shop_name   as   ashop ,  b . shop_name   as   bshop
from   shop   a
        left   outer   join   sale_detai  l   b   on   a . shop_name
= b . shop_name ;
   --  As   the   tables   shop   and   sale_detai  l   both   have
  the   shop_name   column ,  aliases   must   be   used   in   the
select   clause   for   distinguis  hing .
```

`RIGHT OUTER JOIN`: indicates the right join. It returns all records from the right table even if no matching record exists in the left table.

For example.

```
select   a . shop_name   as   ashop ,  b . shop_name   as   bshop
from   shop   a
        right   outer   join   sale_detai  l   b   on   a . shop_name
= b . shop_name ;
```

`FULL OUTER JOIN`: indicates the full join. It returns all records from both the left and the right table.

For example.

```
select   a . shop_name   as   ashop ,  b . shop_name   as   bshop
from   shop   a
        full   outer   join   sale_detai  l   b   on   a . shop_name
= b . shop_name ;
```

If at least one matching record exists in the table, INNER JOIN returns the row. The keyword INNER can be ignored.

```
select   a . shop_name   from   shop   a   inner   join   sale_detai
l   b   on   a . shop_name = b . shop_name ;
```

```
select   a . shop_name   from   shop   a   join   sale_detai  l   b
on   a . shop_name = b . shop_name ;
```

The join condition only allows equivalent conditions connected using and. Only MAPJOIN supports non-equivalent join conditions or multiple conditions connected using or.

```
select   a .*  from   shop   a   full   outer   join   sale_detai  l
  b   on   a . shop_name = b . shop_name
        full   outer   join   sale_detai  l   c   on   a . shop_name
= c . shop_name ;
    --  Supports   n - way   JOIN   examples
select   a .*  from   shop   a   join   sale_detai  l   b   on   a .
shop_name  ! =  b . shop_name ;
   --  Returns   an   error   because   non - equivalent   JOIN
conditions   are   not   supported
```

IMPLICIT JOIN, MaxCompute supports the following JOIN method:

```
SELECT  *  FROM   table1 ,  table2   WHERE   table1 . id  =  table2 .
id ;
-- The   execution   effect   is   equivalent   to
SELECT  *  FROM   table1   JOIN   table2   ON   table1 . id  =
table2 . id ;
```

4.9.6 SEMI JOIN

MaxCompute supports SEMI JOIN. In SEMI JOIN, the right table does not appear in the result set and is only used to filter data in the left table. Supported syntaxes include: LEFT SEMI JOIN and LEFT ANTI JOIN.

LEFT SEMI JOIN

When a JOIN condition is valid, data in the left table is returned. That is, if the ID of a row in mytable1 appears in all IDs in mytable2, this row is saved in the result set.

For example:

```
SELECT  *  from   mytable1   a   LEFT   SEMI   JOIN   mytable2   b
on   a . id = b . id ;
```

Only the data in mytable1 is returned if the ID of mytable1 appears in the ID of mytable2.

LEFT ANTI JOIN

When a JOIN condition is invalid, data in the left table is returned. That is, if the ID of a row in mytable1 does not appear in any ID in mytable2, this row is stored in the result set.

For example:

```
SELECT * from mytable1 a LEFT ANTI JOIN mytable2 b
on a . id = b . id ;
```

Only the data in mytable1 is returned if the ID of mytable1 does not appear in the ID of mytable2.

4.9.7 MAPJOIN HINT

This topic describes how to use a `MAPJOIN` statement to join a large table with one or more small tables. It is faster than common `JOIN` operations.

A typical scenario of `MAPJOIN` is as follows: When the data volume is small, SQL loads all your specified small tables into the memory of the program by performing the `JOIN` operation to join your tables faster.

Note:

When you use `MAPJOIN`, note the following:

- 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 as subqueries.
- When `MAPJOIN` is used and a small table or subquery must be referenced, the alias must be referenced.
- `MAPJOIN` supports non-equivalent `JOIN` conditions or multiple conditions connected by using `OR` statements. You can choose not to use `ON` statements. You can also use `mapjoin on 1 = 1` to express a Cartesian product, for example, `select /* + mapjoin ( a ) */ a . id from shop a join table_name b on 1 = 1`, which may cause data expansion.
- Currently, MaxCompute allows up to 256 small tables to be specified in a `MAPJOIN` statement. If you specify more than 256 small tables, a syntax error is returned.
- If `MAPJOIN` is used, the total memory occupied by all small tables cannot exceed 640 MB. Note that MaxCompute uses compressed storage, so the data size is sharply expanded after small tables are loaded into the memory. The limit of 640 MB refers to the size after small tables are loaded into the memory.

Example:

```
select  /* +  mapjoin ( a ) */
        a . shop_name ,
        b . customer_i  d ,
        b . total_pric  e
from   shop   a   join   sale_detai  l   b
on   a . shop_name  =  b . shop_name ;
```

MaxCompute SQL does not support complex `JOIN` conditions, such as non-equivalent expressions and the `OR` logic, in the `ON` conditions of common JOIN operations. However, `MAPJOIN` supports such operations.

Example:

```
select  /*+  mapjoin ( a ) */
        a . total_pric  e ,
        b . total_pric  e
from   shop   a   join   sale_detai  l   b
on   a . total_pric  e  <  b . total_pric  e   or   a . total_pric  e
 +  b . total_pric  e  <  500 ;
```

4.9.8 HAVING clause

HAVING clauses are used because the Where keyword of MaxCompute SQL cannot be used together with aggregate functions.

Function definition.

```
SELECT   column_nam  e ,  aggregate_  function ( column_nam  e )
FROM   table_name
WHERE   column_nam  e   operator   value
GROUP   BY   column_nam  e
HAVING   aggregate_  function ( column_nam  e )  operator   value
```

Example.

A table named Orders contains four fields: Customer, OrderPrice, Order_date, and Order_id. To query customers whose OrderPrice is smaller than 2,000, The SQL statement is as follows:

```
SELECT   Customer , SUM ( OrderPrice )  FROM   Orders
GROUP   BY   Customer
```

```
HAVING   SUM ( OrderPrice )< 2000
```

4.9.9 Grouping Sets

This topic describes how to use the `GROUPING SETS` clause when you need to execute multiple `UNION ALL` clauses for scenarios where you need to aggregate and analyze data of multiple dimensions.

`GROUPING SETS` by MaxCompute 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 allow the MaxCompute engine to produce better implementation plans with higher performance.

Note:
A number of examples in this topic are demonstrated by using MaxCompute Studio. We recommend that you install MaxCompute Studio by following the instructions provided in Install IntelliJ IDEA before you proceed with subsequent operations.

Example

1. Prepare data.

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

2. Use one of the following two methods to group data:

   - Execute multiple `SELECT` statements.

```
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 ;
```

   - Use `GROUPING SETS` .

```
SELECT   os , device ,  city  , COUNT (*)
```

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

Data is aggregated as follows:

```
+----+--------+------+------------+
| os | device | city | cnt        |
+----+--------+------+------------+
| NULL | NULL | NULL | 7          |
| NULL | NULL | Beijing | 4       |
| NULL | NULL | Shijiazhua ng | 3 |
| ios | Phone | NULL | 1          |
| linux | PC | NULL | 1           |
| linux | Phone | NULL | 1        |
| windows | PC | NULL | 3         |
| windows | Phone | NULL | 1      |
+----+--------+------+------------+
```

Note:

Expressions not used in `GROUPING SETS` use `NULL` as placeholders. You can execute `UNION` statements on grouping sets, such as the `city` column in lines 1 through 5.

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 code:

```
GROUP BY CUBE ( a , b , c ) is equal to GROUPING SETS (( a ,
b , c ),( a , b ),( a , c ),( b , c ),( a ),( b ),( c ),()).

GROUP BY ROLLUP ( a , b , c ) is equal to GROUPING SETS (( a
, b , c ),( a , b ),( a )).
```

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 `NULL` s are indistinguishable from value `NULL` s. 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_I D` 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 code:

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

Data is aggregated as follows:

```
+------------+------------+------------+------------+------------
+------------+------------+------------+
|  a          |  b          |  c          |  _c3         |  ga
    |  gb          |  gc          |  groupingid  |
+------------+------------+------------+------------+------------
+------------+------------+------------+
|  NULL        |  NULL        |  NULL        |  1           |  1
    |  1           |  1           |  7           |
|  NULL        |  NULL        |  3           |  1           |  1
    |  1           |  0           |  6           |
|  NULL        |  2           |  NULL        |  1           |  1
    |  0           |  1           |  5           |
|  NULL        |  2           |  3           |  1           |  1
    |  0           |  0           |  4           |
|  1           |  NULL        |  NULL        |  1           |  0
    |  1           |  1           |  3           |
|  1           |  NULL        |  3           |  1           |  0
    |  1           |  0           |  2           |
|  1           |  2           |  NULL        |  1           |  0
    |  0           |  1           |  1           |
|  1           |  2           |  3           |  1           |  0
    |  0           |  0           |  0           |
+------------+------------+------------+------------+------------
+------------+------------+------------+
```

4.9.10 SELECT TRANSFORM

This topic describes how to use the `SELECT  TRANSFORM` statement to perform operations that MaxCompute SQL does not directly support. Specifically, by using SELECT TRANSFORM, you can 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 user-defined functions (UDFs).

Example code:

```
 SELECT   TRANSFORM ( arg1 ,  arg2  ...)
( ROW   FORMAT   DELIMITED  ( FIELDS   TERMINATED   BY   field_deli
 miter  ( ESCAPED   BY   character_  escape )?)?
( LINES   SEPARATED   BY   line_separ  ator )?
```

```
( NULL   DEFINED   AS   null_value )?)?
 USING  ' unix_comma  nd_line '
( RESOURCES  ' res_name ' (',' ' res_name ')*)?
(  AS   col1 ,  col2  ...)?
( ROW   FORMAT   DELIMITED  ( FIELDS   TERMINATED   BY   field_deli
 miter  ( ESCAPED   BY   character_  escape )?)?
( LINES   SEPARATED   BY   line_separ  ator )? ( NULL   DEFINED   AS
 null_value )?)?
```

Parameters:

- The `SELECT TRANSFORM` keyword can be replaced with the `MAP` or `REDUCE` keyword, but the meaning remains unchanged. However, to make the syntax clearer, we recommend that you use `SELECT TRANSFORM`.
- `arg1 , arg2 ...` indicates arguments in the `TRANSFORM` clause. The format of arguments in the `TRANSFORM` clause is similar to that 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, and then they are entered into the specified child process. The default format is configurable. For more information, see the `ROW FORMAT` clause described in the following section.
- `USING` : specifies the command for starting a child process.

> **Note:**
>
> - In most MaxCompute SQL statements, the `USING` clause can only specify resources. However, with the `SELECT TRANSFORM` statement, the `USING` clause can specify commands to ensure compatibility with the syntax of Hive.
> - The format of the `USING` clause is similar to the syntax of a Shell script. However, a Shell script is actually not executed to start the child process, and the child process is created according to the command input. Therefore, a number of Shell functions such as input and output redirection, pipe, and loop are unavailable. A Shell script can be used as the command for a child process if needed.

- `RESOURCES` : specifies the resources that the specified child process can access. You can use one of the following two methods to specify resources:
  - Use the `RESOURCES` clause, for 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. This clause takes effect globally once it is specified, which means that all SELECT TRANSFORM statements can access the resources specified by this clause.
- `ROW FORMAT` : specifies the input or output format.

  The syntax includes two `ROW FORMAT` clauses: One specifies the input format, and the other specifies the output format. By default, `\ t` is used to separate columns, `\ n` is used to separate rows, and `Null` is represented by `\ N` .

  Note:

  - Only one character is accepted by `field_deli miter` , `character_ escape` , and `line_separ ator` . If you specify a string, the first character in the string takes priority over the others.
  - Hive specifies the syntax for each format. Such syntaxes as inputRecordReader, outputRecordReader, and Serde are supported by MaxCompute. To use these formats, you need to enable compatibility with Hive by adding `set odps . sql . hive . compatible = true ;` preceding SQL statements. For more information about the syntaxes supported by Hive, see Hive.
  - If you specify a syntax such as inputRecordReader or outputRecordReader supported by Hive, statements may be executed at lower speeds.

- `AS` : specifies output columns.
  - You can specify data types in the `AS` clause, for example, `as ( col1 : bigint , col2 : boolean )`. If you do not specify data types, for example, `as ( col1 , col2 )`, strings are returned by default.
  - 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, which may encounter runtime exceptions.
  - You are not allowed to specify data types for only some of the specified columns, for example, `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 values, equivalent to `as ( key , value )`.

Call Shell scripts

In the case that you execute a Shell script 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.

SELECT TRANSFORM is not only a language extension. Simple functions such as AWK , Python, Perl, and Shell allow you to compile scripts in commands, so that you do not need to compile independent script files or upload resources.

Call Python scripts

Python is a simple function that can allow you to compile scripts in commands so that you do not need to compile independent script files or upload resources. The following is an example of how 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 add resources by using the DataWorks console.

3. Use SELECT TRANSFORM to call the resource.

```
Create   table   testdata ( c1   bigint , c2   bigint ); - Creates
  a   test   table .
insert   into   Table   testdata   values  ( 1 , 4 ),( 2 , 5 ),( 3
, 6 ); - Inserts   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 ;
```

The returned information is as follows:

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

Python scripts do not require MaxCompute to run in a Python framework, and they are not subject to any format requirements.

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 );
```

Call Java scripts

Calling a Java script is similar to calling a Python script. 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   RuntimeExc  eption (" 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. Use SELECT TRANSFORM to call the resource.

```
Create   table   testdata ( c1   bigint , c2   bigint ); -  Creates
  a   test   table .
insert   into   Table   testdata   values  ( 1 , 4 ),( 2 , 5 ),( 3
, 6 ); -  Inserts   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 ;
```

The returned information is as follows:

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

You can run most Java utilities by using the preceding method.

Note:

Although user-defined table-valued function (UDTF) frameworks are provided for Java and Python, compiling code by using SELECT TRANSFORM is easier. 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, respectively.

Call scripts of other languages

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

An example of how to output column 2 by 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 ;}'"  FROM
testdata ;
```

Note:

Currently PHP and Ruby are not deployed in the MaxCompute cluster. Therefore, MaxCompute does not allow you to call PHP or Ruby scripts.

Call scripts in tandem

SELECT TRANSFORM allows you to call scripts in tandem. For example, you can use `distribute by` and `sort by` to preprocess 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 ;
```

You can use either the `map` or `reduce` keywords with 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 ;
```

SELECT TRANSFORM performance

The performance of SELECT TRANSFORM and UDTF varies depending on the specific scenario. In general, the performance of SELECT TRANSFORM is optimal when the data size is comparatively small, and the performance of UDTF is optimal when the data size is large.

SELECT TRANSFORM is easier to use, and therefore is more suitable for adhoc data analysis.

Benefits of UDTF

- In UDTF, the output and input must follow the specified data types, and therefore UDTF does not require data type conversion as is required by SELECT TRANSFORM .
- In UDTF, processes are not suspended if the operating system pipe is empty or fully occupied as is the case for SELECT TRANSFORM.
- In UDTF, constant parameters do not need to be transmitted, which is required by SELECT TRANSFORM.

Benefits of SELECT TRANSFORM

- SELECT TRANSFORM supports a child process and a parent process and therefore can take advantage of multiple cores in servers.

- SELECT TRANSFORM calls underlying systems to read and write the data to be transmitted, which allows it to have performance that is higher than that of Java.
- SELECT TRANSFORM supports tools such as AWK and can run native code. This offers SELECT TRANSFORM more advantages compared to Java.

4.10 Script Mode SQL

This topic describes Script Mode SQL and how to run this language.

> Note:
> The fees information detailed in the instructions section of Other operations for Script Mode SQL is provided as reference purposes only. The fees displayed on the billing console are the actual fees charged to your account. For more information, see View billing details.

What is Script Mode SQL

MaxCompute supports Script Mode SQL. In script mode type of SQL, statements are compiled as a whole according to the logic in an SQL script file. Then the script file is submitted to MaxCompute to generate one execution plan, so that these statements are scheduled in one queue and run all at once.

Script Mode SQL is used similarly to other common programming languages. This language can assist in compiling scripts more efficiently by eliminating the need to organize statements for these scripts.

Script Mode SQL supports the following tools:

- MaxCompute Studio: For more information, see What is Studio.
- MaxCompute command line interface (CLI): For more information, see Install and configure a client.

Syntax

```
-- set
 set   odps . sql . type . system . odps2 = true ;
[ set   odps . stage . reducer . num = xxx ;]
[...]
-- ddl
 create   table   table1   xxx ;
[ create   table   table2   xxx ;]
[...]
-- dml
@ var1  :=  SELECT  [ ALL  |  DISTINCT ]  select_exp  r ,  select_exp
 r , ...
         FROM   table3
```

```
        [ WHERE   where_cond  ition ];
@ var2  :=  SELECT  [ ALL  |  DISTINCT ]  select_exp  r ,  select_exp
 r , ...
         FROM   table4
        [ WHERE   where_cond  ition ];
@ var3  :=  SELECT  [ ALL  |  DISTINCT ]  var1 . select_exp  r ,  var2
 . select_exp  r , ...
         FROM  @ var1   join  @ var2   on  ...;
 INSERT   OVERWRITE | INTO   TABLE  [ PARTITION  ( partcol1 = val1 ,
 partcol2 = val2  ...)]
         SELECT  [ ALL  |  DISTINCT ]  select_exp  r ,  select_exp  r
 , ...
         FROM  @ var3 ;
[@ var4  :=  SELECT  [ ALL  |  DISTINCT ]  var1 . select_exp  r ,  var
 . select_exp  r , ...  FROM  @ var1
         UNION   ALL  |  UNION
         SELECT  [ ALL  |  DISTINCT ]  var1 . select_exp  r ,  var .
 select_exp  r , ...  FROM  @ var2 ;
   CREATE  [ EXTERNAL ]  TABLE  [ IF   NOT   EXISTS ]  table_name
         AS
         SELECT  [ ALL  |  DISTINCT ]  select_exp  r ,  select_exp  r
 , ...
         FROM   var4 ;]
[...]
```

- Script Mode SQL supports `SET` statements, data manipulation language (DML) statements, and data definition language (DDL) statements (excluding such statements as `DESC` and `SHOW` whose results are displayed on your screen).
- A complete script must start with `SET` statements, followed by DDL statements, and end with DML statements. One part may either be empty or contain several statements. Different types of statements cannot co-occur in one part.
- The at sign `@` indicates a variable.
- A script can contain up to one statement, such as a `SELECT` statement, whose result is displayed on your screen. If one script contains two or more such statements, errors are more likely to occur. Therefore, we recommend that you do not run such `SELECT` statements.
- A script can contain only one `CREATE TABLE AS` statement, and must end with this statement. We recommend that you separate the `CREATE TABLE AS` statement from `INSERT` statements.
- If a statement fails to run, all the other statements in the same script also fail.
- A job is generated to process data only after all the input data is prepared.
- If a table is written and then read, the following error occurs:

```
 insert   overwrite   table   src2   select  *  from   src   where
 key  >  0 ;
@ a  :=  select  *  from   src2 ;
```

```
select * from @ a ;
```

To avoid this error, modify your SQL script as follows:

```
@ a := select * from src where key > 0 ;
  insert overwrite table src2 select * from @ a ;
  select * from @ a ;
```

Example

```
create table if not exists dest ( key string , value
bigint ) partition d by ( d string );
create table if not exists dest2 ( key string , value
bigint ) partition d by ( d string );
@ a := select * from src where value > 0 ;
@ b := select * from src2 where key is not null ;
@ c := select * from src3 where value is not null ;
@ d := select a . key , b . value from @ a left outer
join @ b on a . key = b . key and b . value > 0 ;
@ e := select a . key , c . value from @ a inner join @ c
 on a . key = c . key ;
@ f := select * from @ d union select * from @ e union
select * from @ a ;
insert overwrite table dest partition ( d =' 20171111 ')
select * from @ f ;
@ g := select e . key , c . value from @ e join @ c on e
. key = c . key ;
insert overwrite table dest2 partition ( d =' 20171111 ')
SELECT * from @ g ;
```

Scenarios

We recommend that you use Script Mode SQL in the two following scenarios:

- You require multiple layers of query clauses to be nested into one statement, or require a complicated script to be split into multiple simpler statements.
- You require the input data obtained from multiple sources at long intervals to be combined into a script. However, the input data cannot be combined by using table variables alone.

Run Script Mode SQL by using MaxCompute Studio

Before running Script Mode SQL, you must first install MaxCompute Studio, add your project link, and create a MaxCompute SQL script file. For more information, see Install IntelliJ IDEA, Project space connection management, and Create MaxCompute Script module.

After submitting your script, you can view the corresponding plan for running the script in a directed acyclic graph (DAG). This is the case even though the script contains multiple statements.

Run Script Mode SQL by using MaxCompute Console (odpscmd)

For the following examples, we recommend that you use MaxCompute CLI (odpscmd) v0.27.0 or a later version, which can be downloaded from Directory Listing For odpscmd. After installing the odpscmd tool, you can use the `-s` parameter to submit your script.

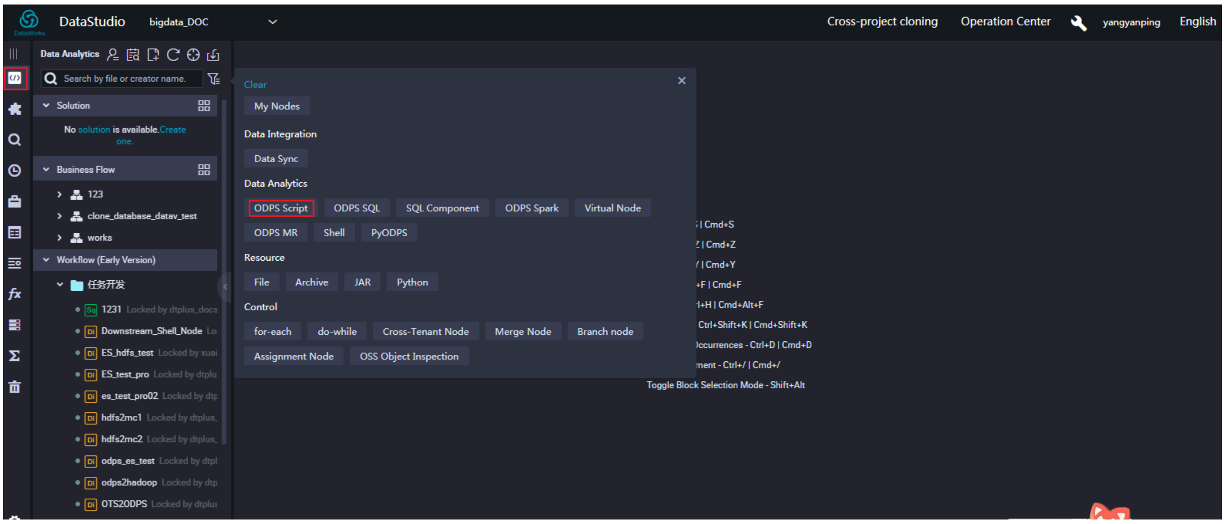
To edit the *myscript.sql* source code file in script mode, run the following command:

```
odpscmd -s myscript.mxql;
```

Note:
`-s` is a parameter similar to `-f` and `-e` rather than a command in the odpscmd tool. The odpscmd tool does not support Script Mode SQL or table variables.

Run Script Mode SQL by using DataWorks

You can create a node that runs in script mode, as shown in the following figure.



On this node, you can compile your script in script mode and then click Run on the toolbar to submit your script to MaxCompute. You can visit the URL of Logview in the command output to obtain the script execution plan and result.

4.11 Common table expression (CTE)

MaxCompute supports CTEs in standard SQL to improve the readability and execution efficiency of SQL statements.

Syntax structure of CTE.

```
WITH
     cte_name   AS

        cte_query

   [, cte_name2   AS

     cte_query2

   ,……]
```

- `cte_name` refers to the CTE name, which must be unique in current WITH clause. The cte_name identifier in any position of the query indicates the CTE.
- `cte_query` is a SELECT statement, whose result set is used to populate the CTE.

Example:

```
INSERT   OVERWRITE   TABLE   srcp   PARTITION  ( p =' abc ')
SELECT  *  FROM  (
    SELECT   a . key ,  b . value
    FROM  (
        SELECT  *  FROM   src   WHERE   key   IS   NOT   NULL  )  a
    JOIN  (
        SELECT  *  FROM   src2   WHERE   value  >  0  )  b
    ON   a . key  =  b . key
)  c
UNION   ALL
SELECT  *  FROM  (
    SELECT   a . key ,  b . value
    FROM  (
        SELECT  *  FROM   src   WHERE   key   IS   NOT   NULL  )  a
    LEFT   OUTER   JOIN  (
        SELECT  *  FROM   src3   WHERE   value  >  0  )  b
    ON   a . key  =  b . key   AND   b . key   IS   NOT   NULL
) d ;
```

A JOIN clause is written on both sides of UNION at the top layer, and same queries are formed on the left table of JOIN. You must repeat this code if writing subqueries.

The preceding statement can be rewritten as follows using the CTE:

```
with
  a   as  ( select  *  from   src   where   key   is   not   null ),
  b   as  ( select  *  from   src2   where   value > 0 ),
  c   as  ( select  *  from   src3   where   value > 0 ),
  d   as  ( select   a . key , b . value   from   a   join   b   on
a . key = b . key  ),
```

```
  e   as  ( select   a . key , c . value   from   a   left   outer
join   c   on   a . key = c . key   and   c . key   is   not   null
)
insert   overwrite   table   srcp   partition  ( p =' abc ')
select  *  from   d   union   all   select  *  from   e ;
```

After rewriting, the subquery corresponding to "a" only need to be rewritten once, and then can be reused subsequently. The WITH clause in the CTE specifies multiple subqueries that can be repeatedly used like variables in the entire statement. Besides being reused, subqueries do not have to be repeatedly nested.

4.12 Explain

The Explain operation of MaxCompute SQL helps to display the description of the final execution plan structure corresponding to a DML statement. The execution plan is the program used at the final stage to run SQL semantics.

Function definition.

```
EXPLAIN  < DML   query >;
```

The execution result of ‘explain’ includes the following:

- The dependency structure of all the tasks corresponding to this DML statement.
- All task dependency structures in a task.
- All operator dependency structures in a task.

For examples.

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

The output result of Explain consists of the following parts:

- The dependency between jobs: `job0   is   root   job` , As the query requires one job (job0), only one row of information is required.
- The dependency between tasks:

  ```
  In   Job   job0 :
  root   Tasks :  M1_Stg1 ,  M2_Stg1
  ```

```
J3_1_2_Stg 1 depends on : M1_Stg1 , M2_Stg1
```

Job0 contains three tasks, among which M1_Stg1 and M2_Stg1 are run first, followed by J3_1_2_Stg1.

The naming rules of tasks are as follows:

- MaxCompute contains four types of tasks: MapTask, ReduceTask, JoinTask, and LocalWork.
- The first letter of a task name represents the current task type. For example, M2Stg1 is a MapTask.
- The number following the first letter represents the current task ID, which must be unique in all tasks corresponding to the current query.
- The numbers separated by underscores (_) represent the direct dependencies of the current task. For example, J3_1_2_Stg1 indicates that the current task (whose ID is 3) depends on two tasks whose IDs are 1 and 2.

· The third part is the operator structure in the task. The operator string describes the execution semantics of a task:

```
In Task M1_Stg1 :
  Data source : yudi_2 . src # Data source describes the
  input content of the current task
  TS : alias : a # TableScanO perator
      RS : order : + # ReduceSink Operator
          keys :
               a . value
          values :
               a . key
          partitions :
               a . value
In Task J3_1_2_Stg 1 :
  JOIN : a INNER JOIN b # JoinOperat or
      SEL : Abs ( UDFToDoubl e ( a . _col0 )), b . _col5 #
SelectOper ator
          FS : output : None # FileSinkOp erator
In Task M2_Stg1 :
  Data source : yudi_2 . src1
  TS : alias : b
      RS : order : +
          keys :
               b . value
          values :
               b . value
          partitions :
```

```
                b . value
```

- Description of operators:
  - `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 to be passed to the next operator are displayed in the Explain results, separated by commas (,).
    - If column references are to be passed, `<alias>.<column_name>` is displayed
    - If expression results are to be transmitted, they are displayed as functions, for example, `func1(arg1_1, arg1_2, func2(arg2_1, arg2_2))`.
    - If constants are to be passed, the values are directly displayed.
  - `FilterOperator`: Describes the logic of WHERE statement blocks in a QUERY statement. A WHERE condition expression is displayed in the Explain results, with the display rules similar to those of SelectOperator.
  - `JoinOperator`: Describes the logic of JOIN statement blocks in a QUERY statement. Both the tables to be joined and the JOIN method are displayed in the Explain results.
  - `GroupByOperator`: Describes the logic of aggregate operations. This structure is displayed if an aggregate function is used in a QUERY statement. The aggregate function content is displayed in the Explain results.
  - `ReduceSinkOperator`: Describes the logic of data distribution operations between tasks. If the result of the current task is to be passed to another task, ReduceSinkOperator must be used at the end of the current task to perform the data distribution operation. The sorting method of output

results, distributed keys, values, and columns used to calculate the hash value are displayed in the Explain results.

- `FileSinkOperator`: Describes the storage operation of final data. If Insert statement blocks exist in the QUERY statement, the target table name is displayed in the Explain results.
- `LimitOperator`: Describes the logic of Limit statement blocks in a QUERY statement. The number of LIMIT is displayed in the Explain results.
- `MapjoinOperator`: Similar to JoinOperator, it describes JOIN operations in large tables.

Note:

If a QUERY statement is so complicated that Explain has too many results, API restrictions are triggered, which leads to incomplete display of Explain results. In this case, you can split the QUERY and perform the Explain operation on each part to understand the job structure.

4.13 VALUES

This topic describes the `INSERT … VALUES` command operation.

In the test phase, you need to prepare some data for simple testing:

- If you want to create a few data records (such as 10 or fewer records), you can use the `INSERT … VALUES` statement to quickly write the data.
- If you want to create a large number of data records (such as more than 10 records), you can incorporate the data records into a .txt or .csv file and then upload the file by using Tunnel. For more information about this method, see Import data. Alternatively, you can incorporate the data records into a file and then import the file by using DataWorks. For more information about this method, see Introduction to console.

Note:

Currently, the `INSERT OVERWRITE` statement cannot insert columns, therefore we recommend that you use the `INSERT INTO` statement instead.

Statement format:

```
INSERT INTO TABLE tablename
```

```
[ PARTITION  ( partcol1 = val1 ,  partcol2 = val2  ...)][ co1name1 ,
 colname2 ...]
[ VALUES  ( col1_value , col2_value ,...),( col1_value , col2_value
 ,...),...]
```

Example 1::

```
drop  table  if  exists  srcp ;
create  table  if  not  exists  srcp  ( key  string  , value
bigint )  partitione  d  by  ( p  string );
insert  into  table  srcp  partition  ( p =' abc ')  values  (' a
', 1 ),(' b ', 2 ),(' c ', 3 );
```

After the preceding statements are complete, the result of Partition `abc` is as follows:

```
|  key  |  value  |  p  |

|  a  |  1  |  abc  |
|  b  |  2  |  abc  |
|  c  |  3  |  abc  |
```

If you want to run the `INSERT` statement to write data into only some columns of a table, use the `insert  list` function as follows.

Example 2:

```
drop  table  if  exists  srcp ;
create  table  if  not  exists  srcp  ( key  string  , value
bigint )  partitione  d  by  ( p  string );
insert  into  table  srcp  partition  ( p )( key , p )  values
(' d ',' 20170101 '),(' e ',' 20170101 '),(' f ',' 20170101 ');
```

After the preceding statements are complete, the result of Partition `20170101` is as follows:

```
|  key  |  value  |  p  |

|  d  |  NULL  |  20170101  |
|  e  |  NULL  |  20170101  |
|  f  |  NULL  |  20170101  |
```

For columns not specified in values, the default value is `NULL`. The `insert list` function is not necessarily used with values, and can also be used with the `insert into … select …` function.

In fact, the values is not only used in the `INSERT` statement, any DML statement can also be used.

The `INSERT … VALUES` method has a limitation: values must be constants. You can use the values table function of MaxCompute to perform some simple operations on the inserted data. For more information, see Example 3.

Example 3:

```
drop table if exists srcp ;
create table if not exists srcp ( key string , value
bigint ) partitione d by ( p string );
insert into table srcp partition ( p ) select concat ( a
, b ), length ( a )+ length ( b ),' 20170102 ' from values (' d
', 4 ),(' e ', 5 ),(' f ', 6 ) t ( a , b );
```

The `values (…), (…) t ( a , b )` is used to define a table named `t` whose columns are `a` and `b` and data types are STRING for column `a` and BIGINT for column `b`. The data types are derived from the values list. In this way, with no physical table prepared, it is possible to simulate a multi-row table with arbitrary data and perform arbitrary calculations.

After the preceding statements are complete, the result of Partition `20170102` is as follows:

```
| key | value | p |

| d4 | 2 | 20170102 |
| e5 | 2 | 20170102 |
| f6 | 2 | 20170102 |
```

The use of `VALUES TABLE` can also replace the combination of `select * from dual` and to spell out the constants as follows:

```
select 1 c from dual
union all
select 2 c from dual ;
```

```
-- The  same  as :
 select  *  from  values  ( 1 ), ( 2 )  as  t  ( c );
```

A special usage of values is as follows.

```
 select  abs (- 1 ),  length (' abc '),  getdate ();
```

As the preceding statement shows, the `SELECT` statement can be run without the `FROM` statement, if the expression list of the `SELECT` statement does not use any upstream table data. The underlying implementation is selecting from an anonymous values table in one row and zero columns. In this way, to test some functions, such as your UD, you do not need to manually create DUAL tables.

Note:

- Values only support constants and do not support functions including ARRAY complex types. Currently, MaxCompute cannot construct corresponding constants. Therefore, we recommend that you modify the statement as follows:

  ```
  insert  into  table  srcp  ( p  =' abc ')  select  ' a ', array
  (' 1 ', ' 2 ', ' 3 ');.
  ```

  which can provide the same effect.
- To write the DATETIME and TIMESTAMP data types through values, specify the type names in the `VALUES` statement, for example:

  ```
  insert  into  table  srcp  ( p  =' abc ')  values  ( datetime '
  2017 - 11 - 11
              00 : 00 : 00 ', timestamp ' 2017 - 11 - 11  00 : 00 :
  00 . 123456789 ');
  ```

4.14 Builtin functions

4.14.1 Compare built-in functions of MaxCompute with MySQL and Oracle

The following table compares the built-in functions used in MaxCompute with those of MySQL and Oracle.

Function type	MaxCompute	MySQL	Oracle
Date functions	DATEDIFF	DATEDIFF	MONTHS_BETWEEN
	DATEADD	DATE_ADD	N/A

	DATEPART	DATE_FORMAT	EXTRACT (datetime)
	DATETRUNC	DATE_FORMAT	EXTRACT (datetime)
	FROM_UNIXTIME	FROM_UNIXTIME	N/A
	GETDATE	NOW	CURRENT_DATE
	ISDATE	STR_TO_DATE (If 'false' is returned, the string cannot be converted to date.)	N/A
	LASTDAY	LAST_DAY	LAST_DAY
	TO_DATE	STR_TO_DATE()	DATE
	TO_CHAR	DATE_FORMAT	TO_CHAR (datetime)
	UNIX_TIMESTAMP	UNIX_TIMESTAMP	N/A
	WEEKDAY	WEEKDAY	N/A
	#unique_6/unique_6_Connect_42_section_rjv_hgm_vdb	WEEKOFYEAR	N/A
	#unique_6/unique_6_Connect_42_section_gb4_g3m_vdb	YEAR	YEAR
	QUARTER	QUARTER	QUARTER
	MONTH	MONTH	MONTH
	#unique_6/unique_6_Connect_42_section_lt5_w3m_vdb	DAY	DAY
	#unique_6/unique_6_Connect_42_section_k4p_fjm_vdb	DAYOFMONTH	N/A
	HOUR	HOUR	HOUR
	MINUTE	MINUTE	MINUTE
	CURRENT_TIMESTAMP	CURRENT_TIMESTAMP	CURRENT_TIMESTAMP
	ADD_MONTHS	ADDDATE	ADD_MONTHS
	LAST_DAY	LAST_DAY	N/A
	NEXT_DAY	N/	NEXT_DAY
	MONTHS_BETWEEN	timestampdiff	MONTHS_BETWEEN

Mathematical functions	ABS	ABS	ABS
	ACOS	ACOS	ACOS
	ASIN	ASIN	ASIN
	#unique_137/unique_137_Connect_42_section_odw_jnm_vdb	ATAN	ATAN
	#unique_137/unique_137_Connect_42_section_ugm_k4m_vdb	CEIL	CEIL
	CONV	CONV	N/A
	COS	COS	COS
	COSH	N/A	COSH
	COT	COT	COT
	EXP	EXP	EXP
	FLOOR	FLOOR	FLOOR
	LN	LN	LN
	LOG	LOG	LOG
	POW	POW	POWER
	RAND	RAND	N/A
	ROUND	ROUND	ROUND
	SIN	SIN	SIN
	SINH	N/A	SINH
	SQRT	SQRT	SQRT
	TAN	TAN	TAN
	#unique_137/unique_137_Connect_42_section_pfh_wym_vdb	N/A	TANH
	TRUNC	TRUNCATE	TRUNC
	LOG2	LOG2	LOG
	LOG10	LOG10	LOG
	BIN	BIN	BITAND
	HEX	HEX	RAWTOHEX
	UNHEX	UNHEX	HEXTORAW
	RADIANS	RADIANS	RADIANS
	DEGREES	DEGREES	DEGREES

	SIGN	SIGN	SIGN
	E	N/A	EXP
	PI	PI	PI
	FACTORIAL	N/A	N/A
	CBRT	N/A	N/A
	SHIFTLEFT	<<	N/A
	SHIFTRIGHT	>>	N/A
	SHIFTRIGHTUNSIGNED	>>>	N/A
Window functions	DENSE_RANK	DENSE_RANK	DENSE_RANK
	RANK	RANK	RANK
	LAG	LAG	LAG
	LEAD	LEAD	LEAD
	PERCENT_RANK	PERCENT_RANK	PERCENT_RANK
	ROW_NUMBER	ROW_NUMBER	ROW_NUMBER
	CLUSTER_SAMPLE	N/A	N/A
	NTILE	NTILE	NTILE
Aggregate functions	COUNT	COUNT	COUNT
	AVG	AVG	AVG
	MAX	MAX	MAX
	MIN	MIN	MIN
	MEDIAN	N/A	MEDIAN
	STDDEV	STDDEV	STDDEV
	STDDEV_SAMP	STDDEV_SAMP	STDDEV_SAMP
	SUM	SUM	SUM
	WM_CONCAT	GROUP_CONCAT	WM_CONCAT
	COLLECT_LIST	N/A	COLLECT
	COLLECT_SET	N/A	COLLECT
	VARIANCE/VAR_POP	VAR_POP	VARIANCE/ VAR_POP
	VAR_SAMP	VAR_SAMP	VAR_SAMP
	COVAR_POP	N/A	COVAR_POP

	COVAR_SAMP	N/A	COVAR_SAMP
	PERCENTILE	N/A	N/A
String functions	CHAR_MATCHCOUNT	N/A	N/A
	CHR	CHAR	CHR
	CONCAT	CONCAT	CONCAT
	GET_JSON_OBJECT	JSON_EXTRACT()	N/A
	INSTR	INSTR	INSTR
	IS_ENCODING	N/A	N/A
	KEYVALUE	N/A	N/A
	LENGTH	LENGTH	LENGTH
	LENGTHB	LENGTHB	LENGTHB
	MD5	MD5	N/A
	REGEXP_EXTRACT	N/A	N/A
	REGEXP_INSTR	REGEXP_INSTR	REGEXP_INSTR
	REGEXP_REPLACE	REGEXP_REPLACE	REGEXP_REPLACE
	REGEXP_SUBSTR	REGEXP_SUBSTR	REGEXP_SUBSTR
	REGEXP_COUNT	N/A	REGEXP_COUNT
	SPLIT_PART	N/A	N/A
	SUBSTR	SUBSTR	SUBSTR
	SUBSTRING	SUBSTRING	SUBSTR
	TOLOWER	LOWER	LOWER
	TOUPPER	UPPER	UPPER
	TO_CHAR	DATE_FORMAT	TO_CHAR
	TRIM	TRIM	TRIM
	LTRIM	LTRIM	LTRIM
	RTRIM	RTRIM	LTRIM
	REVERSE	REVERSE	REVERSE
	SPACE	SPACE	SPACE
	REPEAT	REPEAT	REPEAT
	ASCII	ASCII	ASCII
	CONCAT_WS	CONCAT_WS	N/A

	LPAD	LPAD	LPAD
	RPAD	RPAD	RPAD
	REPLACE	REPLACE	REPLACE
	SOUNDEX	SOUNDEX	SOUNDEX
	SUBSTRING_INDEX	SUBSTRING_INDEX	N/A
	TRANSLATE	N/A	TRANSLATE
	URL_DECODE	N/A	N/A
	URL_ENCODE	N/A	PERCENTILE_CONT
	CRC32	CRC32	N/A
Other functions	CAST	CAST	CAST
	COALESCE	COALESCE	COALESCE
	DECODE	N/A	DECODE
	GET_IDCARD_AGE	N/A	N/A
	GET_IDCARD_BIRTHDAY	N/A	N/A
	GET_IDCARD_SEX	N/A	N/A
	GREATEST	GREATEST	N/A
	ORDINAL	N/A	GREATEST
	LEAST	LEAST	N/A
	MAX_PT	N/A	LEAST
	UUID	UUID	N/A
	SAMPLE	N/A	UID
	IF	IF	IF
	CASE WHEN	CASE WHEN	CASE WHEN
	SPLIT	SPLIT	N/A
	STR_TO_MAP	N/A	N/A
	EXPLODE	N/A	N/A
	MAP	N/A	N/A
	MAP_KEYS	N/A	N/A
	MAP_VALUES	N/A	N/A
	NVL	IFNULL	N/A
	ARRAY	N/A	N/A

	SIZE	N/A	N/A
	ARRAY_CONTAINS	N/A	N/A
	POSEXPLODE	N/A	N/A
	TRANS_ARRAY	N/A	N/A
	INLINE	N/A	N/A
	NAMED_STRUCT	N/A	N/A

4.14.2 Date functions

This article explains various functions that MaxCompute SQL offers to operate datetime types.

DATEADD

Command format:

```
datetime   dateadd ( datetime   date ,  bigint   delta ,  string
datepart )
```

Command description:

Modify the value of date according to a specified unit ‘datepart’ and specified scope ‘delta’.

Parameter description:

- `date` : Datetime type, value of date. If the input is string type, it is converted to ‘datetime’ type by implicit conversion. If it is another type, an exception is indicated.
- `delta` : Bigint type, date scope to be modified. If the input is ‘string’ type or ‘double’ type, it is converted to ‘bigint’ type by implicit conversion. If it is another data type, exception occurs. If ‘delta’ is greater than zero, do ‘add’ operation, otherwise do ‘minus’ operation.
- `datepart` : a String type constant. This field value follows ‘string’ and ‘datetime’ type conversion agreement, where, ‘yyyy’ indicates year; ‘mm’ indicates month.

  See Conversion between String type and Datetime type. In addition, the extensional date format is also supported: year- ‘year’; month- ‘month’ or ‘mon’; day- ‘day’; hour- ‘hour. If it is not a constant or unsupported format or other data type, an exception is indicated.

Return value:Datetime type. If any input is NULL, return NULL.

Note:

- While increasing or decreasing ‘delta’ according to specified unit, it causes the carry or back space for higher unit. Day, month, hour, minute, second are calculated by 10 hexadecimal, 12 hexadecimal, 24 hexadecimal, 60 hexadecimal, 60 hexadecimal respectively.
- If the unit of ‘delta’ is month, the calculation rule is shown as follows:

  If the month part of ‘datetime’ does not cause the spillover of day after adding ‘delta’, then do not change the day, else the day value is set to the last day of the result month.
- The value of ‘datepart’ follows ‘string’ and ‘datetime’ type conversion agreement, that is, ‘yyyy’ indicates year; ‘mm’ indicates month and so on . If no special description exists, related datetime built-in functions follow this agreement. Moreover, if no special instructions, the part of all datetime built-in functions supports extended date format: year- ‘year’; month- ‘month’ or ‘mon’; day- ‘day’; hour- ‘hour.

For example:

```
 if   trans_date  =  2005 - 02 - 28   00 : 00 : 00
dateadd ( trans_date ,  1 , ' dd ') =  2005 - 03 - 01   00 : 00 : 00
-- Add   one   day . The   result   is   beyond   the   last   day
in   February . The   actual   value   is   the   first   day   of
next   month .
dateadd ( trans_date , - 1 , ' dd ') =  2005 - 02 - 27   00 : 00 :
00
-- Minus   one   day .
dateadd ( trans_date ,  20 , ' mm ') =  2006 - 10 - 28   00 : 00 :
00
-- Add   20   months . The   month   spillover   is   caused   and
the   year   is   added  ‘ 1 ’.
If   trans_date  =  2005 - 02 - 28   00 : 00 : 00 ,  dateadd (
transdate ,  1 , ' mm ') =  2005 - 03 - 28   00 : 00 : 00
If   trans_date  =  2005 - 01 - 29   00 : 00 : 00 ,  dateadd (
transdate ,  1 , ' mm ') =  2005 - 02 - 28   00 : 00 : 00
-- No   29th   is   in   Feb . of   2005 . The   date   is
intercepte  d   to   the   last   day   of   current   month .
 If   trans_date  =  2005 - 03 - 30   00 : 00 : 00 ,  dateadd (
transdate , - 1 , ' mm ') =  2005 - 02 - 28   00 : 00 : 00
```

Note:

Here the value of trans_date used only as an example. This simple expression is often used to present the datetime in this file.

In MaxCompute SQL, the datetime type has no direct constant representation, the following usage is wrong:

```
select  dateadd ( 2005 - 03 - 30   00 : 00 : 00 , - 1 , ' mm ')
from  tbl1 ;
```

If you must describe the datetime type constant, try the following methods:

```
select  dateadd ( cast (" 2005 - 03 - 30   00 : 00 : 00 "  as
datetime ), - 1 , ' mm ')  from  tbl1 ;
-- The  String  type  constant  is  converted  to  datatime
type  by  explicit  conversion .
```

DATEDIFF

Command format:

```
bigint  datediff ( datetime  date1 ,  datetime  date2 ,  string
datepart )
```

Command description:

Calculate the difference between two datetime date1 and date2 in specified time unit 'datepart' .

Parameter description:

- `datet1 , date2` : Datetime type, minuend, meiosis. If the input is 'string' , it is converted to 'datetime' by implicit conversion. If it is another data type, an exception indicated.
- `datepart` : a String type constant. The extensional date format is supported. If 'datepart' does not meet the specified format or is other data type, an exception is indicated.

Return value:

Returns the Bigint type. Any input parameter is NULL, return NULL. If date1 is less than date2, then the returned value may be negative.

> Note:
> The lower unit part is cut off according to 'datepart' in the calculation process and then calculate the result.

For example:

```
If  start  =  2005 - 12 - 31   23 : 59 : 59 ,  end  =  2006 - 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 (' 2013 - 05 - 31   13 : 00 : 00 ', ' 2013 - 05 - 31
12 : 30 : 00 ', ' ss ') =  1800
    datediff (' 2013 - 05 - 31   13 : 00 : 00 ', ' 2013 - 05 - 31
12 : 30 : 00 ', ' mi ') =  30
If   start  =  19 : 33 : 23 .  234 ,  end  =  19 : 33 : 23 .  250
 . Dates   with   millisecon ds   do   not   belong   to   the
  standard   datetime   style ,  and   cannot   be   converted
implicitly   directly . Explicit   conversion   is   required   here
:

datediff ( to_date (' 2018 - 06 - 04   19 : 33 : 23 . 250 ', ' yyyy -
MM - dd   hh : mi : ss . ff3 '), to_date (' 2018 - 06 - 04   19 : 33
: 23 . 234 ', ' yyyy - MM - dd   hh : mi : ss . ff3 ') , ' ff3 ') =
16
```

DATEPART

Command format:

```
bigint   datepart ( datetime   date ,  string   datepart )
```

Command format:

Extracts the value of the specified time unit ' datepart' in 'date'.

Parameter description:

Return value:

- `date` **: Datetime type. If the input is 'string' type, it is converted to 'datetime' type. If it is another data type, an exception is indicated.**
- `datepart` **: String type constant. The extensional date format is supported. If 'datepart' does not meet the specified format or is other data type, an exception is indicated.**

Returns the Bigint type. If any input is NULL, return NULL.

For example:

```
datepart (' 2013 - 06 - 08   01 : 10 : 00 ', ' yyyy ') =  2013
```

```
datepart (' 2013 - 06 - 08   01 : 10 : 00 ', ' mm ') =  6
```

DATETRUNC

Command format:

```
datetime   datetrunc  ( datetime   date , string   datepart )
```

Usage::

Return the remained date value after the specified time unit 'datepart' has been intercepted.

Parameter description::

- `date` : Datetime type. If the input is 'string' type, it is converted to 'datetime' type. If it is another data type, an exception indicated.
- `datepart` : String type constant. The extensional date format is supported. If 'datepart' does not meet the specified format or is other data type, an exception is indicated.

Return value:

Datetime type. If any input is NULL, return NULL.

For example:

```
datetrunc (' 2011 - 12 - 07   16 : 28 : 46 ', ' yyyy ') =  2011 - 01
- 01   00 : 00 : 00
datetrunc (' 2011 - 12 - 07   16 : 28 : 46 ', ' month ') =  2011 - 12
- 01   00 : 00 : 00
datetrunc (' 2011 - 12 - 07   16 : 28 : 46 ', ' DD ') =  2011 - 12 -
07   00 : 00 : 00
```

GETDATE

Command format:

```
datetime   getdate ()
```

Command description:

Get present system time. Use UTC+8 as MaxCompute standard time.

Return value:

Datetime type, return present date and time.

Note:

In a MaxCompute SQL task (executed in a distributed manner), 'getdate' always returns a fixed value. The return result is any time in MaxCompute SQL execution period and the precision of time is accurate to seconds.

ISDATE

Command format:

```
boolean isdate ( string date , string format )
```

Command description:

Determines whether a date string can be converted to a datetime value according to corresponding format string. If the conversion is successful, return TRUE, otherwise return FALSE.

Parameter description:

- `date` : date value of String format. If the input is 'bigint', or 'double' or 'datetime', it is be converted to 'string' type. If it is another data type, an exception is indicated.
- `format` : a String type constant. The extensional date format is not supported. If redundant format strings appear in 'format', then get the datatime value corresponding to the first format string, other strings are taken as separators. For example, isdate ('1234-yyyy', 'yyyy-yyyy') returns 'TRUE'.

Return value:

Boolean type. If any parameter is NULL, return NULL.

LASTDAY

Command format:

```
datetime lastday ( datetime date )
```

Command format:

Get the last day in the same month of the date, intercepted to day and the 'hh:mm:ss' part is '00:00:00'.

Parameter description:

`date` : Datetime type. If the input is 'string' type, it is converted to 'datetime' type. If it is another data type, an exception is reported.

Return value:

Datetime type. If the input is NULL, return NULL.

TO_DATE

Command format:

```
datetime  to_date ( string  date ,  string  format )
```

Command description:

Convert a string ‘date’ to the datetime value according to a specified format.

Parameter description:

- `date` : String type, date value to be converted. If the input is ‘bigint’, or ‘double’ or ‘datetime’, it is converted to ‘string’ type by implicit conversion. If it is another data type or null, an exception is indicated.
- `format` : String type constant, date format. If it is not a constant or is other data type, the exception is caused. The field ‘format’ does not support extensional format and other characters are ignored as invalid characters in analysis process.

  The parameter `format` contains ‘yyyy’ at least; otherwise the expecion is indicated. If redundant format strings appear in `format` , then get the datatime value corresponding to the first format string, other strings are taken as separators. For example, `to_date (‘ 1234 - 2234 ’, ‘ yyyy - yyyy ’)` returns ‘1234-01-01 00:00:00’.

  Format format: yyyy is a four-digit year, mm is a two-digit month, DD is a two-digit day, HH is a 24-hour system, MI is a two-digit minute, SS is a two-digit second, FF3 is a three-digit precision millisecond.

Return value:

Datetime type, the format is yyyy-mm-dd hh: mi: ss. If any input is NULL, return NULL.

For example:

```
to_date (' Alibaba201  0 - 12 * 03 ', ' Alibabayyy  y - mm * dd ') =
2010 - 12 - 03   00 : 00 : 00
to_date (' 20080718 ', ' yyyymmdd ') =  2008 - 07 - 18   00 : 00 :
00
to_date (' 2008071820  30 ',' yyyymmddhh  mi ')= 2008 - 07 - 18   20
: 30 : 00
to_date (' 2008718 ', ' yyyymmdd ') =  null
```

```
-- The format does not meet the requiremen ts . An
 exception is thrown .
 to_date (' Alibaba201 0 - 12 * 3 ', ' Alibabayyy y - mm * dd ') =
 null
-- Format is not compatible and exception is thrown .
 to_date (' 2010 - 24 - 01 ', ' yyyy ') = null
-- Format is not compatible and exception is thrown .
 to_date (' 20181030 15 - 13 - 12 . 345 ',' yyyymmdd hh - mi - ss
 . ff3 ')= 2018 - 10 - 30 15 : 13 : 12
```

TO_CHAR

Command format:

```
string to_char ( datetime date , string format )
```

Command description:

Convert the ‘date’ of datetime type to a string according to a specified format.

Parameter description:

- `date` : Datetime type, the date value to be converted. If the input is ‘string’ type, it is converted to ‘datetime’ type by implicit conversion. If it is another data type, an exception indicated.
- `format` : String type constant. If it is not a constant or is other data type, the exception is indicated. In ‘format’, the date format part is replaced with the corresponding data and other characters are output directly.

Return value:

Returns the String type. Any input parameter is NULL, return NULL.

For example:

```
to_char (' 2010 - 12 - 03 00 : 00 : 00 ', ' Alibabayyy y - mm * dd
') = ' Alibaba201 0 - 12 * 03 '
to_char (' 2008 - 07 - 18 00 : 00 : 00 ', ' yyyymmdd ') = '
20080718 '
to_char (' Alibaba201 0 - 12 * 3 ', ' Alibabayyy y - mm * dd ') --
Format is not compatible and exception is thrown .
to_char (' 2010 - 24 - 01 ', ' yyyy ') -- Format is not
compatible and exception is thrown .
to_char (' 2008718 ', ' yyyymmdd ') -- Format is not
compatible and exception is thrown .
```

See TO_CHAR for conversion from other types to string type.

UNIX_TIMESTAMP

Command format:

```
bigint   unix_times  tamp ( datetime   date )
```

Command description:

Convert the date of Datetime type to UNIX format date of Bigint type.

Parameter description:

`date` : Datetime type date value. If the input is ‘string’ type, it is converted to ‘datetime’ type and involved in calculation. If it is another type, an exception indicated.

Return value:

Bigint type, it indicates UNIX format date value. If ‘date’ is NULL, return NULL.

FROM_UNIXTIME

Command format:

```
datetime   from_unixt  ime ( bigint   unixtime )
```

Command description:

Convert the numeric UNIX time value ‘unixtime’ to datetime value.

Parameter description:

`unixtime` : Bigint type, number of seconds, UNIX format date time value. If the input is ‘string’ , ‘double’ , it is converted to ‘bigint’ type by implicit conversion.

Return value:

Datetime type date value. If ‘unixtime’ is NULL, return NULL.

> **Note:**
> If you have `set   odps . sql . hive . compatible = true ;` , and the input type is string, the reture type will be string too.

For example:

```
from_unixt ime ( 123456789 ) = 1973 - 11 - 30 05 : 33 : 09
```

WEEKDAY

Command format:

```
bigint weekday ( datetime date )
```

Command description:

Return the nth day of present week corresponding to the date.

Parameter description:

`date` : Datetime type. If the input is 'string' type, it is converted to 'datetime' type and then involved in operation. If it is another date type, an exception indicated.

Return value:

Bigint type. If the input parameter is NULL, return NULL. Monday is the first day of a week and the return value is 0. Days are in ascending order starting from 0. If the day is Sunday, then return is 6.

WEEKOFYEAR

Command format:

```
bigint weekofyear ( datetime date )
```

Command description:

Return the nth week of a year which the date is included in. Monday is taken as the first day of a week.

Note:
Whether this week belongs to this year, or the next year, it depends on which year (4 days or more) most of the time of this week belongs to.

Parameter description:

`date` : Datetime type. If the input is 'string' type, it is converted to 'datetime' type and then involved in operation. If it is another date type, an exception is indicated.

Return value:

Bigint type. If the input is NULL, return NULL.

For example:

```
select   weekofyear ( to_date (" 20141229 ", " yyyymmdd "))  from
dual ;
Result :
+------------+
|  _c0  |
+------------+
|  1  |
+------------+
- Although   20141229   belongs   to   2014 ,  most   of   the
dates   of   the   week   are   in   2015 ,  therefore ,  the
return   result   is   1 ,  indicating   that   it   is   the   first
  week   of   2015 .
 select   weekofyear ( to_date (" 20141231 ", " yyyymmdd "))  from
dual ;
--  Return   1 .
 select   weekofyear ( to_date (" 20141229 ", " yyyymmdd "))  from
dual ;
--  Return   53 .
```

Maxcomputerte2.0 New Extended Mathematical Functions

With the upgraded version of MaxCompute 2.0, some new date functions are added to the product. If the functions are used to design a new data type compatible with the Hive mode, you must add the following two set statements before the SQL statement of the new functions:

```
set   odps . sql . type . system . odps2 = true ;-- Enable   the
new   type .
```

If you want to submit both at the same time, run the following statements:

```
set   odps . sql . type . system . odps2 = true ;
select   year (' 1970 - 01 - 01   12 : 30 : 00 ')= 1970   from   dual
;
```

The new extended functions are described as follows.

YEAR

Command format:

```
INT   year ( string   date )
```

Command description:

Returns the year of a date.

Parameter description:

`date` : String-type date value. The format must at least include 'yyyy-mm-dd' and cannot include additional strings. Otherwise, null is returned.

Return value:

INT type.

For example:

```
year (' 1970 - 01 - 01   12 : 30 : 00 ') =  1970
year (' 1970 - 01 - 01 ') =  1970
year (' 70 - 01 - 01 ') =  70
year ( 1970 - 01 - 01 ) =  null
year (' 1970 / 03 / 09 ') =  null
year ( null )  Returns   an   exception
```

QUARTER

Command format:

```
INT   quarter ( datetime / timestamp / string   date  )
```

Note:

Before the SQL statement which uses the QUARTER function,add `set odps . sql . type . system . odps2 = true ;` to use the new data type function normally.

Command description:

Returns the quarter of a date, range: 1–4.

Parameter description:

`date` : Datetime, Timestamp, or String-type date value. The format must at least include 'yyyy-mm-dd' . Otherwise, null is returned.

Return value:

Int type, null input returns null.

For example:

```
quarter (' 1970 - 11 - 12   10 : 00 : 00 ') =  4
```

```
quarter (' 1970 - 11 - 12 ') =  4
```

MONTH

Command format:

```
INT   month ( string   date )
```

Note:
Before the SQL statement which uses the MONTH function, add `set   odps . sql . type . system . odps2 = true ;` to use the new data type function normally.

Command description:

Returns the month of a date.

Parameter description:

`date` : String-type date value. Other value types return an exception.

Return value:

INT type.

For example:

```
month (' 2014 - 09 - 01 ') =  9
month (' 20140901 ') =  null
```

DAY

Command format:

```
INT   day ( string   date )
```

Note:
Before the SQL statement which uses the function, add `set   odps . sql . type . system . odps2 = true ;` to use the new data type function normally.

Command description:

Returns the day of a date.

Parameter description:

`date` : String-type date value. Other value types return an exception.

Return value:

INT type.

For example:

```
day (' 2014 - 09 - 01 ') =  1
day (' 20140901 ') =  null
```

DAYOFMONTH

Command format:

```
INT   dayofmonth ( date )
```

Note:
Before the SQL statement which uses the DAYOFMONTH function, add `set   odps . sql . type . system . odps2 = true ;` to use the new data type function normally.

Command description:

Returns the day of a date.

For example, after command `int   dayofmonth ( 2017 - 10 - 13 )` runs, 13 returns.

Parameter description:

`date` : String-type date value. Other value types return an exception.

Return value:

INT type.

For example:

```
dayofmonth (' 2014 - 09 - 01 ') =  1
dayofmonth (' 20140901 ') =  null
```

HOUR

Command format:

```
INT   hour ( string   date )
```

Note:
Before the SQL statement which uses the HOUR function, add `set   odps . sql . type . system . odps2 = true ;` to use the new data type function normally.

Command description:

Returns the hour of a date.

Parameter description:

`date` : String-type date value. Other value types return an exception.

Return value:

Int type.

For example:

```
hour ('2014-09-01 12:00:00')=12
hour ('12:00:00')=12
hour ('20140901120000')=null
```

MINUTE

Command format:

```
INT minute(string date)
```

Note:
Before the SQL statement which uses the MINUTE function, add `set odps.sql.type.system.odps2=true;` to use the new data type function normally.

Command description:

Returns the minute of a date.

Parameter description:

`date` : String-type date value. Other value types return an exception.

Return value:

Int type.

For example:

```
minute ('2014-09-01 12:30:00') = 30
minute ('12:30:00') = 30
```

```
minute (' 2014090112  0000 ') =  null
```

SECOND

Command format:

```
INT  second ( string  date )
```

Note:
Before the SQL statement which uses the SECOND function, add `set  odps . sql . type . system . odps2 = true` ; to use the new data type function normally.

Command description:

Returns the second of a date.

Parameter description:

`date` : String-type date value. Other value types return an exception.

Return value:

INT type.

For example:

```
second (' 2014 - 09 - 01   12 : 30 : 45 ') =  45
second (' 12 : 30 : 45 ') =  45
second (' 2014090112  3045 ') =  null
```

CURRENT_TIMESTAMP

Command format:

```
timestamp  current_ti  mestamp ()
```

Note:
Before the SQL statement which uses the CURRENT_TIMESTAMP function, add `set  odps . sql . type . system . odps2 = true` ; to use the new data type function normally.

Command description:

Returns the current timestamp as a Timestamp-type value. The value is not fixed.

Return value:

Timestamp type.

For example:

```
select   current_ti  mestamp ()  from   dual ;-- Returns  ' 2017 - 08
- 03   11 : 50 : 30 . 661 '
```

ADD_MONTHS

Command format:

```
string   add_months ( string   startdate ,  int   nummonths )
```

Note:

Before the SQL statement which uses the ADD_MONTHS function, add `set   odps . sql . type . system . odps2 = true ;` to use the new data type function normally.

Command description:

Returns the date given by startdate plus the nummonths value.

Parameter description:

- `startdate` : String-type value. The format must at least include the 'yyyy-mm-dd' date. Otherwise, null is returned.
- `num_months` : Int-type value.

Return value:

A String-type date, in the format 'yyyy-mm-dd'.

For 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
```

LAST_DAY

Command format:

```
string   last_day ( string   date )
```

Note:

Before the SQL statement which uses the LAST_DAY function, add `set odps . sql . type . system . odps2 = true` ; to use the new data type function normally.

Command description:

Returns the date of the last day of the month that contains the given date.

Parameter description:

`date` : String type, with the format 'yyyy-MM-dd HH:mi:ss' or 'yyyy-MM-dd' .

Return value:

A String-type date, in the format 'yyyy-mm-dd' .

For example:

```
last_day (' 2017 - 03 - 04 ') = ' 2017 - 03 - 31 '
last_day (' 2017 - 07 - 04   11 : 40 : 00 ') = ' 2017 - 07 - 31 '
last_day (' 20170304 ') =  null
```

NEXT_DAY

Command format:

```
string   next_day ( string   startdate ,  string   week )
```

Note:
Before the SQL statement which uses the NEXT_DAY function, add `set odps . sql . type . system . odps2 = true` ; to use the new data type function normally.

Command description:

Returns the first date larger than the specified startdate that matches the day of the week given by the week parameter. It is the date of a specific day in the next week.

Parameter description:

- `startdate` : String type, with the format 'yyyy-MM-dd HH:mi:ss' or 'yyyy-MM-dd' .
- `week` : String type, the first two or three letters of a day of the week, or the full name of the day of the week. For example: Mo, TUE, or FRIDAY.

Return value:

A String-type date, in the format 'yyyy-mm-dd'.

For 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
```

MONTHS_BETWEEN

Command format:

```
double   months_bet  ween ( datetime / timestamp / string   date1 ,
datetime / timestamp / string   date2 )
```

Note:
Before the SQL statement which uses the MONTHS_BETWEEN function, add `set odps . sql . type . system . odps2 = true ;` to use the new data type function normally.

Command description:

Returns the number of months between date1 and date2.

Parameter description:

- `date1` : Datetime, Timestamp, or String type, with the format 'yyyy-MM-dd HH:mi:ss' or 'yyyy-MM-dd'.
- `date2` : Datetime, Timestamp, or String type, with the format 'yyyy-MM-dd HH:mi:ss' or 'yyyy-MM-dd'.

Return Value:

Returns the Double type.

- When date1 is later than date2, the returned value is positive. When 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.

Examples:

```
months_bet  ween (' 1997 - 02 - 28   10 : 30 : 00 ', ' 1996 - 10 - 30
') =  3 . 9495967741  935485
```

```
months_bet  ween (' 1996 - 10 - 30 ',' 1997 - 02 - 28   10 : 30 : 00
' ) = - 3 . 9495967741  935485
months_bet  ween (' 1996 - 09 - 30 ',' 1996 - 12 - 31 ') = - 3 . 0
```

4.14.3 Mathematical functions

This article introduces you to the mathematical function commands and instructions supported by MaxCompute SQL.

ABS

Function definition:

```
Double   abs ( Double   number )
Bigint   abs ( Bigint   number )
Decimal   abs ( Decimal   number )
```

Usage:

Returns an absolute value.

Parameter description:

`number` : It is any number of Type Double, Bigint, or Decimal.

- If the input is Bigint and return Bigint.
- If the input is Double, return Double.
- If the input is Decimal, return Decimal.

If the input is String, it is converted to Double by implicit conversion. If the input is another type, an error occurs.

Return value:

The return result depends on the type of input parameter. Example, if the input is null, return null.

Note:

When the value of input Bigint type exceeds the maximum value of Bigint, return Double type. In this case, the precision may be absent.

Example:

```
abs ( null ) =  null
abs (- 1 ) =  1
abs (- 1 . 2 ) =  1 . 2
abs ("- 2 ") =  2 . 0
```

```
abs ( 1223208374  5629837659  2387456923  748 ) =  1 . 2232083745
629837e32
```

The following is a completed ABS function example used in SQL. The use methods of other built-in functions (except Window Function and Aggregation Function) are similar.

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

ACOS

Function definition:

```
Double  acos ( Double  number )
Decimal  acos ( Decimal  number )
```

Usage:

Calculates the inverse cosine of a number.

Parameter description:

`number` : Double or Decima type, -1<=number <=1. If the input is String or Bigint, it is converted to Double by implicit conversion. If the input is another type, an error occurs.

Return value:

Returns the Double or Decimal type, the value is between 0 to π. If number is null, return null.

Example:

```
acos (" 0 . 87 ") =  0 . 5155940062  460905
acos ( 0 ) =  1 . 5707963267  948966
```

ASIN

Function definition:

```
Double  asin ( Double  number )
Decimal  asin ( Decimal  number )
```

Usage:

Calculates the inverse sine function of number.

Parameter description:

`number` : Double or Decima type, -1<=number <=1. If the input is String or Bigint, it is converted to Double by implicit conversion. If the input is another type, an error occurs.

Return value:

Returns the Double or Decimal type, the value is between -π/2 to π/2. If the number is null, return null.

Example:

```
asin ( 1 ) =  1 . 5707963267  948966
asin (- 1 ) = - 1 . 5707963267  948966
```

ATAN

Function definition:

```
Double   atan ( Double   number )
```

Usage:

Calculates the back-cut function of number.

Parameter description:

`Number` : Double type, if the input is String or Bigint, it is converted to Double by implicit conversion. If the input is another type, an error occurs.

Return value:

Returns the Double type, the value is between -π/2 to π/2. If the number is null, return null.

Example:

```
atan ( 1 ) =  0 . 7853981633  974483
atan (- 1 ) = - 0 . 7853981633  974483
```

CEIL

Function definition:

```
Bigint   ceil ( Double   value )
Bigint   ceil ( Decimal   value )
```

Usage:

This function returns the smallest integral value not less than the argument.

Parameter description:

`value` : Double or Decimal type, If the input is String or Bigint, it is converted to Double by implicit conversion. If the input is another type, an error occurs.

Return value:

Returns the Bigint type. If the number is null, return null.

Example:

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

CONV

Function definition:

```
String   conv ( String   input ,  Bigint   from_base ,  Bigint
to_base )
```

Usage:

Converts a number into a Hexadecimal number.

Parameter description:

- `input` : an integer to be converted, represented by String. Accept the implicit conversion of Bigint and Double.
- `from_base` , `to_base` : Decimal value, the acceptable values can be 2, 8, 10 and 16. Accept the implicit conversion of String and Double.

Return value:

Returns the String type. If the number is null, return null. The conversion process runs at a 64-bit precision. An exception is thrown when overflow occurs. If the input is a negative value (begin with '-'), an exception is thrown. If the input value is a decimal, it is converted to an integer before hex conversion. The decimal part is excluded.

Example:

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

```
conv (' ab ', 16 , 16 ) = ' ab '
```

COS

Function definition:

```
Double cos ( Double number )
Decimal cos ( Decimal number )
```

Usage:

Input is the radian value.

Parameter description:

`number` : Double or Decimal type. If the input is String, it is converted to Double by implicit conversion. If the input is another type, an error occurs.

Return value:

Returns the Double or Decimal type. If the number is NULL, return NULL.

Example:

```
cos ( 3 . 1415926 / 2 )= 2 . 6794896585 028633e - 8
cos ( 3 . 1415926 )=- 0 . 9999999999 999986
```

COSH

Function definition:

```
Double cosh ( Double number )
Decimal cosh ( Decimal number )
```

Usage:

It is the Hyperbolic cosine function

Parameter description:

`number` : Double or Decimal type. If the input is String, it is converted to Double by implicit conversion. If the input is another type, an error occurs.

Return value:

Returns the Double or Decimal type. If the number is NULL, return NULL.

COT

Function definition:

```
Double cot ( Double number )
```

```
Decimal   cot ( Decimal   number )
```

Usage:

Inputs the radian value.

Parameter description:

`number` : Double or Decimal type. If the input is String or Bigint, it is converted to Double by implicit conversion. If the input is another type, an error occurs.

Return value:

Returns the Double or Decimal type. If the number is NULL, return NULL.

EXP

Function definition:

```
Double   exp ( Double   number )
Decimal   exp ( Decimal   number )
```

Usage:

It is the Exponential function.

Return value:

Returns the exponent value of number.

Parameter description:

`number` : Double or Decimal type. If the input is String or Bigint, it is converted to Double by implicit conversion. If the input is another type, an error occurs.

Return value:

Returns the Double or Decimal type. If the number is NULL, return NULL.

FLOOR

Function definition:

```
Bigint   floor ( Double   number )
Bigint   floor ( Decimal   number )
```

Usage:

Returns the largest integral value not greater than the argument.

Parameter description:

`number` : Double or Decimal type. If the input is String or Bigint type, it is converted to Double by implicit conversion. If the input is another type, an error occurs.

Return value:

Returns the Bigint type. If the input is null, return null.

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
```

LN

Function definition:

```
Double   ln ( Double   number )
Decimal   ln ( Decimal   number )
```

Usage:

Returns the natural logarithm of the number.

Parameter description:

`number` : Double or Decimal type.

- If the input is String or Bigint type, it is converted to Double by implicit conversion . If the input is another type, an error occurs.
- If the number is null, return null. If number is negative or 0, an exception is thrown.

Return value:

Returns the Double or Decimal type.

LOG

Function definition:

```
Double   log ( Double   base ,  Double   x )
Decimal   log  ( decimal   base ,  decimal   X )
```

Usage:

Returns the logarithm of x whose base number is base.

Parameter description:

- `base` : Double or Decimal type. If the input is String or Bigint, it is converted to Double by implicit conversion. If the input is another type, an error occurs.
- `x` : Double or Decimal type. If the input is String or Bigint, it is converted to Double by implicit conversion. If the input is another type, an error occurs.

Return value:

Returns the logarithm value of Double or Decimal type.

- If base or x is null, return null.
- If one of base or x is negative or zero, it causes abnormality.
- If base is 1, it also causes abnormality.

POW

Function definition:

```
Double   pow ( Double   x ,  Double   y )
Decimal   pow ( Decimal   x ,  Decimal   y )
```

Usage:

Return x to the yth power, that is x^y.

Parameter description:

- `X` : Double or Decimal type. If the input is String or Bigint, it is converted to Double by implicit conversion. If the input is another type, an error occurs.
- `Y` : Double or Decimal type. If the input is String or Bigint, it is converted to Double by implicit conversion. If the input is another type, an error occurs.

Return value:

Returns the Double or Decimal type. If X or Y is null, return null.

RAND

Function definition:

```
Double   rand ( Bigint   seed )
```

Usage:

Return a random number (that changes from row to row), Specifying the seed makes sure the generated random number sequence is deterministic, Return value range is from 0 to 1.

Parameter description:

`seed` : Bigint type, random number seed, to determine starting values of the random number sequence.

Return Value:

Returns the Double type.

Example:

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

ROUND

Function definition:

```
Double   round ( Double   number , [ Bigint   Decimal_pl  aces ])
Decimal   round ( Decimal   number , [ Bigint   Decimal_pl  aces ])
```

Usage:

Four to five homes to the specific decimal point position.

Parameter description:

- `number` : Double or Decimal type. If the input is String or Bigint, it is converted to Double by implicit conversion. If the input is another type, an error occurs.
- `Decimal_pl  ace` : A Bigint type constant, four to five homes to the decimal point position. If it is other type, an exception is thrown. If you exclude it, it indicates four to five homes into a single digit. The default value is zero

Return value:

Returns the Double or Decimal type. If `number` or `Decimal_pl  aces` is null, return null.

Note:

`Decimal_pl aces` can be negative. The negative is counted from decimal point to the left. Deletethe decimal part. If decimal_place is greater than the length of the integer part, return 0.

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
```

SIN

Function definition:

```
Double   sin ( Double   number )
Decimal   sin ( Decimal   number )
```

Usage:

Calculates the sine function of number, the input is the radian value.

Parameter description:

`number` : Double or Decimal type. If the input is String or Bigint, it is converted to Double by implicit conversion. If the input is another type, an error occurs.

Return value:

Returns the Double or Decimal type. If the number is NULL, return NULL.

SINH

Function definition:

```
Double   sinh ( Double   number )
Decimal   sinh ( Decimal   number )
```

Usage:

Calculates the hyperbolic sine function of number.

Parameter description:

`number` : Double or Decimal type. If the input is String or Bigint, it is converted to Double by implicit conversion. If the input is another type, an error occurs.

Return value:

Returns the Double or Decimal type. If the number is NULL, return NULL.

SQRT

Function definition:

```
Double   sqrt ( Double   number )
Decimal   sqrt ( Decimal   number )
```

Usage:

Calculates the square root of number.

Parameter description:

`number` **: Double or Decimal type, must be greater than zero, if it is less than zero, an exception occur. If the input is String or Bigint, it is converted to Double by implicit conversion. If the input is another type, an error occurs.**

Return value:

Returns the Double or Decimal type. If the number is NULL, return NULL.

TAN

Function definition:

```
Double   tan ( Double   number )
Decimal   tan ( Decimal   number )
```

Usage:

Calculates the tangent function of the number, the input is the radian value.

Parameter description:

`number` **: Double or Decimal type. If the input is String or Bigint, it is converted to Double by implicit conversion. If the input is another type, an error occurs.**

Return value:

Returns the Double or Decimal type. If the number is NULL, return NULL.

TANH

Function definition:

```
Double   tanh ( Double   number )
```

```
Decimal  tanh ( Decimal  number )
```

Usage:

Calculates the hyperbolic tangent function of number.

Parameter description:

`number` : Double or Decimal type. If the input is String or Bigint, it is converted to Double by implicit conversion. If the input is another type, an error occurs.

Return value:

Returns the Double or Decimal type. If the number is NULL, return NULL.

TRUNC

Function definition:

```
Double  trunc ( Double  number [, Bigint  Decimal_pl aces ])
Decimal  trunc ( Decimal  number [, Bigint  Decimal_pl aces ])
```

Usage:

This function is used to intercept the input number to a specified decimal point place.

Parameter description:

- `number` : Double or Decimal type. If the input is String or Bigint, it is converted to Double by implicit conversion. If the input is another type, an error occurs.
- `Decimal_pl aces` : a Bigint type constant, the decimal point place to intercept the number. Other types are converted to Bigint. If this parameter is excluded, default to intercept to single digit.

Return value:

Returns the Double or Decimal type. If the `number` or `Decimal_pl aces` is NULL, return NULL.

Note:

- If the Double type is returned, the display of the returned result may not be as expected, such as trunc(125.815, 1) (this problem exists in all the systems).
- The part to be truncated is supplemented by zero.

- Decimal_places can be negative. The negative is truncated from the decimal point to the left and delete the decimal part. If Decimal_place are greater than the length of the integer, return zero.

Example:

```
trunc ( 125 . 815 ) =  125 . 0
trunc ( 125 . 815 ,  0 ) = 125 . 0
trunc ( 125 . 815 ,  1 ) =  125 . 8000000000  0001
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
```

Maxcomputerte2.0 New Extended Mathematical Functions

With the upgrade to MaxCompute 2.0, some mathematical functions have been added to the product. If a new function uses a new data type, add the following set statement before using the new functions SQL statement:

```
set  odps . sql . type . system . odps2 = true ;
```

The new extended functions are described as follows.

LOG2

Function definition:

```
Double  log2 ( Double  number )
Double  log2 ( Decimal  number )
```

Note:
Before the SQL statement which uses the LOG2 function, add `set  odps . sql . type . system . odps2 = true ;` to use the new data type function normally.

Usage:

Returns the log base 2 of a specific number.

Parameter description:

`number` : Double or Decimal type.

Return Value:

Returns the Double type. If the input is zero or null, the returned value is null.

The example is as follows:

```
log2 ( null )= null
log2 ( 0 )= null
log2 ( 8 )= 3 . 0
```

LOG10

Function definition:

```
Double   log10 ( Double   number )
Double   log10 ( Decimal   number )
```

Note:

Before the SQL statement which uses the LOG10 function, add `set   odps . sql . type . system . odps2 = true ;` to use the new data type function normally.

Usage:

Returns the log base 10 of the specific number.

Parameter description:

`number` : Double or Decimal type.

Return Value:

Returns the Double type. If the input is zero or null, the returned value is null.

The example is as follows:

```
log10 ( null )= null
log10 ( 0 )= null
log10 ( 8 )= 0 . 9030899869   919435
```

BIN

Function definition:

```
String   bin ( Bigint   number )
```

Note:

Before the SQL statement which uses the function, add `set   odps . sql . type . system . odps2 = true ;` to use the new data type function normally.

Usage:

Returns the binary code expression for the specific number.

Parameter description:

`number` : Bigint type.

Return value:

String type. If the input is zero, then zero is returned; if the input is null, null is returned.

Example:

```
bin ( 0 )=' 0 '
bin ( null )=' null '
bin ( 12 )=' 1100 '
```

HEX

Function definition:

```
String   hex ( Bigint   number )
String   hex ( String   number )
String   hex  ( binary   number )
```

Note:

Before the SQL statement which uses the HEX function, add `set odps . sql . type . system . odps2 = true` ; to use the new data type function normally.

Usage:

This function is used to converts integers or characters to hexadecimal format.

Parameter description:

`number` : If number is of the Bigint type, the hexadecimal format of the number is returned. If this variable is a String type, the hexadecimal format of the string is returned.

Return value:

Returns the String type. If the input is zero, then zero is returned; if the input is null, an exception is returned.

Example:

```
hex ( 0 )= 0
hex (' abc ')=' 616263 '
hex ( 17 )=' 11 '
hex (' 17 ')=' 3137 '
```

```
hex ( null ) results in an exception and returns failed
.
```

Note:

If the input parameter is a Binary type, add `set odps . sql . type . system . odps2 = true ;`, and submit it with SQL to use the new data type normally.

UNHEX

Function definition:

```
BINARY unhex ( String number )
```

Note:

Before the SQL statement which uses the UNHEX function, add `set odps . sql . type . system . odps2 = true ;` to use the new data type function normally.

Usage:

Returns the string represented by a given hexadecimal string.

Parameter description:

`number` : A hexadecimal string.

Return value:

Returns the Binary type. If the input is zero, failed is returned. If the input is null, null is returned.

Example:

```
Unhex (' 616263 ') = ' abc '
unhex ( 616263 )=' abc '
```

RADIANS

Function definition:

```
Double radians ( Double number )
```

Note:

Before the SQL statement which uses the RADIANS function, add `set odps . sql . type . system . odps2 = true ;` to use the new data type function normally.

Usage:

This function is used to converts degrees to radians.

Parameter description:

`number` : Double type.

Return value:

Returns the Double type, if the input is null, null is returned.

Example:

```
radians ( 90 )= 1 . 5707963267  948966
radians ( 0 )= 0 . 0
radians ( null )= null
```

DEGREES

Function definition:

```
Double   degrees ( Double   number )
Double   degrees ( Decimal   number )
```

Note:

Before the SQL statement which uses the function, add `set   odps . sql . type . system . odps2 = true ;` to use the new data type function normally.

Usage:

This function is used to converts radians to degrees.

Parameter description:

`number` : Double or Decimal type.

Return value:

Returns Double data type. If the input is null, null is returned.

Example:

```
degrees ( 1 . 5707963267  948966 )= 90 . 0
degrees ( 0 )= 0 . 0
```

```
Degrees ( null ) = NULL
```

SIGN

Function definition:

```
Double sign ( Double number )
Double sign ( Decimal number )
```

Note:
Before the SQL statement which uses the SIGN function, add `set odps . sql . type . system . odps2 = true ;` to use the new data type function normally.

Usage:

Applies the sign of the input data. 1.0 indicates a positive number and -1.0 indicates a negative number. Otherwise, 0.0 is returned.

Parameter description:

`number` : Double or Decimal type.

Return value:

Returns Double data 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
```

E

Function definition:

```
Double e ()
```

Note:
Before the SQL statement which uses the E function, add `set odps . sql . type . system . odps2 = true ;` to use the new data type function normally.

Usage:

This function is used to return the e value.

Return Value:

Returns the Double type.

Example:

```
e ()= 2 . 7182818284  59045
```

PI

Function definition:

```
Double  pi ()
```

> **Note:**
> Before the SQL statement which uses the PI function, add `set  odps . sql . type . system . odps2 = true ;` to use the new data type function normally.

Usage:

This function is used to return the π value.

Return Value:

Returns the Double type.

Example:

```
pi ()= 3 . 1415926535  89793
```

FACTORIAL

Function definition:

```
Bigint  factorial ( Int  number )
```

> **Note:**
> Before the SQL statement which uses the FACTORIAL function, add `set  odps . sql . type . system . odps2 = true ;` to use the new data type function normally.

Usage:

This function is used to return the factorial for the specific number.

Parameter description:

`number` : Int-type data, range: [0 –20].

Return value:

Returns the Bigint type, if the input is zero, one is returned. If the input is null or outside the range [0 –20], null is returned.

Example:

```
factorial ( 5 )= 120  -- 5 ! =  5 * 4 * 3 * 2 * 1  =  120
```

CBRT

Function definition:

```
Double   cbrt ( Double   number )
```

Note:
Before the SQL statement which uses the CBRT function, add `set   odps . sql . type . system . odps2 = true ;` to use the new data type function normally.

Usage:

This function is used to return the cube root.

Parameter description:

`number` : Double type.

Return value:

Returns Double data type. If the input is null, null is returned.

Example:

```
cbrt ( 8 )= 2
cbrt ( null )= null
```

SHIFTLEFT

Function definition:

```
Int   shiftleft ( Tinyint | Smallint | Int   number1 ,  Int   number2
)
Bigint   shiftleft ( Bigint   number1 ,  Int   number2 )
```

Note:

Before the SQL statement which uses the SHIFTLEFT function, add `set odps . sql . type . system . odps2 = true ;` to use the new data type function normally.

Usage:

Shifts to the left by a given number of places (<<).

Parameter description:

- `number1` : Tinyint|Smallint|Int|Bigint integer.
- `number2` : An Int integer.

Return value:

Returns the Int or Bingint type.

Example:

```
shiftleft ( 1 , 2 )= 4   -- Shifts   the   binary   value   of   1
two   places   to   the   left  ( 1 << 2 , 0001   shifted   to   0100
)
shiftleft ( 4 , 3 )= 32   -- Shifts   the   binary   value   of   4
three   places   to   the   left  ( 4 << 3 , 0100   shifted   to   10
, 0000 )
```

SHIFTRIGHT

Function definition:

```
Int   shiftright ( Tinyint | Smallint | Int   number1 ,  Int
number2 )
Bigint   shiftright ( Bigint   number1 ,  Int   number2 )
```

Note:

Before the SQL statement which uses the SHIFTRIGHT function, add `set odps . sql . type . system . odps2 = true ;` to use the new data type function normally.

Usage:

This function is used for shifts right by a given number of places (>>).

Parameter description:

- `number1` : Tinyint|Smallint|Int|Bigint integer.
- `number2` : An Int integer.

Return value:

Returns the Int or Bigint type.

Example:

```
shiftright ( 4 , 2 )= 1  --  Shifts   the   binary   value   of   4
  two   places   to   the   right  ( 4 >> 2 , 0100   shifted   to
0001 )
shiftright ( 32 , 3 )= 4  --  Shifts   the   binary   value   of   32
  three   places   to   the   right  ( 32 >> 3 , 100000   shifted
to   0100 )
```

SHIFTRIGHTUNSIGNED

The command format is as follows:

```
Int   shiftright  unsigned ( Tinyint | Smallint | Int   number1 ,
Int   number2 )
Bigint   shiftright  unsigned ( Bigint   number1 ,  Int   number2 )
```

Note:
Before the SQL statement which uses the SHIFTRIGHTUNSIGNED function, add `set odps . sql . type . system . odps2 = true` ; to use the new data type function normally.

The command description is as follows:

This function is used for unsigned right shift by a given number of places (>>>).

Parameter description:

- `number1` : Tinyint|Smallint|Int|Bigint integer.
- `number2` : An Int integer.

Return value:

Returns the Int or Bigint type.

Example:

```
shiftright  unsigned ( 8 , 2 )= 2  --  Shifts   the   unsigned
binary   value   of   8   two   places   to   the   right  ( 8 >>> 2
, 1000   shifted   to   0010 )
shiftright  unsigned (- 14 , 2 )= 1073741820   --  Shifts   the
unsigned   binary   value   of  - 14   two   places   to   the
```

```
right  (- 14 >>> 2 ,  11111111   11111111   11111111   11110010
shifted   to   00111111   11111111   11111111   11111100 )
```

4.14.4 Window functions

In MaxCompute SQL, window functions help in analyzing and processing the workflow flexibly. Window function can only appear in the 'select' clause. However using both the nested window function and aggregate function in window function is not allowed. Also, it cannot be used at the same level as that of the aggregation function together.

Currently, in a MaxCompute SQL statement, you can use five window functions.

Window function syntax:

```
 window_fun  c ()  over  ( partition   by  [ col1 , col2 …]
[ order   by  [ col1 [ asc | desc ],  col2 [ asc | desc ]…]]
 windowing_  clause )
```

- `partition by` specifies open window columns. The rows of which partitioned columns have the same values are considered in the same window. Currently, a window can contain at most 100,000,000 rows data. We recommend that the rows must not exceed 5,000,000, otherwise, an error is reported at runtime.
- The clause `order by` specifies how the data is ordered in a window.
- In `windowing_ clause` part, use rows to specify window open way. The two methods are as follows:
  - Rows between x preceding|following and y preceding|following, which indicates the window range is from rows x preceding /following to rows y preceding/following.
  - Rows x preceding|following: the window range is from rows x preceding / following to the present row.
  - 'x', 'y' must be an integer constant that is greater than or equal to 0 and corresponding value range is 0~10000. If the value is 0, it indicates the present row. Use the rows method to specify window range on condition that you have specified 'order by' clause for.

Note:

Not all window functions can be specified window open way using rows. The window functions support this usage include AVG, count, Max, min, StdDev, sum.

COUNT

Function definition:

```
Bigint  count ([ distinct ] expr ) over ( partition  by [ col1
, col2 …]
[ order  by  [ col1 [ asc | desc ], col2 [ asc | desc ]…]] [
windowing_ clause ])
```

Usage:

Calculates the total number of retrieved rows.

Parameter description:

- `expr` : Any data type. When it is NULL, this row is not counted. If the 'distinct' keyword is specified, it indicates using the unique count value.
- `partition by [ col1 , col2 …]`: Specifies the columns to use window function.
- `order by col1 [ asc | desc ], col2 [ asc | desc ]`: If 'order by' clause is not specified, return the count vale of 'expr' in the current window. If 'order by' clause is specified, the return result is ordered according to the specified sequence and the value is a cumulative count value from start row to the current row in the current window.

Return value:

Bigint type.

Note:
If the keyword 'distinct' is specified, the 'order by' clause cannot be used.

Example:

Thethe table 'test_src' already exists and the column 'user_id' of bigint type exists in this 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  |
```

```
   -- the ‘ order by ’ clause is not specified , return
the count value of user_id in the current window .
    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 |

   -- The ‘ order by ’ clause is specified and return
a cumulative count value from start row to current
row in the current window .
```

AVG

Function definition:

```
avg ([ distinct ] expr ) over ( partition by [ col1 , col2 …]
[ order by [ col1 [ asc | desc ], col2 [ asc | desc ]…]] [
windowing_ clause ])
```

Usage:

Calculates the average.

Parameter description:

- `distinct` **: if the keyword ‘distinct’ is specified, it indicates taking average of the unique value.**
- `expr` **: Double type.**
  - **If the input is ‘string’ type or ‘bigint’ type, it is converted to ‘double’ type by implicit conversion and involved in the operation. If it is another data type, an exception is thrown.**
  - **If this value is NULL, then this row is not counted in the calculation.**
  - **If the data type is Boolean, then this row is excluded from the calculation.**
- `partition by [ col1 , col2 ...]`**: Specified the olumns to use window function.**
- `order by col1 [ asc | desc ], col2 [ asc | desc ]`**: If ‘order by’ clause is not specified, return the average of all values in the current window. If ‘order by’ clause is specified, the return result is ordered according to the**

specified sequence and returns the cumulative average from start row to current row in the current window.

Return value:

Double type.

Note:
If the keyword 'distinct' isn specified, the 'order by' clause cannot be used.

MAX

Function definition:

```
max ([ distinct ] expr ) over ( partition by [ col1 , col2 …]
[ order by [ col1 [ asc | desc ], col2 [ asc | desc ]…]] [
windowing_ clause ])
```

Usage:

Calculates the maximum value.

Parameter description:

- `expr` : Any types expect 'Boolean' . If the value is NULL, this row is not involved in the calculation. If the keyword 'distinct' is specified, it indicates taking the max value of the unique value.
- `partition by [ col1 , col2 …]`: Specifies columns to use window function.
- `order by [ col1 [ asc | desc ], col2 [ asc | desc` : If 'order by' clause is not specified, return the maximum value in the current window. If 'order by' clause is specified, the return result is ordered according to the specified sequence and return the maximum value from start row to current row in the current window.

Return value:

Same as the 'expr' type..

Note:
If the keyword 'distinct' is specified, the 'order by' clause cannot be used.

MIN

Function definition:

```
min ([ distinct ]  expr )  over ( partition   by  [ col1 ,  col2 …]
[ order   by  [ col1 [ asc | desc ],  col2 [ asc | desc ]…]] [
windowing_  clause ])
```

Usage:

Calculates the minimum value of the column.

Parameter description:

- `expr` Any types except 'Boolean'. If the value is NULL, this row is not counted in the calculation. If the keyword 'distinct' is specified, it indicates using the minimum value of a unique value.
- `partition by [ col1 , col2 …]`: Specifies columns to use window function.
- `order by [ col1 [ asc | desc ], col2 [ asc | desc ]`: If 'order by' clause is not specified, return the minimum value in the current window. If 'order by' clause is specified, the return result is ordered according to the specified sequence and return the minimum value from start row to current row in the current window.

Return value:

the same type with 'expr'.

> **Note:**
> If the keyword 'distinct' is specified, the 'order by' clause cannot be used.

MEDIAN

Function definition:

```
Double   median ( Double   number1 , number2 ...)  over ( partition
by  [ col1 ,  col2 …])
Decimal   median ( Decimal   number1 , number2 ...)  over ( partition
  by  [ col1 , col2 …])
```

Usage:

Calculates the median.

Parameter description:

- `number1 , number1 …`: 1 to 255 digits of a Double or Decimal type.
  - When the input value is a String type or a Bigint type, the operation is performed after the implicit conversion to a Double type, and other types throw exceptions.
  - Return NULL when the input value is null.
  - When the input value is a Double type, it converts to the Array of Double by default .
- `partition by [ col1 , col2 …]`: Specifies columns to use window function.

Return value:

Double type.

STDDEV

Function definition:

```
 Double  stddev ([ distinct ]  expr )  over ( partition  by  [ col1
 ,  col2 …]
[ order  by  [ col1 [ asc | desc ],  col2 [ asc | desc ]…]] [
 windowing_  clause ])
 Decimal  stddev ([ distinct ]  expr )  over ( partition  by  [ col1
 ,  col2 …]
[ order  by  [ col1 [ asc | desc ],  col2 [ asc | desc ]…]] [
 windowing_  clause ])
```

Usage:

Calculates population standard deviation.

Parameter description:

- `expr` : Double type.
  - If the input is ‘string’ or ‘bigint’ type, it is converted to ‘double’ type and is counted in the operation. If it is another data type, an exception is thrown.
  - If the input value is ‘NULL’, this row is excluded.
  - If the keyword ‘distinct’ is specified, it indicates calculating the population standard deviation of the unique value.
- `partition by [ col1 , col2 ..]`: Specifies columns to use window function.
- `order by col1 [ asc | desc ], col2 [ asc | desc ]`: If ‘order by’ clause is not specified, return the population standard deviation in the current

window. If 'order by' clause is specified, the return result is ordered according to the specified sequence and return the population standard deviation from start row to current row in the current window.

Return value:

When the input is 'decimal' type, return 'decimal'; otherwise, return 'double'.

Example:

```
select  window , seq , stddev_pop (' 1 \ 01 ') over ( partition
  by  window  order  by  seq )  from  dual ;
```

Note:

- If the keyword 'distinct' is specified, the 'order by' clause cannot be used.
- `Stddev_pop` is an alias function of `stddev` function and its usage is the same as that of `stddev`

STDDEV_SAMP

Function definition:

```
Double  stddev_sam p ([ distinct ] expr ) over ( partition  by
 [ col1 , col2 …]
[ order  by  [ col1 [ asc | desc ], col2 [ asc | desc ]…]] [
 windowing_ clause ])
 Decimal  stddev_sam p ([ distinct ] expr ) over (( partition  by
  [ col1 , col2 …]
[ order  by  [ col1 [ asc | desc ], col2 [ asc | desc ]…]] [
 windowing_ clause ])
```

Usage:

Calculate sample standard deviation.

Parameter description:

- `Expr` : Double type.
  - If the input is 'string' or 'bigint' type, it is converted to 'double' type and counted in the operation. If it is another data type, an exception is indicated.
  - If the input value is NULL, this row is excluded.
  - If the keyword 'distinct' is specified, it indicates calculating the sample standard deviation of the unique value.

- `partition by [ col1 , col2 ..]`: Specifies columns to use window function.
- `Order by col1 [ asc | desc ], col2 [ asc | desc ]`: If 'order by' clause is not specified, return the sample standard deviation in the current window. If 'order by' clause is specified, the return result is ordered according to the specified sequence and return the sample standard deviation from start row to current row in the current window.

Return value:

When the input is 'decimal' type, return 'decimal'; otherwise, return 'double'.

Note:
If the keyword 'distinct' is specified, the 'order by' clause cannot be used.

SUM

Function definition:

```
sum ([ distinct ] expr ) over ( partition by [ col1 , col2 …]
[ order by [ col1 [ asc | desc ], col2 [ asc | desc ]…]] [
windowing_ clause ])
```

Usage:

Calculates the sum of elements.

Parameter description:

- `Expr` : Double type.
  - If the input is 'string' or 'bigint' type, it is converted to 'double' type and counted in the operation. If it is another data type, an exception is indicated.
  - If the input value is NULL, this row is excluded.
  - If the keyword 'distinct' is specified, it indicates calculating the sum of the unique value.
- `Partition by [ col1 , col2 ..]`: Specifies columns to use window function.
- `Order by col1 [ asc | desc ], col2 [ asc | desc ]`: If 'order by' clause is not specified, return the sum in the current window. If 'order by' clause

is specified, the return result is ordered according to the specified sequence and return the sum from start row to current row in the current window.

Return value:

- If the input parameter is 'bigint' type, return 'bigint' type.
- If the input parameter is 'Decimal' type, return 'Decimal' type.
- If the input parameter is 'double' type or 'string' type, return 'double' type .

> **Note:**
> If the keyword 'distinct' is specified, the 'order by' clause cannot be used.

DENSE_RANK

Function definition:

```
Bigint  dense_rank () over ( partition  by  [ col1 ,  col2 …]
order  by  [ col1 [ asc | desc ],  col2 [ asc | desc ]…])
```

Usage:

Calculates the dense rank. The data in the same row of col2 has the same rank.

Parameter description:

- `partition by [ col1 , col2 ..]`: Specifies columns to use window function.
- `order by col1 [ asc | desc ], col2 [ asc | desc ]`: Specifies the value which the rank is based on.

Return value:

Bigint type.

Example:

The data in table 'emp' is as follows:

```
|  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, 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
        ,  DENSE_RANK ()  OVER  ( PARTITION   BY   deptno   ORDER   BY
   sal   DESC )  AS   nums -- Deptno   as   a   window   column ,  and
   sort   in   descending   order   according   to   sal .
     FROM   emp ;
-- The   result   is   as   follows :

|  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  |
```

```

```

RANK

Function definition:

```
Bigint   rank ()  over ( partition   by  [ col1 ,  col2 …]
order   by  [ col1 [ asc | desc ],  col2 [ asc | desc ]…])
```

Usage:

Calculates the rank. The ranking of the same row data with col2 drops.

Parameter description:

- `Partition  by  [ col1 ,  col2 ..]`: **Specifies columns to use window function.**
- `Order  by  col1 [ asc | desc ],  col2 [ asc | desc ]`: **Specifies the value which the rank is based on.**

Return value:

Bigint type.

Example:

The data in table 'emp' is as follows:

```
|  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, 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
       ,  RANK ()  OVER  ( PARTITION   BY   deptno   ORDER   BY
sal   DESC )  AS   nums -- Deptno   as   a   window   column ,  and
sort   in   descending   order   according   to   sal .
    FROM   emp ;
-- The   result   is   as   follows :

|  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  |
```

LAG

Function definition:

```
lag ( expr ,  Bigint   offset ,  default )  over ( partition   by  [
col1 ,  col2 …]
[ order   by  [ col1 [ asc | desc ],  col2 [ asc | desc ]…]])
```

Command description:

Take the value of nth row in front of current row in accordance with offset. If the current row number is rn, take the value of the row which row number is rn-offset.

Parameter description:

- `expr` : Any type.
- `offset` : A Bigint type constant. If the input is String type or Double type, convert it to Bigint type by implicit conversion. Offset > 0;
- `default` : Define the default value while the specified range of 'offset' crosses the limit. It is constant and default is null.
- `partition by [ col1 , col2 ..]`: Specifies columns to use window function.
- `order by col1 [ asc | desc ], col2 [ asc | desc ]`: Specifies the order method for return result.

Return Value:

Returns the same with 'expr'.

LEAD

Command format:

```
lead ( expr , Bigint offset , default ) over ( partition by [
col1 , col2 …]
[ order by [ col1 [ asc | desc ], col2 [ asc | desc ]…]])
```

Command description:

Take the value of nth row following current row in accordance with offset. If the current row number is rn, take the value of the row which row number is rn+offset.

Parameter description:

- `expr` : Any type.
- `offset` : A Bigint type constant. If the input is String, Decimal or Double type, convert it to Bigint type by implicit conversion. Offset > 0.
- `default` : Define the default value while the specified range of offset crosses the limit. It is constant.
- `partition by [ col1 , col2 ..]`: Specifies columns to use window function.
- `order by col1 [ asc | desc ], col2 [ asc | desc ]`: Specifies the order method for return result.

Return Value:

Same as the 'expr' type.

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 )   from
  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 )  from
  dual ;
select   c_String_i  n_fact_num , c_String_a , c_int_a , lead (
c_int_a )  over ( partition   by   c_String_i  n_fact_num   order
by   c_String_a )  from   dual ;
```

PERCENT_RANK

Command format:

```
Percent_ra  nk  ()  over  ( partition   by  [ col1 ,  col2 ...]
order   by  [ col1 [ asc | desc ],  col2 [ asc | desc ]…])
```

Command description:

Calculate relative ranking of a certain row in a group of data.

Parameter description:

- `partition   by  [ col1 ,  col2 ..]`: Specifies columns to use window function.
- `order   by   col1 [ asc | desc ],  col2 [ asc | desc ]`: Specifies the value based on the ranking.

Return Value:

Returns the Double type, value scope is [0, 1]. The calculation method of relative ranking is `( rank - 1 )/( number   of   rows  - 1 )`.

Note:
The current limit of rows in a single window cannot exceed 10,000,000.

ROW_NUMBER

Command format:

```
row_number ()  over ( partition   by  [ col1 ,  col2 …]
order   by  [ col1 [ asc | desc ],  col2 [ asc | desc ]…])
```

Command description:

Calculates the row number, beginning from 1.

Parameter description:

- `partition by [ col1 , col2 ..]`: Specifies columns to use window function.
- `order by col1 [ asc | desc ], col2 [ asc | desc ]`: Specifies the order method for return result.

Return Value:

Returns the Bigint type.

Example:

The data in table emp is as follows:

```
| 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 ,  fig - 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 ,  fig - 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 ,  maid - 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  as  a  window  column
 ,  and  sort  in  descending  order  according  to  sal .
     FROM  emp ;
-- The  result  is  as  follows :

|  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  |
```

CLUSTER_SAMPLE

Command format:

```
boolean  cluster_sa  mple ([ Bigint  x ,  Bigint  y ])
over ( partition  by  [ col1 ,  col2 ..])
```

Command description:

Used for Group sampling.

Parameter description:

- `x` : A Bigint type constant, x>=1. If you specify the parameter y, x indicates dividing a window into x parts. Otherwise x indicates selecting x rows records in a window (if x rows are in this window, return true). If x is NULL, return NULL.
- `y` : A Bigint type constant, y>=1, y<=x. It indicates selecting y parts records from x parts in a window (in other words, if y parts records exist, return value is true). If y is NULL, return NULL.
- `partition  by  [ col1 ,  col2 ]`: Specifies columns to use window function.

Return Value:

Returns the Boolean type.

Example:

If two columns key and value are in the table test_tbl, key is grouping field. The corresponding values of key have groupa and groupb, the field value indicates value of key shown as follows:

```
    |  key  |  value  |

    |  groupa  | - 1 . 3476416547  8145  |
    |  groupa  |  0 . 7402126090  46718  |
    |  groupa  |  0 . 1675371278  58695  |
    |  groupa  |  0 . 6303145661  85241  |
    |  GroupA  |  0 . 0112401388  646925  |
    |  groupa  |  0 . 1991657458  75297  |
    |  groupa  | - 0 . 3205433433  53587  |
    |  groupa  | - 0 . 2739309243  65012  |
    |  groupa  |  0 . 3861779589  42063  |
    |  groupa  | - 1 . 0920997668  7047  |
    |  groupb  | - 1 . 1084769093  8643  |
    |  groupb  | - 0 . 7257039783  81499  |
    |  groupb  |  1 . 0506469747  5759  |
    |  groupb  |  0 . 1357512243  93789  |
    |  groupb  |  2 . 1331310204  0396  |
    |  groupb  | - 1 . 1182896078  5008  |
    |  groupb  | - 0 . 8492355115  08911  |
    |  groupb  |  1 . 2791380662  0453  |
    |  groupb  | - 0 . 3308177166  70401  |
    |  groupb  | - 0 . 3001568961  91195  |
    |  groupb  |  2 . 4704244205  196  |
    |  groupb  | - 1 . 2805188208  4434  |
```

To select 10% values from each group, the following MaxCompute SQL is recommended:

```
Select  key ,  Value
    from  (
        Select  key ,  value ,  cluster_sa mple  ( 10 ,  1 )  over
( partition  by  key )  as  flag
        from  tbl
       )  sub
    where  flag  =  true ;

|  Key  |  value  |

|  groupa  |  0 . 1675371278  58695  |
|  groupb  |  0 . 1357512243  93789  |
```

NTILE

Command format:

```
BIGINT  ntile ( BIGINT  n )  over ( partition  by  [ col1 ,  col2
…]
```

```
[ order   by  [ col1 [ asc | desc ],  col2 [ asc | desc ]…]] [
 windowing_  clause ]))
```

Command description:

Used to cut grouped data into N slices in order and return the current slice value, if the slice is uneven, the distribution of the first slice is increased by default.

Parameter description:

N: bigint data type.

Return Value:

Returns the bigint type.

Example:

The data in the table EMP is as follows:

```
|  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 ,  maid - 12 - 30   00 : 00 : 00 ,  1300 ,
 10
```

All employees now need to be divided into three groups according to Sal high to low cut, and get the serial number of the employee's own group.

```
 Select   deptno ,  ename ,  Sal ,  ntile  ( 3 )  over  ( partition
 by   depno   order   by   Sal   DESC )  as   nt3   from   EMP ;
--  Execution   results   as   follows
```

```
| 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 |
```

4.14.5 Aggregate functions

The relation between the input and the output of aggregate functions is a many-to-one relationship; that is, to aggregate multiple input records into an output record. Use it with the group by clause in SQL.

COUNT

Function definition:

```
bigint count ([ distict | all ] value )
```

Usage:

Counts the record numbers.

Parameter description:

- distinct|all: Specifies whether to remove duplicate records while counting. The default all counts all records. If the field ‘distinct’ is specified, then a unique count value is used.
- value: Any type. If the value is NULL, the corresponding row is not counted. Count (*), returns all rows.

Return Value:

Returns the Bigint type.

Example:

```
-- If the table tbla has the column col1 and the
data type is Bigint .
```

```
+-------+
|  COL1  |
+-------+
|  1  |
+-------+
|  2  |
+-------+
|  NULL  |
+-------+
 select   count (*)  from   tbla ;  --  value   is   3 .
 select   count ( col1 )  from   tbla ;  --  value   is   2
```

Use the aggregation function with the group by clause. Example, suppose that the table test_src has two columns, key is a String type, and value is a Double type.

```
--  The   data   of   test_src   is   shown   as   follows :
+-----+-------+
|  key  |  value  |
+-----+-------+
|  a  |  2 . 0  |
+-----+-------+
|  a  |  4 . 0  |
+-----+-------+
|  b  |  1 . 0  |
+-----+-------+
|  b  |  3 . 0  |
+-----+-------+
--  Now   run   following   sentence   and   get   the   result :
 select   key ,  count ( value )  as   count   from   test_src   group
   by   key ;
+-----+-------+
|  key  |  count  |
+-----+-------+
|  a  |  2  |
+-----+-------+
|  b  |  2  |
+-----+-------+
--  The   aggregatio  n   function   calculates   the   aggregate
 value   that   has   the   same   key   value . The   preceding
 rules   apply   to   the   following   aggregate   functions   also .
```

AVG

Function definition:

```
 double   avg ( double   value )
 decimal   avg ( decimal   value )
```

Usage:

Calculates the average value.

Parameter description:

value: Double or Decimal type. If the input is String or Bigint type, it is converted to Double type by implicit conversion. If it is another data type, an exception is thrown.

If this value is NULL, a corresponding row is not counted in the calculation. The input cannot be Boolean type.

Return value:

If the input is Decimal type, then return Decimal type. If it is the other valid types, then return Double type.

Example:

```
-- If the table tbla has a column value and its
 data type is Bigint .
+--------+
| value |
+--------+
| 1 |
| 2 |
| NULL |
+--------+
-- the avg of this column is : ( 1 + 2 )/ 2 = 1 . 5
 select avg ( value ) as avg from tbla ;
+-------+
| avg |
+-------+
| 1 . 5 |
+-------+
```

MAX

Function definition:

```
max ( value )
```

Usage:

Calculates the maximum value.

Parameter description:

value: Any data type. If the column value is NULL, the corresponding row is not counted in the operation. Values of the Boolean type are excluded from calculation.

Return value:

The return value is matchs the value type.

Example:

```
-- If the table tbla has a column clo1 and its
 data type is Bigint .
+-------+
| col1 |
+-------+
| 1 |
+-------+
```

```
|  2  |
+-------+
|  NULL  |
+-------+
 Select   max  ( value )  from   tbla ; --  return   value   is   2
```

MIN

Function definition:

```
MIN ( value )
```

Usage:

Calculates the minimum value of the column.

Parameter description:

Any data type. If the column value is NULL, the corresponding row is not counted in the operation. A Boolean type is excluded from the operation.

Example:

```
--  If   the   table   tbla   has   a   column   value   and   its
 data   type   is   Bigint .
+-------+
|  value |
+-------+
|  1  |
+-------+
|  2  |
+-------+

+-------+
 Select   min  ( value )  from   tbla ; --  return   value   is   1
```

MEDIAN

Function definition:

```
double   median ( double   number )
decimal   median ( decimal   number )
```

Usage:

Calculates the median.

Parameter description:

number: Double or Decimal type. If the input is String or Bigint type, it is converted to Double type and is counted in the operation. If it is another data type, an exception is thrown.

Return value:

Returns the Double or Decimal type.

Example:

```
-- If the table tbla has a column value and its
 data type is Bigint .
+-------+
| value |
+-------+
| 1 |
+-------+
| 2 |
+-------+
| 3 |
+-------+
| 4 |
+-------+
| 5 |
+-------+
 select MEDIAN ( value ) from tbla ; -- return value is 3
 . 0
```

STDDEV

Function definition:

```
 double stddev ( double number )
 decimal stddev ( decimal number )
```

Usage:

Calculates a population standard deviation.

Parameter description:

number: Double type or Decimal type. If the input is String or Bigint type, it is converted to Double type and is counted in operation. If it is another data type, an exception is thrown.

Return value:

Returns a Double or Decimal type.

Example:

```
-- If the table tbla has a column value and its
 data type is Bigint .
+-------+
| value |
+-------+
| 1 |
+-------+
| 2 |
+-------+
| 3 |
+-------+
```

```
| 4 |
+-------+
| 5 |
+-------+
 select   STDDEV ( value )  from   tbla ;  --  return   value   is   1
 . 4142135623  730951
```

STDDEV_SAMP

Function definition:

```
double   stddev_sam  p ( double   number )
decimal   stddev_sam  p ( decimal   number )
```

Usage:

Calculates a sample standard deviation.

Parameter description:

number: Double type or Decimal type. If the input is String or Bigint type, it is converted to Double type and is counted in operation. If it is another data type, an exception is thrown.

Return value:

Returns a Double or Decimal type.

Example:

```
--  If   the   table   tbla   has   a   column   value   and   its
 data   type   is   Bigint .
+-------+
| value |
+-------+
| 1 |
+-------+
| 2 |
+-------+
| 3 |
+-------+
| 4 |
+-------+
| 5 |
+-------+
 select   STDDEV_SAM  P ( value )  from   tbla ; --  return   value
 is   1 . 5811388300  841898
```

SUM

Function definition:

```
sum ( value )
```

Usage:

Calculates the sum of elements.

Parameter description:

value: Double, Decimal, or Bigint type. If the input is String type, it is converted to Double type and counted in operation. If the value in the column is NULL, this row is counted A Boolean type excluded from this calculation.

Return value:

If the input parameter is Bigint type, return Bigint type. If the input parameter is Double type or String type, return Double type.

Example:

```
-- If the table tbla has a column value and its
 data type is Bigint .
+-------+
| value |
+-------+
| 1   |
+-------+
| 2   |
+-------+
| NULL  |
+-------+
 select sum ( value ) from tbla ; -- return value is 3
```

WM_CONCAT

Function definition:

```
string wm_concat ( string separator , string str )
```

Usage:

Uses a specific separator to link the value in str.

Parameter description:

- · Separator: a String type constant. Constants of other types or non-constants can throw exceptions.
- Str: String type. If the input is String type, it is converted to Double type and is counted in operation. If it is another data type, an exception is thrown.

Return value:

Returns the String type.

Note:

For the sentence `select wm_concat (',', name ) from test_src`;, if test_src is empty set, this MaxCompute SQL sentence returns NULL.

COLLECT_LIST

Function definition:

```
ARRAY collect_li st ( col )
```

Usage:

Within a given group, the expression specified by col is used to aggregate the data into an array.

Parameter description:

col: A table column can be any data type.

Return value:

Returns the ARRAY type.

Note:

Please add `set odps . sql . type . system . odps2 = true ;` in front of the SQL statement that uses this function, and submit it with SQL to use the new data type normally.

COLLECT_SET

Function definition:

```
ARRAY collect_se t ( col )
```

Usage:

Within a given group, the expression specified by col is used to aggregate the data into an array of non-repeating elements.

Parameter description:

col: A table column can be any data type.

Return value:

Return ARRAY type.

Note:

Please add `set odps . sql . type . system . odps2 = true` ; in front of the SQL statement that uses this function and submit it with SQL to use the new data type function normally.

4.14.6 String functions

This article introduces the string functions such as CHAR_MATCHCOUNT, CHR, CONCAT, GET_JSON_OBJECT, INSTR, IS_ENCODING supported by MaxCompute.

CHAR_MATCHCOUNT

Command format:

```
bigint char_match count ( string str1 , string str2 )
```

Usage:

Calculates the total number of times each character in str1 is duplicated in str2.

Parameter description:

- str1, str2: String type, must be effective UTF-8 strings. If invalid character is in matching process, return a negative value.
- Return value: Bigint type, Any NULL input, return NULL.

Example:

```
 char_match count (' abd ',' aabc ') = 2
-- Two strings ' a ', ' b ' in str1 appear in str2 .
```

CHR

Command format:

```
string chr ( bigint ascii )
```

Usage:

Convert the specified ASCII code ‘ascii’ into character.

Parameter description:

- ascii: Bigint type ASCII value. If the input is ‘string’ or ‘double’, it is converted to ‘bigint’ by implicit conversion. If the input is other types, an exception is thrown.
- Return value: String type. The parameter value range is [0,255]. An exception is thrown if exceeding this range. If the input is NULL, return NULL.

CONCAT

Command format:

```
string  concat ( string  a ,  string  b ...)
```

Usage:

The return value is a result of connecting all strings.

Parameter description:

- a, b··· String type. If the input is Bigint, Double, Decimal or Datetime, it is converted to String by implicit conversion. If the input is other types, an exception is thrown.
- String: Return value: String type. If no parameter exists or a certain parameter is NULL, return NULL.

Example:

```
concat (' ab ',' c ') = ' abc '
concat () =  NULL
concat (' a ',  null , ' b ') =  NULL
```

GET_JSON_OBJECT

Command format:

```
STRING  GET_JSON_O  BJECT ( STRING  json , STRING  path )
```

Usage:

In a standard json string, the specified string is extracted according to the path.

Parameter description:

- json: String type, standard json format string.
- path: String type, describing the path in json, starting with a dollor sign ($). For a description of the new implementation, see JsonPath.
  - $: Root object
  - . : Child operator
  - [] : Subscript operator for array
  - * : Wildcard for []
- String: Returns string type.

Note:

- Return NULL if json is null or invalid json format.
- Return NULL if path is null or invalid (does not exist in json).
- If json is valid and path also exists, the corresponding string is returned.

Example:

```
+-----+
 json
+-----+
{" store ":
{" fruit ":[{" weight ": 8 ," type ":" apple "},{" weight ": 9 ," type
 ":" pear "}],
" bicycle ":{" price ": 19 . 95 ," color ":" red "}
},
" email ":" amy @ only_for_j  son_udf_te  st . net ",
" owner ":" amy "
}
```

Use the following query process to extract information in the JSON object:

```
 odps >  SELECT   get_json_o  bject ( src_json . json , '$. owner ')
 FROM   src_json ;
 amy
 odps >  SELECT   get_json_o  bject ( src_json . json , '$. store .
 fruit \[ 0 ]')  FROM   src_json ;
{" weight ": 8 ," type ":" apple "}
 odps >  SELECT   get_json_o  bject ( src_json . json , '$.
 non_exist_  key ')  FROM   src_json ;
 NULL
```

Example:

```
 get_json_o  bject ('{" array ":[[" aaaa ", 1111 ],[" bbbb ", 2222 ],
[" cccc ", 3333 ]]}','$. array [ 1 ][ 1 ]')= " 2222 "
 get_json_o  bject ('{" aaa ":" bbb "," ccc ":{" ddd ":" eee "," fff
 ":" ggg "," hhh ":[" h0 "," h1 "," h2 "]}," iii ":" jjj "}','$. ccc .
 hhh [*]') = "[" h0 "," h1 "," h2 "]"
 get_json_o  bject ('{" aaa ":" bbb "," ccc ":{" ddd ":" eee "," fff
 ":" ggg "," hhh ":[" h0 "," h1 "," h2 "]}," iii ":" jjj "}','$. ccc .
 hhh [ 1 ]') = " h1 "
```

INSTR

Command format:

```
 bigint   instr ( string   str1 ,  string   str2 [,  bigint
 start_posi  tion [,  bigint   nth_appear  ance ]])
```

Usage:

Calculates where substring str2 is located in str1.

Parameter description:

- str1: String type. If the input is Bigint, Double, Decimal or Datetime, it is converted to String by implicit conversion. If the input is other types, an exception is thrown.
- str2: String type. If the input is Bigint, Double, Decimal or Datetime, it is converted to String by implicit conversion. If the input is other types, an exception is thrown.
- start_position: Bigint type, for other types, an exception is thrown. It indicates from which character of str1 a search must be started from and the default starting position is the first character position 1. If it is less than 0, it causes abnormality.
- nth_appearance: bigint type, greater than 0, represents position of the second match of a substring in the string. If the chain is of a different type or less than or equal to 0, an exception is thrown.
- Return value: Bigint type.

Note:

- If str2 is not found in str1, return 0.-
- If any input parameter is null, return null
- If str2 is NULL and always can be matched successfully, instr (‘abc’ , ‘’) returns 1.

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
```

IS_ENCODING

Command format:

```
boolean   is_encodin  g ( string   str ,  string   from_encod  ing ,
string   to_encodin  g )
```

Usage:

Determine whether the input string ‘str’ can be changed into a character set ‘to_encoding’ from a specified character set ‘from_encoding’ . It can be used to Determine whether the input is garbled. The common use is to set ‘from_encoding’ to be ‘utf-8’ and ‘to_encoding’ to be ‘gbk’ .

Parameter description:

- str: String type, if the input is NULL, return NULL. The empty string can be assumed to be belonged to any character set.
- from_encoding, to_encoding: String type, source, destination character sets. If the input is NULL, return NULL.
- Return value: Boolean type. If 'str' can be converted successfully, return true, otherwise, return false.

Example:

```
 is_encodin  g (' test ', ' utf - 8 ', ' gbk ') =  true
 is_encodin  g (' test ', ' utf - 8 ', ' gbk ') =  true
--  These   two   traditiona  l   Chinese   characters   are   in
 GBK   stock   in   China .
 is_encodin  g (' test ', ' utf - 8 ', ' gb2312 ') =  false
--  The   grapheme   inventory   of  ' GB2312 '  does   not   contain
   these   two   Chinese   characters .
```

KEYVALUE

Command format:

```
KEYVALUE ( STRING   srcStr , STRING   split1 , STRING   split2 ,
STRING   key )
KEYVALUE ( STRING   srcStr , STRING   key ) // split1  = ";",  split2
= ":"
```

Usage:

split 'srcStr' into 'key-value' pairs by split1 and separate 'key-value' pairs by split2. Return the value corresponding to key.

Parameter description:

- srcStr: Source string to be split.
- key: Specified to return the nth string. After the source string is split by 'split1' and 'split2', return the corresponding value according to the specification of the 'key' value.
- split1, split2: Strings used as delimiters by which 'srcStr' is split. If these two parameters are not specified in the expression, the default value of 'split1' is ';' and that of 'split2' is ':'. If a string that has been split by split1 and has multiple split2, the return result is not defined.

Return value:

- String type.
- If 'split1' or 'split2' is NULL, return NULL.

- If ‘scrStr’ and ‘key’ are NULL or in case of no matched ‘key’, return NULL.
- If multiple ‘key-value’ matches, return the value corresponding to the first matched key.

Example 1:

```
keyvalue (' 0 : 1 \; 1 : 2 ',  1 ) = ' 2 '
```

Note:

The source string is "0:1\;1:2". As split1 and split2 are not specified, the default split1 is ";" and split2 is ":".

After the 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.

Example 2:

```
keyvalue ("\; decreaseSt  ore : 1 \; xcard : 1 \; isB2C : 1 \; tf
: 21910 \; cart : 1 \; shipping : 2 \; pf : 0 \; market : shoes \;
instPayAmo  unt : 0 \;","\;",":"," tf ") = " 21910 "  value : 21910 .
```

Note:

The source string is as follows:

```
“\; decreaseSt  ore : 1 \; xcard : 1 \; isB2C : 1 \; tf : 21910 \;
 cart : 1 \; shipping : 2 \; pf : 0 \; market : shoes \; instPayAmo
 unt : 0 \;”
```

The key-value pairs derived from the split after splitting according to the split1 '\;' are as follows:

```
decreaseSt  ore : 1 ,  xcard : 1 ,  isB2C : 1 ,  tf : 21910 ,  cart :
1 ,  shipping : 2 ,  pf : 0 ,  market : shoes ,  instPayAmo  unt : 0
```

After you split, follow the split2 ":", the results are as follows:

```
decreaseSt  ore   1
 xcard   1
 isB2C   1
 tf   21910
 cart   1
 shipping   2
```

```
pf    0
market    shoes
instPayAmo   unt    0
```

The value of the key parameter is "tf", the return value of the corresponding value parameter is 21910.

LENGTH

Command format:

```
bigint   length ( string   str )
```

Usage:

Return the length of a string.

Parameter description:

- str: String type. If the input is Bigint, Double, Decimal or Datetime, it is converted to String by implicit conversion. If the input is other types, an exception is thrown.
- Return value: Bigint type. If 'str' is NULL, return NULL. If 'str' is non UTF-8 coding format, return -1.

Example:

```
length (' hi !  China ') =  6
```

LENGTHB

Command format:

```
bigint   lengthb ( string   str )
```

Usage:

Return the length of 'str' and its unit is byte.

Parameter description:

- str: String type. If the input is Bigint, Double, Decimal or Datetime, it is converted to String by implicit conversion. If the input is other types, an exception is thrown.
- Return value: Bigint type. If 'str' is NULL, return NULL.

Example:

```
lengthb (' hi !   China ') =  10
```

MD5

Command format:

```
string   md5 ( string   value )
```

Usage:

Calculate the md5 value of input string.

Parameter description:

- value: String type. If the input value is of the Bigint, Double, Decimal or Datetime type, it is implicitly converted to the String type before calculation. If the input value is of another type, an exception is thrown. If the input is NULL, return NULL.
- Return value: String type.

REGEXP_EXTRACT

Command format:

```
string   regexp_ext  ract ( string   source ,  string   pattern [,
bigint   occurrence ])
```

Usage:

Split the string source according to pattern (regular expression rules), and return the characters of the occurrence(nth) group.

Parameter description:

- source: String type, a string to be searched.
- pattern: A string type constant. If pattern is a null string, an exception is thrown. If ‘group’ is not specified in pattern, then also an exception is thrown.
- Occurrence: A bigint type constant, must be greater than 0 or equal to 0. If it is other type or less than 0, an exception is thrown. If not specified, the default value is 1, which indicates returning the first group. If ‘occurrence’ is equal to 0, then return substrings that satisfy the entire ‘pattern’.
- Return value: String type. Any input is NULL, return NULL.

Example:

```
regexp_ext  ract (' foothebar ', ' foo (. *?)(  bar )',  1 ) =  the
```

```
 regexp_ext  ract (' foothebar ', ' foo (. *?)(  bar )',  2 ) =  bar
 regexp_ext  ract (' foothebar ', ' foo (. *?)(  bar )',  0 ) =
 foothebar
 regexp_ext  ract (' 8d99d8 ', ' 8d (\\ d +) d8 ') =  99
--  If   regular   SQL   is   submitted   on   MaxCompute ,  two  "\"
 must   be   used   as   the   shift   character .
 regexp_ext  ract (' foothebar ', ' foothebar ')
--  The   exception   is   thrown . ‘ group ’  is   not   specified
 in  ‘ pattern ’.
```

REGEXP_INSTR

Function definition:

```
bigint   regexp_ins  tr ( string   source ,  string   pattern [,
bigint   start_posi  tion [,  bigint   nth_occurr  ence [,  bigint
return_opt  ion ]]])
```

Usage:

Returns the start position/end position of the substring, which matches the pattern with the source from start_position and nth_occurrence.. Any input parameter is null , return null.

Parameter description:

- **source: String type, to be searched.**
- **pattern: A string type constant. If ‘pattern’ is null, an exception is thrown.**
- **start_position: Bigint type constant, the start position of search. If it is not specified, default value is 1. If it is other type or a value is less than or equal to 0, an exception is thrown.**
- **nth_occurrence: A bigint type constant. If not specified, the default value is 1. It appears at the first position, when searched. If it is less than or equal to 0 or other type, an exception is thrown.**
- **return_option: A bigint type constant. Its value is 0 or 1. If it is other type or an invalid value, an exception is thrown. 0 indicates returning the start position of the matched value. 1 indicates returning the end position of the matched value.**
- **Return value: Bigint type, the start or end position of a matched substring in source specified by return_option.**

Example:

```
regexp_ins  tr (" i   love   www . taobao . com ", " o [[: alpha :]]{
1 }",  3 ,  2 ) =  14
```

REGEXP_REPLACE

Command format:

```
string   regexp_rep  lace ( string   source ,  string   pattern ,
string   replace_st  ring [,  bigint   occurrence ])
```

Usage:

replace the substring in source which is matched ‘pattern’ for nth occurrence to be a specified string ‘replace_string’ and then return.

Parameter description:

- source: String type, a string to be replaced.
- pattern: String type constant. The pattern to be matched. If it is null, an exception is thrown.
- replace_string: String type, the string after replacing matched pattern.
- occurrence: Bigint type constant, must be greater than or equal to 0. It indicates replacing nth matching to be replace_string. If it is 0, it indicates all matched substrings have been replaced. If it is other type or less than 0, an exception is thrown. It can be 0 by default.
- Return value: String type. When referencing a group which is not existent, do not replace the string. Returns NULL when the source, pattern, occurrence parameter is entered as null, returns NULL, replace_string is null, but pattern will not match, if the replace_string is null and the pattern is matched, returns the original string.

Note:

When the reference group does not exist, it is considered to be undefined.

Example:

```
regexp_rep  lace (" 123 . 456 . 7890 ", "([[: digit :]]{ 3 })\\.([[:
digit :]]{ 3 })\\.([[: digit :]]{ 4 })",
"(\\ 1 )\\ 2 -\\ 3 ",  0 ) = "( 123 ) 456 - 7890 "
regexp_rep  lace (" abcd ", "(.)", "\\ 1  ",  0 ) = " a   b   c   d
"
regexp_rep  lace (" abcd ", "(.)", "\\ 1  ",  1 ) = " a   bcd "
regexp_rep  lace (" 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
 nonexisten t group is not defined .
 regexp_rep lace (" abcd ", "(. *)(.)$", "\\ 2 ", 0 ) = " d "
 regexp_rep lace (" abcd ", " a ", "\\ 1 ", 0 ) = " bcd "
-- No group definition is in pattern , so '\ 1 '
 references a nonexisten t group ,
 -- Please avoid this . The result to reference
 nonexisten t group is not defined .
```

REGEXP_SUBSTR

Command format:

```
string regexp_sub str ( string source , string pattern [,
bigint start_posi tion [, bigint nth_occurr ence ]])
```

Usage:

Starting from start_position, find a substring in source which matches with a specified pattern for the nth occurrence.

Parameter description:

- source: String type, string to be searched.
- pattern: A string type constant. The pattern to be matched. If it is null, an exception is thrown.
- start_position: A Bigint type constant, must be greater than 0. Other types or less than equal to 0 throw exceptions. If not specified the default value is 1, which indicates a match begins with the first character of source. If not specified, default value is 1. It indicates a matching value from the first character of source.
- nth_occurrence: a Bigint type constant, must be greater than 0. If not specified, the default value is 1. It indicates the return substring of the first matched value. If not specified, the default value is 1. It indicates the return substring of the first matched value.
- Return value: String type. Any input parameter is NULL, return NULL. If no matching record exists, return NULL.

Example:

```
regexp_sub str (" I love aliyun very much ", " a [[: alpha
:]]{ 5 }") = " aliyun "
regexp_sub str (' I have 2 apples and 100 bucks !', '[[:
blank :]][[: alnum :]]*', 1 , 1 ) = " have "
```

```
regexp_sub str (' I have 2 apples and 100 bucks !', '[[:
blank :]][[: alnum :]]*', 1 , 2 ) = " 2 "
```

REGEXP_COUNT

Command format:

```
bigint regexp_cou nt ( string source , string pattern [,
bigint start_posi tion ])
```

Usage:

Counts the number of occurrences that a substring matches with a specified pattern, starting from start_position in source.

Parameter description:

- Source: String type, the string to be searched. If it is the other type, an exception is thrown.
- Pattern: String type constant, the pattern to be matched. If it is a null string or other data type, an exception is thrown.
- start_position: Bigint type constant, must be greater than 0. If it is other data type or a value which is less than or equal to 0, an exception is thrown. If not specified , default value is 1, which indicates a matched value from the first character of source.
- Return value: Bigint type. If matching does not exists, return 0. If any input parameter is null, return null.

Example:

```
regexp_cou nt (' abababc ', ' a . c ') = 1
regexp_cou nt (' abcde ', '[[: alpha :]]{ 2 }', 3 ) = 1
```

SPLIT_PART

Command format:

```
string split_part ( string str , string separator , bigint
start [, bigint end ])
```

Usage:

Split the string str according to the separator and return the substring from nth start part to nth end part.

Parameter description:

- str: String type, the string to be split. If it is Bigint, Double, Decimal or Datetime , it is converted to a String in an implicit conversion. If it is other data type, an exception is thrown.
- separator: A string type constant, the separator used to split the string. It can be a character or a string. If it is other data type, an exception is thrown.
- start: A bigint type constant, must be greater than 0. If it is not a constant or other data type, an exception is thrown. It indicates the start number of the return part (start from 1). If the end is not specified, returns the part specified by ‘start’ .
- ‘end’ : A bigint type constant, must be greater than or equal to ‘start’ , otherwise an exception is thrown. It refers to the end number of the return part. If it is not a constant or is other data type, then also an exception is thrown. It can be excluded as it indicates the last part.

Return value: String type. If any parameter is null, return null. If separator is an empty string, return the source string str.

Note:

- If ‘delimiter’ does not exist in str, then specify ‘start’ as 1, and return the entire str. If the input value is an empty string, the output value is an empty string.
- If the start value is greater than the number of parts after split, for example, the split produces 6 parts but the ‘start’ value is greater than 6, then returns an empty string.

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 ) = ''
```

SUBSTR

Command format:

```
string substr ( string str , bigint start_posi tion [,
bigint length ])
```

Usage:

Returns a substring of ‘str’ from start_position with the given length.

Parameter description:

- ‘str’ : String type. If the input is Bigint, Double, Decimal or Datetime, it is converted to String in an implicit conversion. If it is other data type, an exception is thrown.
- The start_position:Bigint type starts at 1. Returns empty strings when start_posi tion is 0.When start_position is negative, the starting position is counted backwards from the end of the string, the last character is -1, and the previous number is -2,-3 and so on. Other types throw exceptions.
- length: Bigint type, must be greater than 0. If it is other type or less than 0, an exception is thrown. This parameter indicates the length of a child string.
- Return value: String type. If the input is NULL, return NULL.

Note:

If the length is excluded, return the substring from start to end.

Example:

```
substr (" abc ",  2 ) = " bc "
substr (" abc ",  2 ,  1 ) = " b "
substr (" abc ",- 2 , 2 )=" bc "
substr (" abc ",- 3 )=" abc "
```

SUBSTRING

Command format:

```
string   substring ( string | binary   str ,  int   start_posi  tion
[,  int   length ])
```

Usage:

Returns the substring of ‘str’ from start_position with the given length.

Parameter description:

- str: String or Binary type, returns NULL or throws an exception for the other type
- ‘start_position’ : Int type, starting at 1. Returns empty strings when start_posi tion is 0.When start_position is negative, the starting position is counted backwards from the end of the string, the last character is-1, and the previous number is in turn-2,-3 and so on. Other types throw exceptions.
- length: Bigint type, must be greater than 0. If it is other type or less than 0, an exception is thrown. This parameter indicates the length of the child string.
- Return value: String type. If the input is NULL, return NULL.

Note:
If the length is excluded, return the substring from start to end.

For example:

```
substring (' abc ',  2 ) = ' bc '
substring (' abc ',  2 ,  1 ) ='" b '
substring (' abc ',- 2 , 2 )=' bc '
substring (' abc ',- 3 , 2 )=' ab '
substring ( BIN ( 2345 ), 2 , 3 )=' 001 '
```

TOLOWER

Command format:

```
string   tolower ( string   source )
```

Usage:

Input the lowercase string corresponding to the English string source.

Parameter description:

- Source: String type. If the input is Bigint, Double, Decimal or Datetime, it is converted to String in an implicit conversion. If it is other data type, an exception is throwm.
- Return Value: String type. If the input is NULL, return NULL.

Example:

```
tolower (" aBcd ") = " abcd "
tolower (" Haha   Cd ") = " haha   cd "
```

TOUPPER

Command format:

```
string   toupper ( string   source )
```

Usage:

Output the uppercase string corresponding to the English string 'source'.

Parameter description:

- Source: String type. If the input is Bigint, Double, Decimal or Datetime, it is converted to String in an implicit conversion. If it is other data type, an exception is throwm.

- Return Value: String type. If the input is NULL, return NULL.

Example:

```
toupper (" aBcd ") = " ABCD "
toupper (" HahaCd ") = " HAHACD "
```

TO_CHAR

Command format:

```
string   to_char ( boolean   value )
string   to_char ( bigint   value )
string   to_char ( double   value )
string   to_char ( decimal   value )
```

Usage:

Convert Boolean type, Bigint type or Double type to corresponding String type.

Parameter description:

- Value: Boolean, Bigint or Double type is acceptable. If it is other data type, an exception is thrown. For formatted output of the datetime type, see another function TO_CHAR that has the same name.
- Return value: String type. If the input is NULL, return NULL.

Example:

```
to_char ( 123 ) = ' 123 '
to_char ( true ) = ' TRUE '
to_char ( 1 . 23 ) = ' 1 . 23 '
to_char ( null ) =  NULL
```

TRIM

Command format:

```
string   trim ( string   str )
```

Usage:

Removes left space and right space for the input string str.

Parameter description:

- ‘str’: String type. If the input is Bigint, Double, Decimal or Datetime, it is converted to String in an implicit conversion. If it is other data type, an exception is throwm.
- Return value: String type. If the input is NULL, return NULL.

LTRIM

Command format:

```
string   ltrim ( string   str )
```

Usage:

Removes the left space for the input string str.

Parameter description:

- 'str': String type. If the input is Bigint, Double, Decimal or Datetime, it is converted to String in an implicit conversion. If it is other data type, an exception is throwm.
- Return value: String type. If the input is NULL, return NULL.

Example:

```
select   ltrim ('  abc  ')  from   dual ;
Returns :
+-----+
|  _c0  |
+-----+
|  abc  |
+-----+
```

RTRIM

Command format:

```
string   rtrim ( string   str )
```

Usage:

Removes the right space for the input string str.

Parameter description:

- 'str': String type. If the input is Bigint, Double, Decimal or Datetime, it is converted to String in an implicit conversion. If it is other data type, an exception is throwm.
- Return value: String type. If the input is NULL, return NULL.

Example:

```
select   rtrim (' a   abc  ')  from   dual ;
Returns :
+-----+
|  _c0  |
+-----+
```

```
| a   abc  |
+------+
```

REVERSE

Command format:

```
STRING   REVERSE ( string   str )
```

Usage:

Returns a reversed-order string.

Parameter description:

- str: String type. If the input is Bigint, Double, Decimal or Datetime, it is converted to String in an implicit conversion. If it is other data type, an exception is throwm.
- Return value: String type. If the input is NULL, return NULL.

Example:

```
 select   reverse (' abcedfg ')  from   dual ;
 Returns :
+------+
|  _c0  |
+------+
|  gfdecba  |
+------+
```

SPACE

Command format:

```
STRING   SPACE ( bigint   n )
```

Usage:

A space string function that returns a string of length n.

Parameter description:

- n: Bigint type. The length cannot exceed 2 MB. If it is NULL, an exception is thrown .
- Return value: String type.

Example:

```
select   length ( space ( 10 ))  from   dual ; ---- Returns   10 .
```

```
select   space ( 4000000000  00 )  from   dual ; ---- Error ,  the
length   exceeds   2   MB .
```

REPEAT

Command format:

```
STRING   REPEAT ( string   str ,  bigint   n )
```

Usage:

Returns the str string that is repeated for n times.

Parameter description:

- ‘str’ : String type. If the input is Bigint, Double, Decimal or Datetime, it is converted to String in an implicit conversion. If it is other data type, an exception is throwm.
- n: Bigint type. The length does not exceed 2 MB. If it is NULL, an exception is thrown.
- Return value: String type.

Example:

```
select   repeat (' abc ', 5 )  from   lxw_dual ;
Returns : abcabcabca  bcabc
```

ASCII

Command format:

```
Bigint   ASCII ( string   str )
```

Usage:

Returns the ascii of the first character of str.

Parameter description:

- str: String type. If the input is Bigint, Double, Decimal or Datetime, it is converted to String in an implicit conversion. If it is other data type, an exception is throwm.
- Return value: Bigint type.

Example:

```
select   ascii (' abcde ')  from   dual ;
```

```
Returns : 97
```

Maxcomputerte2.0 Extension function

With the upgrade to MaxCompute 2.0, some mathematical functions have been added to the product. If a new function uses a new data type, you must add the following set statement before using the new functions SQL statement:

```
set  odps . sql . type . system . odps2 = true ;
```

Note:
Add set odps before the SQL statement that uses the function `set  odps . sql . type . system . odps2  =  true ;`, and commit runs with SQL to use the new data type function normally.

The enhanced and extended string functions are described as follows.

CONCAT_WS

Command format:

```
string  concat_ws ( string  SEP , string  a , string  b ...)
string  concat_ws ( string  SEP , array )
```

Note:
Add set odps before the SQL statement that uses the function `set  odps . sql . type . system . odps2  =  true ;`, and commit runs with SQL to use the new data type function normally.

Usage:

Concatenates all strings in the parameters, connected by the specified delimiter.

Parameter description:

- SEP: String-type delimiter. If not specified, an exception is returned.

Return value:

String type. If no parameters exist or any parameter is null, return null.

Example:

```
concat_ws (':',' name ',' hanmeimei ')=' name : hanmeimei '
```

```
concat_ws (':',' avg ', null ,' 34 ')= null
```

LPAD

Command format:

```
string  lpad ( string  a ,  int  len ,  string  b )
```

Note:
Add set odps before the SQL statement that uses the function `set odps . sql . type . system . odps2 = true ;`, and commit runs with SQL to use the new data type function normally.

Usage:

Uses string b to pad string a to the left to the place specified by len.

Parameter description:

- len: Int-type integer.
- a/b···: String type.

Return value:

String type. If len is smaller than the number of places in a, a is truncated from the left to obtain a string with the number of places specified by len. If len is 0, return empty.

Example:

```
lpad (' abcdefgh ', 10 ,' 12 ')=' 12abcdefgh '
lpad (' abcdefgh ', 5 ,' 12 ')=' abcde '
lpad (' abcdefgh ', 0 ,' 12 ')  Returns  a  blank  result
```

RPAD

Command format:

```
string  rpad ( string  a ,  int  len ,  string  b )
```

Note:
Add set odps before the SQL statement that uses the function `set odps . sql . type . system . odps2 = true ;`, and commit runs with SQL to use the new data type function normally.

Usage:

Uses string b to pad string a to the right to the place specified in len.

Note:

You need to add the set odps statement before the SQL statement that uses the function `set odps . sql . type . system . odps2 = true` , otherwise the error is reported.

Parameter description:

- len: Int-type integer.
- a/b···: String type.

Return value:

String type. If len is smaller than the number of places in a, a is truncated from the left to obtain a string with the number of places specified by len. If len is 0, return empty.

Example:

```
rpad (' abcdefgh ', 10 ,' 12 ')=' abcdefgh12 '
rpad (' abcdefgh ', 5 ,' 12 ')=' abcde '
rpad (' abcdefgh ', 0 ,' 12 ')  Returns   a   blank   result
```

REPLACE

Command format:

```
string   replace ( string   a ,  string   OLD ,  string   NEW )
```

Note:

Add set odps before the SQL statement that uses the function `set odps . sql . type . system . odps2 = true` ;, and commit runs with SQL to use the new data type function normally.

Usage:

Uses string NEW to replace the portion of string a that completely matches string OLD and returns string a.

Parameter description:

The parameters are all String type.

Return value:

String type. If the input is null, return null.

Example:

```
replace (' ababab ',' abab ',' 12 ')=' 12ab '
replace (' ababab ',' cdf ',' 123 ')=' ababab '
replace (' 123abab456  ab ', null ,' abab ')= null
```

SOUNDEX

Command format:

```
string  soundex ( string  a )
```

Note:
Add set odps before the SQL statement that uses the function `set odps . sql . type . system . odps2 = true ;`, and commit runs with SQL to use the new data type function normally.

Usage:

Converts a normal string to a soundex string.

Parameter description: a is of type String.

Return value: String type. If the input value is NULL, return NULL.

Example:

```
soundex (' hello ')=' H400 '
```

SUBSTRING_INDEX

Command format:

```
string  substring_  index ( string  a , string  SEP ,  int
count ))
```

Note:
Add set odps before the SQL statement that uses the function `set odps . sql . type . system . odps2 = true ;` and commit runs with SQL to use the new data type function normally.

Usage:

Truncates string a to the portion in front of the delimiter specified by count. If count is positive, the portion to the left of the delimiter is used. If count is negative, the portion to the right is used.

Parameter description: a/sep belong to the string type, and count belongs to the int type.

Return value:

String type. If the input is null, return null.

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
```

4.14.7 Other functions

This article shows you how to use functions such as cast, decode, least, array, split, map, and so on.

CAST

Function definition:

```
cast ( expr   as  < type >)
```

Convert the result of expression to object type. For example, cast (‘1’ as bigint) is to convert string ‘1’ to bingint ‘1’ . If the conversion is unsuccessful or the conversion is not supported, an exception occurs.

Note:

- cast (double as bigint) converts double type value to bigint type value.
- 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 composed of numerals expressed in the float or exponent form, it will be converted into a value of the double type first and then into a value of the bigint type.

- cast(string as datetime) or cast(datetime as string) adopts the default format `yyyy - mm - dd hh : mi : ss`.

COALESCE

Function definition:

```
coalesce ( expr1 ,  expr2 , ...)
```

Usage:

Return the first value which is not NULL from the list. If all values in the list are NULL , return NULL.

Parameter description:

expr: value to be tested. All these values have the same data type or be NULL, otherwise an expection occurs.

Return value:

Return value type is the same as parameter type.

> Note:
> There must be one parameter at least, otherwise an exception occurs.

DECODE

Function definition:

```
decode ( expression ,  search ,  result [,  search ,  result ]...[,
default ])
```

Usage:

Implement the selection function of if-then-else branch.

Parameter description:

- expression: expression to be compared.
- search: A search string to be compared with the expression.
- result: the returned value when the values of search and expression match.
- default: it is optional. If all search items do not match the expression, return this default value. If it is not specified, return NULL.

Return Value:

- return matched search.
- If no matching record exists, return default.
- If default is not specified, return NULL.

Note:

- You must specify at least three parameters.
- All of the result types must be the same or NULL. Inconsistent data type causes an exception. All of the search and expression types must be consistent, otherwise an exception is reported.
- If the option search in decode has repeated record and has been matched, return the first value.

Example:

```
Select
decode ( customer_i  d ,
1 , ' Taobao ',
2 , ' Alipay ',
3 , ' Aliyun ',
Null , ' N / A ',
' Others ')  as   result
from   sale_detai  l ;
```

The decode function mentioned previously implements the function in following if-then-else sentence:

```
if   customer_i  d  =  1   then
result  := ' Taobao ';
elsif   customer_i  d  =  2   then
result  := ' Alipay ';
elsif   customer_i  d  =  3   then
result  := ' Aliyun ';
...
else
result  := ' Others ';
end   if ;
```

Note:

- Calculating NULL= NULL by MaxCompute SQL, return NULL, while the values of NULL and NULL are equal in decode function.
- In the preceding example, if the value of `customer_i  d` is NULL, decode function returns N/A as a result.

GET_IDCARD_AGE

Function definition:

```
get_idcard  _age ( idcardno )
```

Usage:

Returns the current age based on the ID number which is the difference of the current year and the year of birth identified in the ID.

Parameter description:

idcardno: String type, ID number of 15-digit or 18-digit. In the calculation, the validity of the ID is checked according to the province code and the last digit, and Null is returned if the check fails.

Return Value:

Returns the Bigint type. Input is Null, returns Null. Returns Null if the difference of the current year and the year of birth is larger than 100.

GET_IDCARD_BIRTHDAY

Function definition:

```
get_idcard  _birthday ( idcardno )
```

Usage:

Returns date of birth based on the ID number.

Parameter description:

idcardno: String type, ID number of 15-digit or 18-digit. In the calculation, the validity of the ID is checked according to the province code and the last digit, and Null is returned if the check fails.

Return Value:

Returns the Datetime type. Input is Null, returns Null.

GET_IDCARD_SEX

Function definition:

```
get_idcard  _sex ( idcardno )
```

Usage:

Returns the gender based on the ID number and the value is either M (male) or F (female).

Parameter description:

idcardno: String type, ID number of 15-digit or 18-digit. In the calculation, the validity of the ID is checked according to the province code and the last digit, and Null is returned if the check fails.

Return Value:

Returns the String type. Input is Null, returns Null.

GREATEST

Function definition:

```
greatest ( var1 ,  var2 , ...)
```

Usage:

Return the greatest input parameter.

Parameter description:

var1/var2: Its type can be Bigint, Double, Decimal, Datetime or String type. If all values are NULL, return NULL.

Return 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 the least value.

  If the input parameter types are different,

  - For Double, Bigint, Decimal and String type, convert them to be Double type.
  - For String and Datetime, convert them to be Datetime type.
  - Other implicit conversion is not allowed.

ORDINAL

Function definition:

```
ordinal ( bigint   nth ,  var1 ,  var2 , ...)
```

Usage:

Return the location value specified by ‘nth’ after the input variables are sorted by small to large.

Parameter description:

- nth: Bigint type, specify the location to return its value. If it is NULL, return NULL.
- var1/var2: Its type can be Bigint, Double, Datetime or String type.

Return Value:

- The value in nth bit. If the implicit conversion is not needed, return type is the same as input parameter type.
- If implicit conversion is in input parameters,
  - For Double, Bigint and String type, convert them to be Double type.
  - For String and Datetime type, convert them to be Datetime type.
  - Other implicit conversion is not allowed.
- NULL is the least value.

Example:

```
ordinal ( 3 ,  1 ,  3 ,  2 ,  5 ,  2 ,  4 ,  6 ) =  2
```

LEAST

Function definition:

```
least ( var1 ,  var2 , ...)
```

Usage:

return the least value in input parameter.

Parameter description:

var1/var2: Its type can be Bigint, Double, Decimal, Datetime or String type. If all values are NULL, return NULL.

Return Value:

- The least value in input parameter; If the implicit conversion is not needed, return type is the same as input parameter type.

- If implicit conversion is in input parameters,
  - For Double, Bigint and String type, convert them to be Double type.
  - For 'string' type and 'datetime' type, convert them to be 'datetime' type.
  - Converts to Decimal type when Decimal type compares to Double, Bigint or String type.
  - Other implicit conversion is not allowed.
- NULL is the least value.

MAX_PT

Function definition:

```
max_pt ( table_full  _name )
```

Usage:

For a partitioned table, this function returns the maximum value of the level-one partition of the partitioned table, which is sorted alphabetically, and there is a corresponding data file for the partition.

Parameter description:

table_full_name: String type, specifys the name of table, which must be with the name of project, for example: prj.src). You must own read permission on this table.

Return Value:

Return value: Returns the value of the largest level-one partition.

Example:

Example: Suppose that 'tbl' is a partitioned table, all partitions of the table are as follows, and there are data files:

```
pt  =‘ 20120901 ’
pt  =‘ 20120902 ’
```

In the following statement, the return value of `max_pt` is '20120902', and the MaxCompute SQL statement reads the data in 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.

UUID

Function definition:

```
string   uuid ()
```

Usage:

Return a random ID. Example: `29347a88 - 1e57 - 41ae - bb68 - a9edbdd942 12`.

Note:
UUID returns a random global ID with a low probability of duplication.

SAMPLE

Function definition:

```
boolean   sample ( x ,  y ,  column_nam  e )
```

Usage:

sample all values of column_name according to the setting of x and y and filter out the rows which do not meet the sampling condition.

Parameter description:

- x, y: Bigint type, indicates hash to x portions, take yth portions. y can be ignored.
  - If y is ignored, take the first portion. If y in parameter is ignored, then column_name is ignored at the same time.
  - x and y are Bigint constants and greater than 0. If it is other data type or less than or equal to 0, an exception is thrown. If y&gt, x exception is also thrown. If any input of x and y is NULL, return NULL.
- column_name: the destination column to be sampled.
  - column_name can be omitted, in which case, a random sample is taken according to the values of x and y.
  - It can be any data type and the column value can be NULL. Do not need implicit type conversion.
  - If column_name is the constant NULL, an exception is reported.

Return Value:

Boolean type.

Note:

To avoid data skew brought by NULL value, NULL values in column_name will be carried out a uniform hash in x portions. 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:

Suppose that the table tbla is existent and a column cola is in this table:

```
select * from tbla where sample ( 4 , 1 , cola ) = true
;
-- The values are carried out Hash into 4 portions
and take the first portion .
select * from tbla where sample ( 4 , 2 ) = true ;
-- The values do random Hash into 4 portions for
each row of data and take the second portion .
```

CASE WHEN EXPRESSION

MaxCompute provides two kinds of case when syntax formats, as follows:

```
case
when ( _condition 1 ) then result1
when ( _condition 2 ) then result2
...
else resultn
end
case
when ( _condition 1 ) then result1
when ( _condition 2 ) then result2
when ( _condition 3 ) then result3
...
else resultn
end
```

Case when expression can return different values according to the computing result of expression values flexibly.

The following sentences is used to get the region according to different shop_name:

```
select
case
when shop_name is null then ' default_re gion '
when shop_name like ' hang %' then ' zj_region '
end as region
```

```
From   sale_detai  l ;
```

Note:

- If the types of result include Bigint and Double, convert them to Double type and then return the result.
- If the types of result include string type, convert them to be string type and then return the result. If the conversion is unsuccessfully, the error is reported. (such as Boolean type).
- Expect these, the conversion between other types is not allowed.

If expression

Function definition:

```
if ( testCondit  ion ,  valueTrue ,  valueFalse  OrNull )
```

Usage:

Judge if testCondition is true. If it is true, return valueTrue, otherwise return valueFalse or Null.

Parameter description:

- testCondition: The expression to be judged. Boolean type.
- valueTrue: It returns when the expression testCondition is true.
- valueFalseOrNull: It returns when the expression testCondition is not true and also can be null.

Return Value:

The return type is the same as the valueTrue or valueFalseOrNul type.

Example:

```
select   if ( 1 = 2 , 100 , 200 )  from   dual ;
-- Returned   results :
+ ------------ +
|  _c0  |
+------------+
|  200  |
```

```
+------------+
```

SPLIT

Function definition:

```
split ( str ,  pat )
```

Purpose: After the STR is split by Pat, the array is returned.

Parameter description:

- str: String type, specifies the string to be separated.
- pat: String type, specifies the delimiter, supports regular expressions.

Return Value:

`array  < string >`

The result is the elements in str separated by pat.

Example:

```
 select   split (" a , b , c ",",")  from   dual ;
 Results :
+-------+
|  _c0  |
+-------+
| [ a ,  b ,  c ] |
+-------+
```

Note:

Set commands supported by MaxCompute SQL and MapReduce for MaxCompute 2.0

- Once data type such as Tinyint、Smallint、 Int、 Float、Varchar or TIMESTAMP BINARY is involved when running an SQL statement, `set   odps . sql . type . system . odps2 = true ;` must be added before the SQL statement. The set statement and SQL statement are submitted simultaneously.

- Project level: that is, the project level is supported for new type opening. The project owner can be set to project as needed, with the following commands:

```
set  odps . sql . type . system . odps2 = true ;
```

STR_TO_MAP

Function declaration:

```
str_to_map ( text  [,  delimiter1  [,  delimiter2 ]])
```

Purpose: use ‘delimiter1’ to separate ‘text’ into K-V pairs, then use ‘delimiter2’ to separate each K-V pair.

Parameter description

- text: String type, specifies the string to be separated.
- delimiter1: string type, separator that does not specify the default ','.
- delimiter1: string type, separator, default to '=' when not specified '.

Return value: map <string, string >. The elements are the K-V results of the separation of 'text' by the strings 'delimiter1' and 'delimiter2'.

Example:

```
Select  fig  (' test1  & amp ;  1 - test2  &  2  ','-','& amp ;');
```

Return result:

```
+------------+
|  A  |
+------------+
| { Test1 :  1 ,  Test2 :  2 } |
```

EXPLODE

Function definition:

```
explode ( var )
```

Usage:

Converts one row of data into a multi-row UDTF.

- If var is Array type, the array stored in the column is converted to multiple rows.
- If var is Map type, each key-value pair of the map stored in the column is converted to a row with two columns, one column for the key and one for the value.

Parameter description:

```
var : array < T > type or map < K , V > type .
```

Return Value:

Rows after conversion are returned.

Note:

The following restrictions apply when using UDTF:

- One select can only have one UDTF and no other columns can appear.
- It cannot be used with group by, cluster by, distribute by, or sort by.

Example:

```
explode ( array ( null , ' a ', ' b ', ' c ')) col
```

MAP

Function definition:

```
MAP map ( K key1 , V value1 , K key2 , V value2 , ...)
```

Usage:

Uses the given key/value pairs to create a map.

Parameter descriptio:

key/value

- All key types are consistent, including those after implicit conversion, and must be basic.
- All value types are consistent, including those after implicit conversion, and can be of any type.

Return Value:

Returns the map type.

Example:

For example, the fields in t_table are(c1 bigint,c2 string,c3 string, c4 bigint ,c5 bigint), with the following data

```
+------------+----+----+------------+------------+
| c1           | c2  | c3  | c4            | c5            |
+------------+----+----+------------+------------+
| 1000           | k11  | k21  | 86            | 15            |
| 1001           | k12  | k22  | 97            | 2            |
```

```
|  1002         |  k13  |  k23  |  99           |  1            |
+------------+----+----+------------+------------+
```

Execute SQL:

```
select   map ( c2 , c4 , c3 , c5 )  from   t_table ;
```

The result is as follows:

```
+ ---- +
|  _c0  |
+------+
| { k11 : 86 ,  k21 : 15 } |
| { k12 : 97 ,  k22 : 2 } |
| { k13 : 99 ,  k23 : 1 } |
+------+
```

MAP_KEYS

Function definition:

```
ARRAY   map_keys ( map < K ,  V >)
```

Usage:

Returns an array of all the keys in the map parameter.

Parameter description:

map: map type data.

Return value:

Returns the array type, enter null, and null.

Example:

For example, the field of `t_table_ma p` is (`c1   bigint , t_map   map < string , bigint >`), data as follows

```
+------------+-------+
|  C1  |  t_map  |
+ ------------ + ------- +
|  1000         | { k11 : 86 ,  k21 : 15 } |
|  1001         | { k12 : 97 ,  k22 : 2 } |
|  1002         | { k13 : 99 ,  k23 : 1 } |
```

```
+------------+-------+
```

Execute SQL:

```
select   c1 , map_keys ( t_map )  from   t_table_ma  p ;
```

The result is as follows:

```
+------------+------+
|  c1         |  _c1   |
+------------+------+
|  1000        | [ k11 ,  k21 ] |
|  1001        | [ k12 ,  k22 ] |
|  1002        | [ k13 ,  k23 ] |
+------------+------+
```

MAP_VALUES

Function definition:

```
ARRAY   map_values ( map < K ,  V >)
```

Usage:

Returns an array of all the values in the map parameter.

Parameter description:

map: map-type data.

Return Value:

Returns the array type, enter null, and null.

Example:

```
select   map_values ( map (' a ', 123 ,' b ', 456 ));
Results :
[ 123 ,  456 ]
```

ARRAY

Function definition:

```
ARRAY   array ( value1 , value2 , ...)
```

Usage:

Creates an array using the given values.

Parameter description:

value: This parameter can be of any type, but all the values must be of the same type.

Return Value:

Returns the array type.

Example:

For example, the fields in `t_table` are (c1 bigint,c2 string,c3 string, c4 bigint ,c5 bigint), with the following data

```
+------------+----+----+------------+------------+
|  c1          |  c2  |  c3  |  c4          |  c5          |
+------------+----+----+------------+------------+
|  1000        |  k11  |  k21  |  86          |  15          |
|  1001        |  k12  |  k22  |  97          |  2           |
|  1002        |  k13  |  k23  |  99          |  1           |
+------------+----+----+------------+------------+
```

Execute SQL:

```
select   array ( c2 , c4 , c3 , c5 )  from   t_table ;
```

Results:

```
+------+
|  _c0  |
+------+
| [ k11 ,  86 ,  k21 ,  15 ] |
| [ k12 ,  97 ,  k22 ,  2 ] |
| [ k13 ,  99 ,  k23 ,  1 ] |
+ ---- +
```

SIZE

Function definition:

```
INT   size ( map )
INT   size ( array )
```

Usage:

- `size ( map < K ,  V >)` returns the number of K/V pairs in the given map.
- `size ( array < T >)` returns the number of elements in the given array.

Parameter description:

- `map < K ,  V >`: Map-type data.
- `array < T >`: Array-type data.

Return Value:

Returns the Int type.

Example:

```
select size ( map (' a ', 123 ,' b ', 456 )) from dual ;--
Returns 2
select size ( map (' a ', 123 ,' b ', 456 ,' c ', 789 )) from
dual ;-- Returns 3
select size ( array (' a ',' b ')) from dual ;-- Returns 2
select size ( array ( 123 , 456 , 789 )) from dual ;-- Returns
3
```

ARRAY_CONTAINS

Function definition:

```
boolean array_cont ains ( ARRAY < T > a , value v )
```

Usage:

Checks if the given array a contains v.

Parameter description:

- a: Array-type data.
- v: The given v must be of the same type as the data in the array.

Return Value:

Returns the Boolean type.

Example:

If the field of `t_table_ar ray` is (`c1 bigint , t_array array < string >`), the data is as follows:

```
+ ------------ + --------- +
| c1           | t_array  |
+------------+---------+
| 1000         | [ k11 , 86 , k21 , 15 ] |
| 1001         | [ k12 , 97 , k22 , 2 ] |
| 1002         | [ k13 , 99 , k23 , 1 ] |
+------------+---------+
```

Execute SQL:

```
select c1 , array_cont ains ( t_array ,' 1 ') from t_table_ar
ray ;
```

Results:

```
+------------+------+
| c1           | _c1    |
+------------+------+
| 1000         | false  |
| 1001         | false  |
```

```
|  1002        |  true  |
+------------+------+
```

SORT_ARRAY

Function definition:

```
ARRAY   sort_array ( ARRAY < T >)
```

Usage:

This function used to sorts the given array.

Parameter description:

`ARRAY < T >`: Array-type data, the data in the array can be of any type.

Return Value:

Returns the 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   dual ;
Results :
[ a ,  b ,  c ,  f ] [ 2 ,  4 ,  5 ,  5 ,  7 ,  8 ] [ He ,  You ,  Me
 ]
```

Execute SQL

```
Select   sort_array  ( C1 ),  sort_array  ( C2 ),  sort_array  ( C3
)  from   t_array ;
```

Return result:

```
[ a ,  b ,  c ,  f ] [ 2 ,  4 ,  5 ,  5 ,  7 ,  8 ] [ He ,  You ,  Me
 ]
```

POSEXPLODE

Function definition:

```
posexplode ( ARRAY < T >)
```

Usage:

Explodes 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.

Parameter description:

ARRAY: Array-type data, the data in the array can be of any type.

Return Value:

Returns the table generation function.

Example:

```
select   posexplode ( array (' a ',' c ',' f ',' b '))  from   dual ;
Results :
+------------+-----+
|  pos  |  val  |
+------------+-----+
|  0   |   a   |
|  1   |   c   |
|  2   |   f   |
|  3   |   b   |
+------------+-----+
```

STRUCT

Function definition:

```
STRUCT   struct ( value1  , value2  , ...)
```

Usage:

Creates a struct using the given value list.

Parameter description:

value: Each value can be of any type.

Return Value:

Returns the `STRUCT < col1 : T1 ,  col2 : T2 , ... >` Type. field names are sequential: col1, col2, …

Example:

```
select   struct (' a ', 123 ,' ture ', 56 . 90 )  from   dual ;
Results :
{ col1 : a ,  col2 : 123 ,  col3 : ture ,  col4 : 56 . 9 }
```

NAMED_STRUCT

Function definition:

```
STRUCT   named_stru  ct ( string   name1 ,  T1   value1 ,  string
name2 ,  T2   value2 , ...)
```

Usage:

Creates a struct using the given name/value list.

Parameter description:

- value: Each value can be of any type.
- name: Specifies the name of a String-type field.

Return Value:

Returns the `STRUCT < name1 : T1 ,  name2 : T2 , ... >`type. The field names of the generated struct are sequential: name1, name2, …

Example:

```
select   named_stru  ct (' user_id ', 10001 ,' user_name ',' LiLei
',' married ',' F ',' weight ', 63 . 50 )  from   dual ;
Results :
{ user_id : 10001 ,  user_name : LiLei ,  married : F ,  weight : 63 .
5 }
```

INLINE

Command Format:

```
inline ( array < struct < f1 : T1 ,  f2 : T2 , ... >>)
```

as shown in the following figure:

Explodes the given struct array. Each element is given one row and each struct element corresponds to one column in each row.

Parameter description:

`STRUCT < f1 : T1 ,  f2 : T2 , ... >`: The values in the array can be of any type.

Return Value:

Returns the table generation function.

Example:

If the field in Table t_table is (`t_struct   struct < user_id : bigint , user_name : string , married : string , weight : double >` <user_id: bigint,="" user_name:="" string,="" married:="" weight:="" double="">), the table data is as follows:</user_id:>

```
+----------+
|  T_struct  |
+----------+
{ user_id : 10001 ,  user_name : LiLei ,  married : F ,  weight : 63 .
5 }
{ user_id : 10001 ,  user_name : LiLei ,  married : F ,  weight : 63 .
5 }
```

```
+-----------+
```

Execute SQL:

```
select   inline ( array ( t_struct ))  from   t_table ;
```

Return result:

```
+------------+----+----+-----------+-----------+
|  user_id     |  user_name  |  married   |  weight      |
+------------+----+----+-----------+-----------+
|  10001       |  LiLei      |  N         |  63 . 5        |
|  10002       |  HanMeiMei  |  Y         |  43 . 5        |
+------------+----------+--------+-----------+
```

TRANS_ARRAY

Function definition:

```
trans_arra  y  ( num_keys ,  separator ,  key1 , key2 ,…, col1 ,
col2 , col3 )  as  ( key1 , key2 ,…, col1 ,  col2 )
```

Usage:

A UDTF that converts one row of data to multiple rows, and converts an array separated with fixed-separator format in column into multiple rows.

Parameter description:

- num_keys: Bigint type constant, must be larger than or equal to 0. It is used as the number of columns to transpose key when converting to multiple rows.
- Key: Duplicate columns in multiple rows when converting one row to multiple rows.
- separator: String type constant. It is a separator used to split a string into multiple elements. Exception is thrown when it is null.
- keys: As column of key when you transpose. It is specified by num_keys. If num_keys specifies that all columns are keys (that is, num_keys equals the number of all columns), only one row is returned.
- cols: An array to convert to rows. All columns after keys are considered as an array to be transposed. String type. The stored contents are arrays of string format, such as "Hangzhou; Beijing; shanghai", they are arrays separated by ";".

Return Value:

Transposed rows, new column names are specified by as. The type of column that is as key remains unchanged, and all other columns are String type. The number of rows to be split depends on the array that has maximum number, no-value locales are complemented with NULL.

Note:

The following restrictions apply when using UDTF:

- All columns that are considered as keys must be placed front, and columns to be transposed must be placed behind.
- One select can only have one UDTF and no other columns can appear.
- One select can only have one UDTF and no other columns can appear.

Example:

The data in the t_table table is as follows:

```
+----------+---------+-----------+
|  login_id  |  login_ip  |  login_time  |
+----------+---------+-----------+
 wangwangA   192 . 168 . 0 . 1 , 192 . 168 . 0 . 2   2012010101  0000
 , 2012010201  0000
|  Wangwangb  |  192 . 168 . 25 . 10 ,  192 . 168 . 67 . 22 ,  192 ,
 168 . 6 .  3  |  maid ,  2012022308  0000  |
+----------+---------+-----------+
```

Execute SQL:

```
trans_arra  y ( 1 , ",",  login_id ,  login_ip ,  login_time )  as  (
login_id , login_ip , login_time )
```

Results:

```
+----------+---------+-----------+
|  Login_id  |  login_ip  |  login_time  |
+----------+---------+-----------+
|  wangwangB  |  192 . 168 . 45 . 10  |  2012011101  0000  |
|  wangwangB  |  192 . 168 . 67 . 22  |  2012011201  0000  |
|  wangwangB  |  192 . 168 . 6 . 3  |  2012022308  0000  |
|  wangwangA  |  192 . 168 . 0 . 1  |  2012010101  0000  |
|  wangwangA  |  192 . 168 . 0 . 2  |  2012010201  0000  |
+----------+---------+-----------+
```

If the table contains the following data:

```
Login_id   LOGIN_IP   LOGIN_TIME
wangwangA   192 . 168 . 0 . 1 , 192 . 168 . 0 . 2   2012010101  0000
```

NULL is complemented to the no-value locales in the array:

```
Login_id   Login_ip   Login_time
wangwangA   192 . 168 . 0 . 1   2012010101  0000
```

```
wangwangA    192 . 168 . 0 . 2    NULL
```

4.15 UDF

4.15.1 UDF Summary

MaxCompute provides many built-in functions to meet the computing requests of the users.

A User Defined Function (UDF) is similar to any other Built-in Function. For the corresponding relationship between Java and MaxCompute data types, see Parameters and Return Value Types.

If you use Maven to search "odps-sdk-udf" from Maven to get different versions of Java SDK,the configuration is as follows:

```
< dependency >
    < groupId > com . aliyun . odps </ groupId >
    < artifactId > odps - sdk - udf </ artifactId >
   < version > 0 . 29 . 10 - public </ version >
</ dependency >
```

In MaxCompute, you can expand two types of UDF:

UDF Class	Description
UDF(User Defined Scalar Function)	User Defined Scalar function. The relationship between input and output is a one-to-one relationship. Read a row data and write an output value.
UDTF (UserDefined Table Valued Function)	User-defined table valued functions are used in scenarios where the calling of one function leads to multiple rows of data being output. It is a unique user-defined function which can return multiple fields, while UDFcan only output a return value.
UDAF（User Defined Aggregation Function）	User Defined Aggregation Function (UDAF), the relationship between its input and output is one-to-many relationships. That is to aggregate multiple input records to an output value. It can be used with a Group By clause.. For more information, see #unique_113Aggregation Functions.

Note:

- UDF stands for the set of user-defined functions, including User Defined Scalar Function, User Defined Aggregation Function and User Defined Table Valued Function. In a narrower sense, it represents user User Defined Scalar Function. The document uses this term frequently and the readers can judge the specific meaning according to the context .
- If the system prompts that memory is insufficient with an UDF involved in the SQL statement, configure `set odps . sql . udf . joiner . jvm . memory = xxxx` ; to resolve this issue. This is because the data is huge and data skew also exists., This leads the memory size to occupythe task, which exceeds the default memory size.

MaxCompute UDF supports cross-project sharing. A UDF in project_b can be used in project_a. For more information, , see Authorization in Security Guide documentation. other_project:udf_in_other_project(arg0, arg1) as res from table_t;。

UDF Examples

Please see UDF Example in Quick Start Volume.

4.15.2 Java UDF

MaxCompute UDF includes three types: UDF, UDAF, and UDTF. This article focuses on how to implement these three functions through Java.

Parameter and return value type

The data types of UDF supported by MaxCompute SQL include thebasic types: bigint , double, boolean, datetime, decimal, string, tinyint, smallint, int, float, varchar, binary, and timestamp. Complex types: array, map, and struct.

- The use of some basic types including tinyint, smallint, int, float, varchar, binary, and timestamp through Java UDF is as follows:
  - UDTF get 'signature' by @Resolve annotation, for example, `@ Resolve (" smallint -> varchar ( 10 )")`.
  - UDF gets 'signature' by the reflection analysis 'evaluate' . In this case, the MaxCompute built-in type and the Java type comply with one-to-one mapping.
  - UDAF gets the signature with the @Resolve annotation, and maxcompute2.0 supports the use of new types in annotations, for example, `@ Resolve (" smallint -> varchar ( 10 )")`.

- JAVA UDF uses three complex data types : 'array' , 'map' , and 'struct' :
  - UDAFs and UDTFs specify signature by @Resolve annotation, for example, `@ Resolve (" array < string >, struct < a1 : bigint , b1 : string >, string -> map < string , bigint >, struct < b1 : bigint >")`.
  - The UDF maps the input and output types of the UDF through the signature of the evaluate method, reference is made to the mapping of the maxcompute type to the Java type. In this relationship, Array maps java.util.List, Map maps java.util.Map, and Struct maps com.aliyun.odps.data.Struct.
  - UDAF gets the signature with the @Resolve annotation, and MaxCompute2.0 supports the use of new types in annotations, for example, `@ Resolve (" smallint -> varchar ( 10 )")`.

> **Note:**
>
> - com.aliyun.odps.data.Struct does not see field name and field type from reflection, so it must be complemented by @Resolve annotation. In other words, to use Struct in a UDF, add the @Resolve annotation to the UDF class . This annotation only affects overloads of parameters or return values that contain com.aliyun.odps.data.Struct.
> - *Currently, only one @Resolve annotation can be provided on class. Therefore, only one overload in a UDF with a struct parameter or return value can exist.*

The following table lists the relations between MaxCompute and Java data types.

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
Decimal	java.math.BigDecimal
Boolean	java.lang.Boolean
String	java.lang.String
Varchar	com.aliyun.odps.data.Varchar

MaxCompute Type	Java Type
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:

- The corresponding data type in Java and the return value data type is the object. Make sure that the first letter is uppercase.
- The NULL value in SQL is represented by a NULL reference in Java; therefore, ‘Java primitive type’ is not allowed because it cannot represent a NULL value in SQL.
- Here, Java type corresponding to the ‘array’ type is ‘list’.

UDF

To implement UDF, the class ‘com.aliyun.odps.udf.UDF’ must be inherited and the ‘evaluate’ method must be applied. The ‘evaluate’ method must be a non-static public method. The parameter type and return value type of Evaluate method is considered as UDF signature in SQL. It means that the user can implement multiple evaluate methods in UDF. To call UDF, the framework must match the correct evaluate method according to the parameter type called by UDF.

Note: Classes with the same class name but different functional logic mustappear in different jar packages. For example, UDF (UDAF/UDTF): udf1, udf2 correspond to the resources udf1.jar and udf2.jar respectively, if both jars contain com.aliyun.UserFunction.class, when two udfs are used in the same SQL statement, the system randomly loads one of the classes. This causes inconsistency in the udf execution behavior or compilation failure.

UDF samples are as follows:

```
package   org . alidata . odps . udf . examples ;
  import   com . aliyun . odps . udf . UDF ;

public   final   class   Lower   extends   UDF  {
  Public   String   evaluate  ( string   s  ){
```

```
    If  ( Stream  =  NULL  ){
        return   null ;
    }
        return   s . toLowerCas  e ();
  }
}
```

UDF is initialized and terminated through `void   setup ( ExecutionC  ontext ctx )` and `void   close ()`.

The use method of UDF is similar to built-in functions in MaxCompute SQL. For more information, see Built-in Functions.

Other UDF examples

In the following code, UDF with three overloads is defined. The first, second, and third overloads use ARRAY, MAP, and STRUCT respectively as a parameter. Since the third overloads use a struct as a parameter or return value, therefore, a `@ Resolve` annotation must be placed on the UDF class to specify the specific type of struct.

```
@ Resolve  (" struct ,  string ->  string  ")
 public   class   UdfArray   extends   UDF  {
   public   String   evaluate ( List   vals ,  Long   len ) {
     return   vals . get ( len . intValue ());
  }
   Public   String   evaluate  ( MAP   map ,  string   key  ){
     return   map . get ( key );
  }
   public   String   evaluate ( Struct   struct ,  String   key ) {
   return   struct . getFieldVa  lue (" a ") +  key ;
 }
}
```

The user can pass the complex type directly into the UDF:

```
 create   function   my_index   as   ' UdfArray '  using   ' myjar . jar
 ';
 select   id ,  my_index ( array (' red ', ' yellow ', ' green '),
 colorOrdin  al )  as   color_name   from   colors ;
```

UDAF

To implement Java UDAF, inherit the class ‘com.aliyun.odps.udf.Aggregator’ and the following interfaces must be applied:

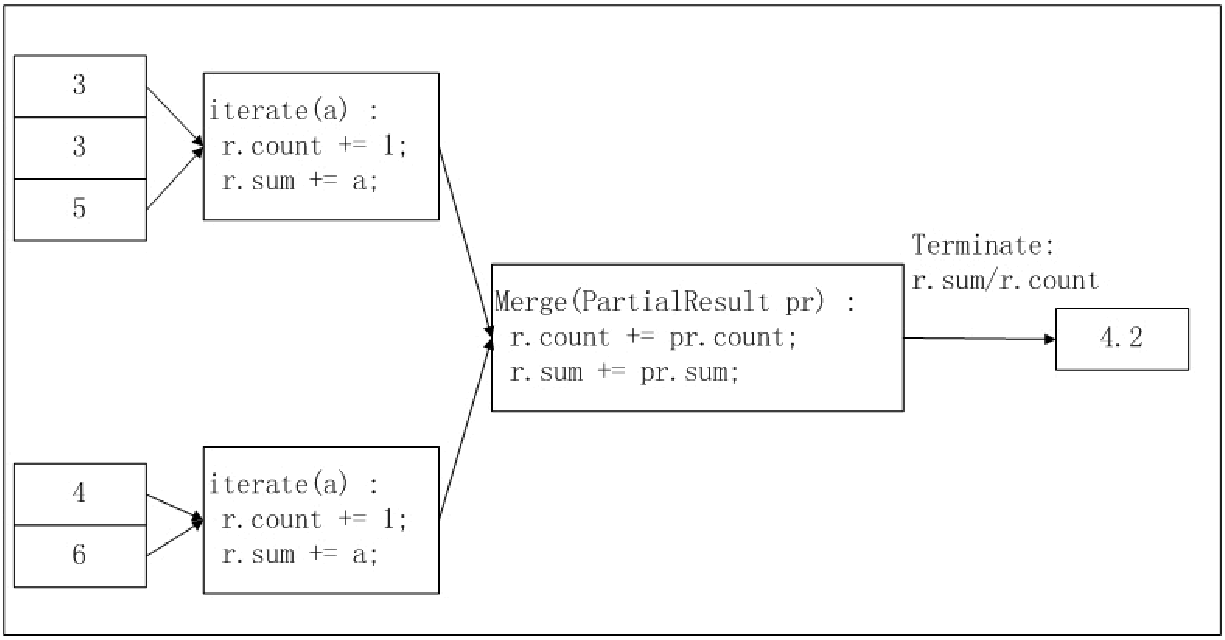
```
 public   abstract   class   Aggregator   implements   ContextFun
 ction  {
  @ Override
   public   void   setup ( ExecutionC  ontext   ctx )  throws
 UDFExcepti  on  {

  }
  @ Override
   public   void   close ()  throws   UDFExcepti  on  {
```

```
   }
   /**
    *  Create   an   aggregate   buffer
    * @ return   Writable  -  Aggregate   buffer
    */
    abstract   public   Writable   newBuffer ();
   /**
    * @ param   buffer :  aggregatio  n   buffer
    * @ param   args :  specified   parameter   to   call   UDAF   in
  SQL
    * @ throws   UDFExcepti  on
    */
    abstract   public   void   iterate ( Writable   buffer ,  Writable
  []  args )  throws   UDFExcepti  on ;
   /**
    *  generate   final   result
    * @ param   buffer
    * @ return   final   result   of   Object   UDAF
    * @ throws   UDFExcepti  on
    */
    abstract   public   Writable   terminate ( Writable   buffer )
  throws   UDFExcepti  on ;
    abstract   public   void   merge ( Writable   buffer ,  Writable
  partial )  throws   UDFExcepti  on ;
 }
```

The three most important interfaces are ‘iterate’, ‘merge’, and ‘terminate’. The main logic of UDAF relies on these three interfaces. In addition, user must realize defined Writable buffer.

Take ‘achieve average calculation’ as an example and next figure describes the realization logical and computational procedure of this function in MaxCompute UDAF:



In the preceding figure , the input data is sliced according to a certain size.For more information about slicing, see MapReduce). The size of each slice is suitable for a worker to complete in the specified time. This slice size must be configured manually by the user.

The calculation process of UDAF is divided into two steps:

- In the first step, each worker counts the data quantity and total sum in a slice. You can consider the data quantity and total sum in each slice as an intermediate result .
- In the second step, a worker gathers the information of each slice generated in the first stage. In the final output, r.sum / r.count is the average of all input data.

Use the following UDAF encoding example to calculate the average:

```
 import   java . io . DataInput ;
 import   java . io . DataOutput ;
 import   java . io . IOExceptio  n ;
 import   com . aliyun . odps . io . DoubleWrit  able ;
 import   com . aliyun . odps . io . Writable ;
 import   com . aliyun . odps . udf . Aggregator ;
 import   com . aliyun . odps . udf . UDFExcepti  on ;
 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   IOExceptio
 n  {
       out . writeDoubl  e ( sum );
       out . writeLong ( count );
    }
    @ Override
     public   void   readFields ( DataInput   in )  throws
 IOExceptio  n  {
       sum  =  in . readDouble ();
       count  =  in . readLong ();
    }
  }
   private   DoubleWrit  able   ret  =  new   DoubleWrit  able ();
  @ Override
   public   Writable   newBuffer () {
     return   new   AvgBuffer ();
  }
  @ Override
   public   void   iterate ( Writable   buffer ,  Writable []  args )
 throws   UDFExcepti  on  {
     DoubleWrit  able   arg  = ( DoubleWrit  able )  args [ 0 ];
     AvgBuffer   buf  = ( AvgBuffer )  buffer ;
     if  ( arg  ! =  null ) {
       buf . count  +=  1 ;
       buf . sum  +=  arg . get ();
    }
  }
  @ Override
   public   Writable   terminate ( Writable   buffer )  throws
 UDFExcepti  on  {
     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   UDFExcepti  on   {
        AvgBuffer   buf  = ( AvgBuffer )  buffer ;
        AvgBuffer   p  = ( AvgBuffer )  partial ;
        buf . sum  +=  p . sum ;
        buf . count  +=  p . count ;
     }
   }
```

Note:

- For Writable's readFields function, since the partial writable object can be reused, the same object readFields function is called multiple times. This function expects the entire object to be reset each time it is called. If the object contains a collection, it must be emptied.
- The use method of UDAF is similar to aggregation functions in MaxCompute SQL. For more information, see Aggregation Functions.
- How to run UDTF is similar to UDF. For more information, see Java UDF Development.

UDTF

Java UDTF class must inherit the class 'com.aliyun.odps.udf.UDTF'. This class has four interfaces:

Interface Definition	Description
public void setup(ExecutionContext ctx) throws UDFException	The initialization method to call user-defined initialization behavior before UDTF processes the input data. 'Setup' will be called first and once for each worker.
public void process(Object [] args) throws UDFException	The framework calls this method. Each record in SQL calls 'process' once accordingly. The parameters of 'process' are the specified UDTF input parameters in SQL. The input parameters are passed in as Object[], and the results are output through 'forward' function. The user must call 'forward' in the 'process' function by itself to determine the output data.

Interface Definition	Description
public void close() throws UDFException	The termination method of UDTF. The framework calls this method, and only once; that is, after processing the last record.
public void forward(Object …o) throws UDFException	The user calls the 'forward' method to output data . Each 'forward' represents the output of a record, corresponding to the column specified by UDTF 'as' clause in SQL.

A UDTF program sample is as follows:

```
 package   org . alidata . odps . udtf . examples ;
 import   com . aliyun . odps . udf . UDTF ;
 import   com . aliyun . odps . udf . UDTFCollec  tor ;
 import   com . aliyun . odps . udf . annotation . Resolve ;
 import   com . aliyun . odps . udf . UDFExcepti  on ;
//  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
 UDFExcepti  on  {
        String   a  = ( String )  args [ 0 ];
        Long   b  = ( Long )  args [ 1 ];
        for  ( String   t :  a . split ("\\ s +")) {
          forward ( t ,  b );
      }
    }
  }
```

Note:

The preceding example is for reference only. How to run UDTF is similar to using UDF. For more information, see Java UDF Development.

In SQL,use this UDTF as the following example. Suppose that the register function name in MaxCompute is 'user_udtf'.

```
 select   user_udtf ( col0 ,  col1 )  as  ( c0 ,  c1 )  from
 my_table ;
```

Suppose the values of col0 and col1 in my_table are:

```
+------+------+
|  col0  |  col1  |
+------+------+
|  A   B  |  1  |
|  C   D  |  2  |
```

```
+------+------+
```

Then the 'SELECT' result is:

```
+----+----+
| c0  |  c1  |
+----+----+
|  A  |  1  |
|  B  |  1  |
|  C  |  2  |
|  D  |  2  |
+----+----+
```

Instructions

UDTFs are often used as following in SQL:

```
select  user_udtf ( col0 ,  col1 )  as  ( c0 ,  c1 )  from
my_table ;
select  user_udtf ( col0 ,  col1 ,  col2 )  as  ( c0 ,  c1 )  from
 ( select  *  from  my_table  distribute  by  key  sort  by
key )  t ;
select  reduce_udt  f ( col0 ,  col1 ,  col2 )  as  ( c0 ,  c1 )
from  ( select  col0 ,  col1 ,  col2  from  ( select  map_udtf (
a0 ,  a1 ,  a2 ,  a3 )  as  ( col0 ,  col1 ,  col2 )  from  my_table
)  t1  distribute  by  col0  sort  by  col0 ,  col1 )  t2 ;
```

But using UDTF has the following limits:

- Other expressions are not allowed in the same SELECT clause:

  ```
  select  value ,  user_udtf ( key )  as  mycol  ...
  ```

- UDTF cannot be nested.

  ```
  select  user_udtf1 ( user_udtf2 ( key ))  as  mycol ...
  ```

- It cannot be used with 'group by / distribute by / sort by' in the same SELECT clause.

  ```
  select  user_udtf ( key )  as  mycol  ...  group  by  mycol
  ```

Other UDTF Examples

In UDTF, learn more aboutMaxCompute Resources. The following describes how to use UDTFs to read MaxCompute resources:

1. Compile a UDTF program. Once the compilation is successful, export the Jar package (udtfexample1.jar).

   ```
   package  com . aliyun . odps . examples . udf ;
   import  java . io . BufferedRe  ader ;
   import  java . io . IOExceptio  n ;
   import  java . io . InputStrea  m ;
   import  java . io . InputStrea  mReader ;
   ```

```
 import   java . util . Iterator ;
 import   com . aliyun . odps . udf . ExecutionC  ontext ;
 import   com . aliyun . odps . udf . UDFExcepti  on ;
 import   com . aliyun . odps . udf . UDTF ;
 import   com . aliyun . odps . udf . annotation . Resolve ;
/**
 *  project :  example_pr  oject
 *  table :  wc_in2
 *  partitions :  p2 = 1 , p1 = 2
 *  columns :  colc , colb
 */
@ Resolve (" string , string -> string , bigint , string ")
 public   class   UDTFResour  ce   extends   UDTF  {
   ExecutionC  ontext   ctx ;
   long   fileResour  ceLineCoun  t ;
   long   tableResou  rce1Record  Count ;
   long   tableResou  rce2Record  Count ;
  @ Override
   public   void   setup ( ExecutionC  ontext   ctx )  throws
 UDFExcepti  on  {
   this . ctx  =  ctx ;
   try  {
    InputStrea  m   in  =  ctx . readResour  ceFileAsSt  ream ("
 file_resou  rce . txt ");
    BufferedRe  ader   br  =  new   BufferedRe  ader ( new
 InputStrea  mReader ( in ));
    String   line ;
    fileResour  ceLineCoun  t  =  0 ;
    while  (( line  =  br . readLine ()) ! =  null ) {
      fileResour  ceLineCoun  t ++;
   }
    br . close ();
    Iterator < Object []>  iterator  =  ctx . readResour  ceTable ("
 table_reso  urce1 "). iterator ();
    tableResou  rce1Record  Count  =  0 ;
    while  ( iterator . hasNext ()) {
      tableResou  rce1Record  Count ++;
      iterator . next ();
   }
    iterator  =  ctx . readResour  ceTable (" table_reso  urce2 ").
 iterator ();
    tableResou  rce2Record  Count  =  0 ;
    while  ( iterator . hasNext ()) {
      tableResou  rce2Record  Count ++;
      iterator . next ();
   }
 }  catch  ( IOExceptio  n   e ) {
    throw   new   UDFExcepti  on ( e );
 }
}
   @ Override
    public   void   process ( Object []  args )  throws
 UDFExcepti  on  {
      String   a  = ( String )  args [ 0 ];
      long   b  =  args [ 1 ] ==  null  ?  0  : (( String )  args [
 1 ]). length ();
      forward ( a ,  b , " fileResour  ceLineCoun  t =" +
 fileResour  ceLineCoun  t  + "| tableResou  rce1Record  Count ="
     +  tableResou  rce1Record  Count  + "| tableResou  rce2Record
 Count =" +  tableResou  rce2Record  Count );
    }
```

```
}
```

2. Add resources in MaxCompute:

```
Add file file_resou rce . txt ;
Add jar udtfexampl e1 . jar ;
Add table table_reso urce1 as table_reso urce1 ;
Add table table_reso urce2 as table_reso urce2 ;
```

3. Create UDTF (my_udtf) in MaxCompute:

```
create function mp_udtf as com . aliyun . odps . examples .
udf . UDTFResour ce using
' udtfexampl e1 . jar , file_resou rce . txt , table_reso urce1
, table_reso urce2 ';
```

4. Create the resource tables: table_resource1, table_resource2 and the physical table tmp1 in MaxCompute. Insert corresponding data into the tables.
5. Run this UDTF.

```
select mp_udtf (" 10 "," 20 ") as ( a , b , fileResour
ceLineCoun t ) from tmp1 ;
Return result :
+-------+-----------+-------+
| a | b | fileResour ceLineCoun t |
+-------+-----------+-------+
| 10 | 2 | fileResour ceLineCoun t = 3 | tableResou
rce1Record Count = 0 | tableResou rce2Record Count = 0 |
| 10 | 2 | fileresour celinecoun t = 3 | tableResou
rce1Record Count = 0 | tableResou rce2Record Count = 0 |
+-------+-----------+-------+
```

UDTF Examples—Complex Data Types

The code in the following example defines 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. Since the third overload uses ‘struct’ as the parameter or returned value, the UDF class must havethe @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 . getFieldVa lue (" a ") + key ;
 }
```

```
}
```

Users can pass in the complex data type in the UDF:

```
create   function   my_index   as   ' UdfArray '   using   ' myjar . jar
';
select   id ,  my_index ( array (' red ', ' yellow ', ' green '),
colorOrdin  al )  as   color_name   from   colors ;
```

Hive UDF Compatibility Example

MaxCompute 2.0 supports Hive-style UDFs. Some Hive UDFs and UDTFs can be used directly in MaxCompute.

Notice:
Currently, the compatible Hive version is 2.1.0, and the corresponding Hadoop version is 2.7.2. UDFs that are developed in other versions of Hive/Hadoop may need to be recompiled using this Hive/Hadoop version.

Example:

```
package   com . aliyun . odps . compiler . hive ;
import   org . apache . hadoop . hive . ql . exec . UDFArgumen
tException ;
import   org . apache . hadoop . hive . ql . metadata . HiveExcept
ion ;
import   org . apache . hadoop . hive . ql . udf . generic .
GenericUDF ;
import   org . apache . hadoop . hive . serde2 . objectinsp  ector .
ObjectInsp  ector ;
import   org . apache . hadoop . hive . serde2 . objectinsp  ector .
ObjectInsp  ectorFacto  ry ;
import   java . util . ArrayList ;
import   java . util . List ;
import   java . util . Objects ;
public   class   Collect   extends   GenericUDF  {
 @ Override
  public   ObjectInsp  ector   initialize ( ObjectInsp  ector []
objectInsp  ectors )  throws   UDFArgumen  tException  {
    if  ( objectInsp  ectors . length   ==   0 ) {
      throw   new   UDFArgumen  tException (" Collect :  input   args
  should  >=  1 ");
   }
    for  ( int   i  =  1 ;  i  <  objectInsp  ectors . length ;  i +
+) {
      if  ( objectInsp  ectors [ i ] ! =  objectInsp  ectors [ 0 ]) {
        throw   new   UDFArgumen  tException (" Collect :  input   oi
  should   be   the   same   for   all   args ");
      }
   }
    return   ObjectInsp  ectorFacto  ry . getStandar  dListObjec
tInspector ( objectInsp  ectors [ 0 ]);
 }
 @ Override
  public   Object   evaluate ( DeferredOb  ject []  deferredOb  jects
)  throws   HiveExcept  ion  {
```

```
    List < Object >  objectList  =  new   ArrayList <>( deferredOb
jects . length );
    for  ( DeferredOb  ject   deferredOb  ject  :  deferredOb  jects
) {
      objectList . add ( deferredOb  ject . get ());
    }
    return   objectList ;
  }
  @ Override
  public   String   getDisplay  String ( String []  strings ) {
    return  " Collect ";
  }
}
```

Note:

For the use of Hive UDF, see:

- https://cwiki.apache.org/confluence/display/Hive/HivePlugins
- https://cwiki.apache.org/confluence/display/Hive/DeveloperGuide+UDTF
- https://cwiki.apache.org/confluence/display/Hive/GenericUDAFCaseStudy

The UDF can pack any type and amount of parameters into array to output. Suppose that the output jar package is named test.jar:

```
-- Add   resource
 Add   jar   test . jar ;
-- Create   function
 CREATE   FUNCTION   hive_colle  ct   as  ' com . aliyun . odps .
 compiler . hive . Collect '  using  ' test . jar ';
-- Use   function
 set   odps . sql . hive . compatible = true ;
 select   hive_colle  ct ( 4y , 5y , 6y )  from   dual ;
+-------+
|  _c0  |
+-------+
| [ 4 ,  5 ,  6 ] |
+-------+
```

Note:

The UDF supports all data types, including array, map, struct, and other complex types.

Note:

- MaxCompute’ s add jar command permanently creates a resource in the project, specify the jar when creating an UDF, but you cannot automatically add all jars to the classpath.
- To use compatible Hive UDF, add `set   odps . sql . hive . compatible = true ;` opposite the SQL statement, and submit it with SQL statement.

- When using compatible Hive UDFs, you must pay attention to JAVA sandbox limits of MaxCompute.

4.15.3 Python UDF

The MaxCompute UDF consists of UDF, UDAF, and UDTF functions. This article explains how to implement these three functions through MaxCompute Python.

RESTRICTED ENVIRONMENT

The Python version of MaxCompute UDF is 2.7 and executes user code in sandbox mode; that is, the code is executed in a restricted environment.

- Read and Write local files
- Promoter process
- Start thread
- Use SOCKET to communicate
- Other system calls

Because of these restrictions, user-uploaded code must be implemented throughj pure Python, and the C extension module is disabled.

In addition, not all modules are available in the Python standard library, and modules that involve these features are disabled. Description of available modules in the standard library are as follows:

- All modules implemented by pure Python are available.

- The following modules are available in C-implemented extended modules.
  - 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
- unicodedat
- _weakref
- cPickle

- Some modules have limited functionalities. For example, the sandbox limits the degree to which user code can write data to the standard output and the standard error output; that is, `sys . stdout / sys . stderr` can write 20 KB at most; otherwise, the excessive characters will be ignored.

Third-party Libraries

Common third-party libraries are installed in the operating environment to supplement the standard library. The supported third-party libraries also include numpy.

Note:

The use of third-party libraries is also subject to 'prohibit local', 'network I/O', and other restrictions. Therefore, APIs that have such functions are also prohibited in a third-party library.

Parameters and return value types

The parameters and return values are specified as follows:

```
@ odps . udf . annotate ( signature )
```

MaxCompute SQL data types that are currently supported by the Python UDF include bigint, String, double, Boolean, and datetime. The SQL statement must determine the parameter type and the return value type for all functions before execution. So for Python, a dynamically-typed language, you must specify the function signature by adding a decorator to the UDF class.

The function signature is specified by a string. The syntax is as follows:

```
 arg_type_l  ist  '->'  type_list
  arg_type_l  ist :  type_list  | '*' | ''
 type_list : [ type_list  ',']  type
' bigint ' | ' string ' | ' double ' | ' boolean ' | ' datetime '
```

- The left side of the arrow indicates the type of the parameter and the right side indicates the type of the returned value.

- Only the UDTF returned value can be multiple columns, while UDF and UDAF can only return one column.
- '*' represents varargs. By using varargs, UDF/UDTF/UDAF can match any type of parameter.

A valid signature example is as follows:

```
The ' bigint , double -> string ' # parameter is bigint ,
double , and the return value is string

The ' bigint , boolean -> string , datetime '# udtf parameter
 is bigint , Boolean , the return value is string ,
datetime

'*-> string ' # variable length parameter , input parameter
arbitrary , return value string

The '-> doubles ' # parameter is empty and the return
value is double
```

At the query semantic parsing stage, unqualified signatures are removed, and an error is returned. The execution is then stopped. During execution, the UDF parameter will be passed to the user as the type specified by the function signature. The type of the user returned value must be consistent with the type specified by the function signature; otherwise, an error is returned. MaxCompute SQL data type corresponds to the Python type as follows:

ODPS SQL type	Bigint	String	Double	Boolean	Datetime
Python Type	int	str	float	bool	int

Note:

- Datetime type is passed to user code in the form of an int, with a value of epoch UTC Number of milliseconds from time to date. The user can deal with 'datetime' type through the 'datetime' module in the Python standard library.
- NULL corresponds to NONE in Python.

In addition, the parameter of odps.udf.int(value[, silent=True]) has been adjusted . Parameter 'silent' is added. . When 'silent' is true, if the value cannot be converted into 'int' , report no error and return NONE.

UDF

Implementation of the Python UDF is very simple. You are required to define a `new-style class`, and implements the `evaluate` method. For 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
```

Note:

A Python UDF must have its signature specified through annotate.

Since October 16, 2018, the use of Python UDF in the MaxCompute public cloud environment has been fully opened.

UDAF

- `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 marshallable object (such as list, dict), and the size of the buffer must not increase with the amount of data, in case of limit, Buffer size after Marshal must not exceed 2 MB.
- 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 merger’ into ‘buffer’ .
- BaseUDAF.terminate(buffer): This method converts the median ‘buffer’ into the MaxCompute SQL basic types.

An example of an average value of UDAF is as follows:

```
@ 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 ]
```

UDTF

- `class odps.udf.BaseUDTF`: The basic class of Python UDTF. Users inherit this class and implement methods such as process, close, and so on.
- BaseUDTF.__init__(): The initialization method, the inheritance class, if you implement this method, the base class's initialization method, super(BaseUDTF, self).__init__() must be called in the beginning.

  The `init` method can only be called once during the entire UDTF life cycle; that is, before the first record is processed. When the UDTF must save the internal state, all states can be initialized in this method.
- BaseUDTF. process ([args,...]): This is one of the MaxCompute methods. The framework calls this method. Each record in SQL calls ‘process’ once accordingly. The parameters of ‘process’ are the specified UDTF input parameters in SQL.
- BaseUDTF.forward([args, ...]): The UDTF output method, which is called by user codes. Each time ‘forward’ is called, a record is output. The parameters of ‘forward’ are the UDTF output parameters specified in SQL.
- BaseUDTF.close(): The termination method of UDTF. This method is called by the MaxCompute SQL framework and only to be called once; that is, after processing the last record.

Examples of UDTF are:

```
# coding : utf - 8
#  explode .  py


 from   odps . udf   import   annotate

 from   odps . udf   import   BaseUDTF



@ annotate (' string  ->  string ')
 class   Explode ( BaseUDTF ):
   """ Output   string   comma - separated   to   multiple   records
   """

    def   process ( self ,  arg ):
        props  =  arg . split (',')
```

```
        for   p   in   props :
           self . forward ( p )
```

Note:

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 returned value type cannot be deduced, but all output parameters will be considered to be ‘String’ type. So when ‘forward’ is called, all output values must be converted into ‘str’ type.

Referring to resources

Python UDF can reference resource files through the ‘odps.distcache’ module. Currently, referencing file resources and table resources are supported.

- odps.distcache.get_cache_file(resource_name)
  - Returns the resource content for the specified name. resource_name: ‘str’ type, corresponding to the existing resource name in the current project. If the resource name is invalid or has no responding resources, returns an error.
  - The return value is file-like object the caller must call the `close` method to release the open resource file after this object has been used.

  The example of using ‘get_cache_file’ is as follows:

```
@ annotate (' bigint -> string ')
 class   DistCacheE  xample ( object ):

 def   __init__ ( self ):
     cache_file  =  get_cache_  file (' test_distc  ache . 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 )
```

- odps.distcache.get_cache_table(resource_name):
  - Returns the contents of the specified resource table. resource_name: 'str' type, corresponding to the existing resource table name in the current project. If the resource name is invalid or has no responding resources, returns an error.
  - Returned value: Returned value is a 'generator' type. The caller obtains the table content through traversal. Each traversal has a record stored in the table in the form of a tuple.

The example of using 'get_cache_table' is as follows:

```
 from   odps . udf   import   annotate
 from   odps . distcache   import   get_cache_  table

@ annotate ('-> string ')
 class   DistCacheT  ableExampl  e ( 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 )
```

4.15.4 UDTF usage

This topic describes how to use Java user-defined table-valued functions (UDTFs) and Python UDTFs.

Usage

In typical cases, a UDTF is used as follows in Structured Query Language (SQL):

```
select   user_udtf ( col0 ,  col1 ,  col2 )  as  ( c0 ,  c1 )  from
my_table ;
select   user_udtf ( col0 ,  col1 ,  col2 )  as  ( c0 ,  c1 )  from
 ( select  *  from   my_table   distribute   by   key   sort   by
key )  t ;
select   reduce_udt  f ( col0 ,  col1 ,  col2 )  as  ( c0 ,  c1 )
from  ( select   col0 ,  col1 ,  col2   from  ( select   map_udtf (
a0 ,  a1 ,  a2 ,  a3 )  as  ( col0 ,  col1 ,  col2 )  from   my_table
)  t1   distribute   by   col0   sort   by   col0 ,  col1 )  t2 ;
```

UDTFs are subject to the following limits:

- A `select` clause cannot contain any other expressions.

```
select value , user_udtf ( key ) as mycol ...
```

- A UDTF cannot be nested.

```
select user_udtf1 ( user_udtf2 ( key )) as mycol ...
```

- A `select` clause cannot be used with a `group by`, `distribute by`, or `sort by` clause.

```
select user_udtf ( key ) as mycol ... group by mycol
```

4.16 UDT

MaxCompute has introduced the User-defined type (UDT) based on the new generation SQL engine. UDT allows you to reference classes or objects of third-party languages in SQL statements to obtain data or call methods.

Scenarios

UDT 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, some tasks can be performed by calling built-in Java classes only once. The procedure of using user defined functions (UDFs) to complete these tasks is complex.
- Scenario 2: You need to call a third-party library in SQL statements to implement the corresponding function. You want to use a function provided by a third-party library directly in a SQL statement, instead of wrapping the function 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 executed only after it is compiled. You want to reference objects and classes of these languages in SQL statements.

Overview

UDT allows you to reference classes or objects of third-party languages in SQL statements to obtain data or call methods.

There are major differences between UDT supported by MaxCompute and other SQL engines. UDT supported by other SQL engines are similar to the struct composite type in MaxCompute. Some proprietary SQL languages provide features that allow you to call third-party libraries, such as the CREATE TYPE statement in Oracle databases. UDT supported by MaxCompute is similar to the CREATE TYPE statement. A UDT contains both fields and methods. In addition, MaxCompute does not require that you use Data Definition Language (DDL) statements to define type mappings. Instead, MaxCompute allows you to reference types directly in SQL statements.

Example:

```
set odps . sql . type . system . odps2 = true ;
-- Enable new data type support in MaxCompute . The
following example will use a new type of Integer (
int ).
SELECT java . lang . Integer . MAX_VALUE ;
```

The output is as follows:

```
+-----------+
| max_value |
+-----------+
| 2147483647 |
+-----------+
```

You can shorten the statement by removing java.lang in the same way as in Java:

```
set odps . sql . type . system . odps2 = true ;
SELECT Integer . MAX_VALUE ;
```

The expression in the preceding SELECT statement is similar to a Java expression and is executed in the same way as in Java. The expression specifies a UDT in MaxCompute.

You can use UDF to implement all functions provided by UDT. If you use a UDF to implement the same function, you need to follow these steps:

1. Define a UDF class.

```
package com . aliyun . odps . test ;
public class IntegerMax Value extends com . aliyun . odps
. udf . UDF {
  public Integer evaluate () {
     return Integer . MAX_VALUE ;
  }
}
```

2. Compile the UDF and pack it into a JAR package. Upload the JAR package and create a function.

```
add jar odps - test . jar ;
```

```
create   function   integer_ma  x_value   as  ' com . aliyun . odps
. test . IntegerMax  Value '  using  ' odps - test . jar ';
```

3. Call the function in a SQL statement.

```
select   integer_ma  x_value ();
```

Using a UDT simplifies this procedure. By using UDT, you can use external functions provided by other languages in SQL statements more easily.

How UDT works

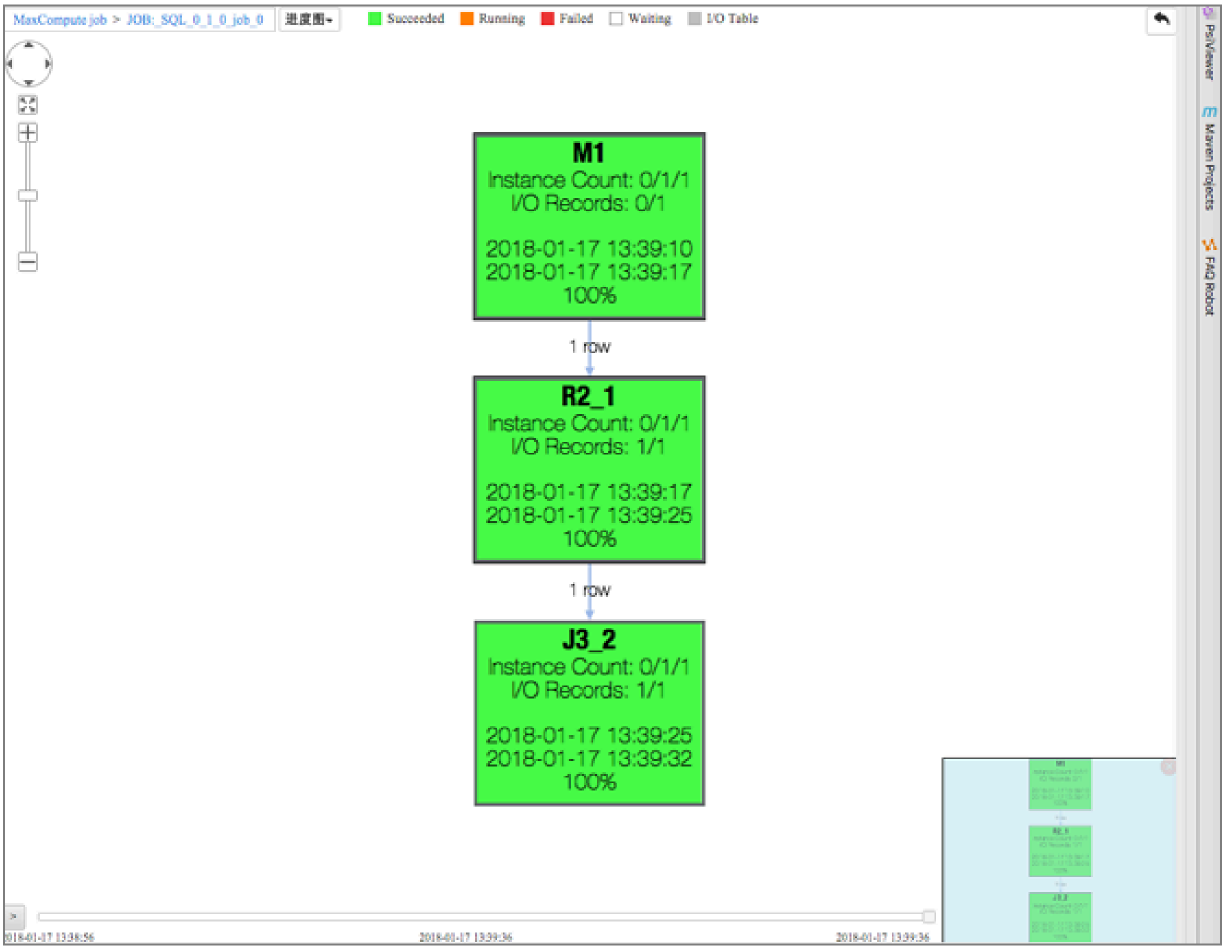
The example shows how to use UDT to access Java static fields. You can use UDT to implement more functions. The following example shows the UDT execution procedure and its functions.

```
--   Sample   data
@ table1  :=  select  *  from   values  (' 1000000000  0000000000  0
 ')  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
```

The output is follows:

```
1000000000  0000000010  0
```

This example also shows how to retrieve UDT columns using subqueries, which is difficult to complete using UDF. The x column retrieved by variable a is java.math.BigInteger type. It is 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.



This figure shows that a UDT has three stages: M1, R2, and J3. When a Join clause is used, data reshuffling is required, which is the same as MapReduce. Data is processed at multiple stages. Typically, data processing at different stages are performed in different processes or different physical machines.

Only the new java.math.BigInteger(x) method is called at the M1 stage.

The java.math.BigInteger.valueOf(y) and x.add(y).toString() methods are called separately at the J3 stage. These methods are called at different stages in different processes or physical machines. The UDT encapsulates these stages and acts as a JVM .

Features

- UDT currently only supports Java. Other languages will be supported in later versions.

- UDT also allows you to upload JAR packages and directly reference the packages. UDT has provided flags.
  - You can use `set odps . sql . session . resources` to specify one or more resources that you need to reference and separate the resources with commas (,). Example: `set odps . sql . session . resources = foo . sh , bar . txt ;`.

    Note:
    This flag is the same as the resource setting flag in Select Transform. Therefore, this flag controls two functions. For example, you can use a UDT to reference the UDF JAR package that we have mentioned in the Overview section.

    ```
    set odps . sql . type . system . odps2 = true ;
    set odps . sql . session . resources = odps - test . jar ;
    -- To reference the JAR package , you must first upload the package to the correspond ing project and make sure that it is a JAR type resource .
    select new com . aliyun . odps . test . IntegerMax Value (). evaluate ();
    ```
  - You can use `odps . sql . session . java . imports` to specify one or more default JAR packages separated with commas (,). It is similar to the Java import statement. You can specify a class path, such as `java . math . BigInteger`, or use `*`. Currently, `static import` is not supported.

    For example, you can use a UDT to reference the UDF JAR package that we have mentioned in Overview.

    ```
    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 JAR package .
    ```

```
select new IntegerMax Value (). evaluate ();
```

- UDT supports the following operations:
  - 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.

  Note:

  - Only public methods and public fields are supported.
  - Identifiers in UDT include package names, class names, method names, and field names. All identifiers are case-sensitive.
  - UDT supports type conversion and SQL syntax, for example, cast (1 as java.lang.Object). UDT does not support type conversion using Java syntax, for example, (Object)1.
  - Anonymous classes and lambda expressions are not supported. They may be supported in later versions.
  - UDT is typically used in expressions. Functions that do not return values cannot be called in expressions. Therefore, UDT currently does not support calling functions that do not return values. This issue will be resolved in a later version.
- By default, you can reference all classes provided by Java SDK.

  Note:

  The runtime currently uses JDK1.8. Later versions may be not supported.
- All operators use the MaxCompute SQL semantics. 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 equal (=) operator. The equal (=) operator in SQL statements is used as a comparison operator. To compare two Java objects, you must call the equals method. You cannot use the equal (=) operator to verify whether two objects are equal. When UDT are used, you cannot guarantee that one object is equal to another object. For more information, see the following descriptions.

- Java data types are mapped to built-in data types. For more information, see the data type mapping table in Java UDFs. The mapping table can be applied to UDT.
  - 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 ()`.
  - UDT can be used in built-in functions and UDF. 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.

> **Note:**
> 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.

- UDT completely support Java generics. For example, based on the parameter type, the compiler knows the type of the value returned by the `java . util . Arrays . asList ( new  java . math . BigInteger (' 1 '))` method is `java . util . List < java . math . BigInteger >`.

> **Note:**
> You must set the type parameter in a construct function or use java.lang.Object, which 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 >`.

- UDT does not have a clear definition of equal objects. 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 UDT, you must use the equals method to compare two objects instead of using the equal (=) operator.

The correlations between objects in a row or column can be guaranteed. However, the correlations between objects in different rows or columns are not guaranteed.

- Currently, UDT cannot be used as shuffle keys in the join, group by, distribute by, sort by, order by, and cluster by clauses.

  UDT can be used at 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. Instead, you 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. This applies the built-in type to Java type mapping rules.
- UDT have made the data type conversion rules more flexible:
  - 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 applies the native conversion rules. The conversion may change the data. For example, java.lang .Long type data can be forcibly converted to java.lang.Integer type data. It is a process of converting built-in BIGINT type data to INT type data. This process may cause data changes or even data precision changes.
- Currently, you cannot save UDT objects, which means that you cannot add UDT objects to tables. DDL does not support UDT. You cannot create tables that contain UDT, unless you convert the data to built-in types using implicit conversion. In addition, the final output cannot be UDT type. To resolve this issue, you can call the toString() method to convert the UDT data to java.lang.String type data because all Java classes support the toString() method. 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 by calling the `java . util . Objects . toString (...)` method for debugging. 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 auto serialization. You can then save the byte [] arrays. The saved byte[] arrays can be deserialized to binary type.

Some classes may have their own serialization and deserialization methods, such as protobuffer. To save UDT, you must call serialization and deserialization methods to convert the data to binary data.

- You can use UDT to achieve the function provided by the scalar function. With the built-in functions collect list and explode, you can use UDT to achieve the functions provided by the aggregator and table functions.

UDT examples

- Example of using Java arrays

```
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   initializi  ng   an
ArrayList .
    new   Integer [][] {  new   Integer [] { c1 ,  c2 },  new
Integer [] { c3 ,  c4 } },  --  Create   a   multidimen  sional
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 );
```

- Example of using JSON

The runtime of UDT carries a JSON dependency (version 2.2.4), which can be directly used in JSON.

```
set   odps . sql . type . system . odps2 = true ;
set   odps . sql . session . java . imports = java . util .*, java
, com . google . gson . *; --  To   import   multiple   packages ,
separate   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 >) -- Deserializ  e   the   JSON   string .  The
```

```
gson   also   forcibly   converts   the   deserializ  ed   result
from   List < Object >  type   to   List < String >  type .
from  @ a ;
```

Compared with built-in function get_json_object, this method is simple and it improves efficiency by extracting content from the JSON string and then deserializing the string to a supported data type.

In addition to JSON 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).

- Example of using composite types

  Built-in types of array and map are mapped to java.util.List and java.util.Map, respectively. Results:

  - Java objects in classes calling the java.util.List or java.util.Map interface can be used in MaxCompute SQL composite type data processing.
  - Array and map type data in MaxCompute can directly call the List or Map interface.

```
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   indexing .
    Objects . toString ( a ),        --  With   this   method ,
you   can   now   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 ;
```

- Example of aggregation

To use UDT to achieve aggregation, 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_li st ( 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 data .
@ c := select if ( cnt % 2 == 1 , new BigDecimal ( values
[ cnt div 2 ]), new BigDecimal ( values [ cnt div 2 -
1 ]. add ( values [ 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. Using the built-in aggregator or UDAF object is more efficient . We recommend that you use the built-in aggregator if possible. Aggregating all data in a group increases the risk of data skew.

If the logic of the UDAF object is to aggregate all data, which is the same as the built -in function wm_concat, using the collect_list function is more efficient than using the UDAF object.

- Example of using the table-valued function

  The table-valued function allows you to input and output multiple rows and columns. To input or output multiple rows and columns, follow these steps:

  1. To input multiple rows or columns, reference the example of using the aggregate function.
  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 splitting result in 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 ; --
 Deserializ  e   the   JSON   string .
@ c  :=  select   cast ( e   as   java . util . Map < Object ,
 Object >)  m   from  @ b   lateral   view   explode ( l )  t   as
   e ;  --  Call   the   explode   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   Object   type .
```

Features, performance, and security

UDT has the following features:

- Easy to use. You do not need to define any functions.
- You can directly use all functions supported by the JDK. This improves the flexibilit y of SQL.
- You can directly reference objects and classes of other languages in SQL statements , which is easy to manage.
- You can directly reference libraries of other languages. This enables you to reuse your code.
- You can achieve functions based on the object-oriented concept.

Improvements that will be made to UDT later:

- UDT will support functions that do not return values, including functions that return values but the returned values are ignored and the passed in data is used, such as the add method provided by the List interface. This method returns the list that you have passed in.
- Anonymous classes and lambda expressions will be supported.
- You can use UDT as shuffle keys.
- More languages will be supported, such as Python.

The execution procedure of UDT is similar to UDF. UDT and UDFs have almost the same performance. In addition, the compute engine has been greatly improved. Therefore, UDT has higher performance in certain scenarios.

- 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.
- The runtime of UDT is based on Codegen. It is not based on reflection. Therefore, no performance reduction is experienced. Multiple UDT is wrapped in one FunctionCall and executed at the same time. For example, you may think that multiple UDT methods are called in `values [ x ]. add ( values [ y ]). divide ( java . math . BigInteger . valueOf ( 2 ))`, but actually only one method is called. UDT focus on small-granularity data processing. However, this does not incur additional overhead for the interface where multiple functions are called.

UDT is restricted by the Java sandbox model, as same as UDF. To perform restricted operations, you must enable sandbox isolation or apply to join a sandbox whitelist.

4.17 UDJ

Based on the MaxCompute 2.0 computing engine, MaxCompute introduces a new interface: user defined join (UDJ) to the user defined function (UDF) framework. This interface allows you to handle multiple tables more flexibly based on user-defined methods. It also simplifies the operations performed in the underlying distributed system using MapReduce. This is a major improvement of MaxCompute in big data processing based on NewSQL.

Overview

MaxCompute provides multiple native Join methods, 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 do not support handling multiple tables.

In most cases, you can build your code framework using UDFs. However, the current UDF, UDTF, and UDAF frameworks only support handling one table. 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 handling multiple tables, you even have to use custom MapReduce framework instead of SQL, in order to complete the required computing task.

In any situation, these operations require technological expertise and may cause the following issues:

- For the computing platform, calling multiple join methods in SQL statements may cause a "black box," which is complex and difficult to execute with the least 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.

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 the client log records for a user. Each record contains the user ID, operation time, and operation.

Requirement: 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.

The sample data is as follows:

payment

user_id	time	pay_info
2656199	2018-02-13 22:30:00	gZhvdySOQb
8881237	2018-02-13 08:30:00	pYvotuLDIT
8881237	2018-02-13 10:32:00	KBuMzRpsko

user_client_log

user_id	time	content
8881237	2018-02-13 00:30:00	click MpkvilgWSmhUuPn
8881237	2018-02-13 06:14:00	click OkTYNUHMqZzlDyL
8881237	2018-02-13 10:30:00	click OkTYNUHMqZzlDyL

The following is a record in the user_client_log table.

user_id	time	content
8881237	2018-02-13 00:30:00	click MpkvilgWSmhUuPn

The following payment record has the time closest to the operation time in the preceding client log record.

user_id	time	pay_info
8881237	2018-02-13 08:30:00	pYvotuLDIT

These two records are merged as follows:

8881237	2018-02-13 00:30:00	click MpkvilgWSmhUuPn, pay pYvotuLDIT

The merging result of the two tables is as follows:

user_id	time	content
8881237	2018-02-13 00:30:00	click MpkvilgWSmhUuPn, pay pYvotuLDIT
8881237	2018-02-13 06:14:00	click OkTYNUHMqZzlDyL, pay pYvotuLDIT

user_id	time	content
8881237	2018-02-13 10:30:00	click OkTYNUHMqZzlDyL, pay KBuMzRpsko

Call native join operations

If you use standard join methods, you have to join these two tables based on the common user_id field. You must locate the payment record that has the closest time to the operation time in each client log record. 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_clien  t_log   u
ON   p . user_id   =  u . user_id   and   abs ( p . time  -  u . time
) =  min ( abs ( p . time  -  u . time ))
```

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. However, you cannot call the aggregate function in the join condition. Therefore, this task cannot be completed by calling the standard join method.

In a distributed system, the join method merges rows retrieved from two or more tables based on a field that is shared by these tables. If you use the join method in standard SQL, you only have a few options to handle the merged data. Therefore, a generic interface, such as UDJ, is required to handle the merged data in a customized manner and output the result. This interface may be integrated as a plug-in.

Use Java to write UDJ code

The following describes how to use UDJ to achieve a function that cannot be implemented by calling a native join method.

Prerequisites

Since UDJ is a new feature, a new SDK is required.

```
< dependency >
  < groupId > com . aliyun . odps </ groupId >
  < artifactId > odps - sdk - udf </ artifactId >
  < version > 0 . 29 . 10 - public </ version >
  < scope > provided </ scope >
```

```
</ dependency >
```

The SDK contains a new abstract class UDJ. By extending this UDJ, you can implement all UDJ functions.

```
 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 . ArrayRecor  d ;
 import   com . aliyun . odps . data . Record ;
 import   com . aliyun . odps . udf . DataAttrib  utes ;
 import   com . aliyun . odps . udf . ExecutionC  ontext ;
 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   the   right   table ,  find   the
 nearest   record   of   the   left   table   and
 *  merge   two   records .
 */
@ Resolve ("-> string , bigint , string ")
 public   class   PayUserLog  MergeJoin   extends   UDJ  {
   private   Record   outputReco  rd ;
  /**  Will   be   called   prior   to   the   data   processing
 phase .  User   could   implement
   *  use   this   method   to   do   initializa  tion   work .
   */
  @ Override
   public   void   setup ( ExecutionC  ontext   executionC  ontext ,
 DataAttrib  utes   dataAttrib  utes ) {
     //
     outputReco  rd  =  new   ArrayRecor  d ( 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   the   left   table
 correspond  ing   to   the   current   key
   * @ param   right   Group   of   records   of   the   right   table
   correspond  ing   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 ) {
     outputReco  rd . setString ( 0 ,  key . getString ( 0 ));
     if  (!  right . hasNext ()) {
      //  Empty   the   right   group   and   do   nothing .
       return ;
    }  else   if  (!  left . hasNext ()) {
      //  Empty   left   group .  Output   all   records   of   the
 right   group   without   merge .
       while  ( iter . hasNext ()) {
         Record   logRecord  =  right . next ();
         outputReco  rd . setBigint ( 1 ,  logRecord . getDatetim  e (
 0 ). getTime ());
         outputReco  rd . setString ( 2 ,  logRecord . getString ( 1
 ));
```

```
          output . yield ( outputReco  rd );
       }
        return ;
     }
      ArrayList < Record >  pays  =  new   ArrayList <>();
     //  The   left   group   of   records   will   be   iterated
  from   the   start   to   the   end
     //  for   each   record   of   the   right   group ,  but   the
  iterator   cannot   be   reset .
     //  So   we   save   every   record   of   the   left   to   an
  ArrayList .
      left . forEachRem  aining ( pay  ->  pays . add ( pay . clone
  ()));
      while  ( right . hasNext ()) {
        Record   log  =  right . next ();
        long   logTime  =  log . getDatetim  e ( 0 ). getTime ();
        long   minDelta  =  Long . MAX_VALUE ;
        Record   nearestPay  =  null ;
       //  Iterate   through   all   records   of   the   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 . getDatetim  e
  ( 0 ). getTime ());
          if  ( delta  <  minDelta ) {
            minDelta  =  delta ;
            nearestPay  =  pay ;
          }
       }
       //  Merge   the   log   record   with   the   nearest   pay
  record   and   output   the   result .
        outputReco  rd . setBigint ( 1 ,  log . getDatetim  e ( 0 ).
  getTime ());
        outputReco  rd . setString ( 2 ,  mergeLog ( nearestPay .
  getString ( 1 ),  log . getString ( 1 )));
        output . yield ( outputReco  rd );
     }
   }
    String   mergeLog ( String   payInfo ,  String   logContent ) {
      return   logContent  + ",  pay  " +  payInfo ;
   }
   @ Override
    public   void   close () {
   }
 }
```

> **Note:**
>
> In this example, the NULL values in the entries are not processed. To simplify the data processing procedure for better presentation, this example assumes 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 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 RAM. Typically, the RAM has enough space to store the payment data of a user generated in one day. What if this assumption is invalid? How can we resolve this issue? This issue will be discussed in topic Use the SORT BY clause

Create a UDJ in MaxCompute

After you have written the UDJ code in Java, upload the code to MaxCompute SQL as a plug-in. You must register the code with MaxCompute first. Assume that the code is packed into JAR package *odps - udj - example . jar* .

Use the Add JAR command to upload the JAR package to MaxCompute as follows:

```
add   jar   odps - udj - example . jar ;
```

Use the CREATE FUNCTION statement to create UDJ function pay_user_log_merge_join, referencing the corresponding Java class and using the odps-udj-example.jar JAR package.

`com . aliyun . odps . udf . example . udj . PayUserLog  MergeJoin :`

```
create   function   pay_user_l  og_merge_j  oin
  as  ' com . aliyun . odps . udf . example . udj . PayUserLog
MergeJoin '
  using  ' odps - udj - example . jar ';
```

Use UDJ in MaxCompute SQL

After you have registered UDJ in the database, the function can be used by MaxCompute SQL.

1. Create a sample source table

```
create   table   payment  ( user_id   string , time   datetime ,
pay_info   string );
create   table   user_clien  t_log ( user_id   string , time
datetime , content   string );
```

2. Create sample data:

```
Create   the   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_clien  t_log   table
 INSERT   OVERWRITE   TABLE   user_clien  t_log   VALUES
(' 1000235 ',  datetime  ' 2018 - 02 - 13   00 : 25 : 36 ', ' click
   FNOXAibRjk  IaQPB '),
(' 1000235 ',  datetime  ' 2018 - 02 - 13   22 : 30 : 00 ', ' click
   GczrYaxvki  PultZ '),
(' 1335656 ',  datetime  ' 2018 - 02 - 13   18 : 30 : 00 ', ' click
   MxONdLckpA  FUHRS '),
(' 1335656 ',  datetime  ' 2018 - 02 - 13   19 : 54 : 00 ', ' click
   mKRPGOciFD  yzTgM '),
(' 2656199 ',  datetime  ' 2018 - 02 - 13   08 : 30 : 00 ', ' click
   CZwafHsbJO  PNitL '),
(' 2656199 ',  datetime  ' 2018 - 02 - 13   09 : 14 : 00 ', ' click
   nYHJqIpjev  kKToy '),
(' 2656199 ',  datetime  ' 2018 - 02 - 13   21 : 05 : 00 ', ' click
   gbAfPCwrGX  vEjpI '),
(' 2656199 ',  datetime  ' 2018 - 02 - 13   21 : 08 : 00 ', ' click
   dhpZyWMuGj  BOTJP '),
(' 2656199 ',  datetime  ' 2018 - 02 - 13   22 : 29 : 00 ', ' click
   bAsxnUdDhv  fqaBr '),
(' 2656199 ',  datetime  ' 2018 - 02 - 13   22 : 30 : 00 ', ' click
   XIhZdLaOoc  QRmrY '),
(' 4356142 ',  datetime  ' 2018 - 02 - 13   18 : 30 : 00 ', ' click
   DYqShmGbIo  WKier '),
(' 4356142 ',  datetime  ' 2018 - 02 - 13   19 : 54 : 00 ', ' click
   DYqShmGbIo  WKier '),
(' 8881237 ',  datetime  ' 2018 - 02 - 13   00 : 30 : 00 ', ' click
   MpkvilgWSm  hUuPn '),
(' 8881237 ',  datetime  ' 2018 - 02 - 13   06 : 14 : 00 ', ' click
   OkTYNUHMqZ  zlDyL '),
(' 8881237 ',  datetime  ' 2018 - 02 - 13   10 : 30 : 00 ', ' click
   OkTYNUHMqZ  zlDyL '),
(' 9890100 ',  datetime  ' 2018 - 02 - 13   16 : 01 : 00 ', ' click
   vOTQfBFjcg  XisYU '),
(' 9890100 ',  datetime  ' 2018 - 02 - 13   16 : 20 : 00 ', ' click
   WxaLgOCcVE  vhiFJ ')
;
```

3. In MaxCompute SQL, use the UDJ function you have created:

```
 SELECT   r . user_id ,  from_unixt  ime ( 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_clien  t_log
)  u
 ON   p . user_id  =  u . user_id
 USING   pay_user_l  og_merge_j  oin ( p . time ,  p . pay_info ,  u
 . time ,  u . content )
 r
 AS  ( user_id ,  time ,  content )
```

```
;
```

The syntax of UDJ is similar to the standard join syntax. The only difference is that the USING clause is added to UDJ.

- The name of the UDJ function in SQL is pay_user_log_merge_join.
- (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.

Execute this SQL statement, and the result is as follows:

```
+---------+------------+---------+
| user_id | time       | content |
+---------+------------+---------+
| 1000235 | 2018 - 02 - 13  00 : 25 : 36 | click  FNOXAibRjk
 IaQPB  |
| 1000235 | 2018 - 02 - 13  22 : 30 : 00 | click  GczrYaxvki
 PultZ  |
| 1335656 | 2018 - 02 - 13  18 : 30 : 00 | click  MxONdLckpA
 FUHRS , pay  PEqMSHyktn  |
| 1335656 | 2018 - 02 - 13  19 : 54 : 00 | click  mKRPGOciFD
 yzTgM , pay  PEqMSHyktn  |
| 2656199 | 2018 - 02 - 13  08 : 30 : 00 | click  CZwafHsbJO
 PNitL , pay  pYvotuLDIT  |
| 2656199 | 2018 - 02 - 13  09 : 14 : 00 | click  nYHJqIpjev
 kKToy , pay  pYvotuLDIT  |
| 2656199 | 2018 - 02 - 13  21 : 05 : 00 | click  gbAfPCwrGX
 vEjpI , pay  PEqMSHyktn  |
| 2656199 | 2018 - 02 - 13  21 : 08 : 00 | click  dhpZyWMuGj
 BOTJP , pay  PEqMSHyktn  |
| 2656199 | 2018 - 02 - 13  22 : 29 : 00 | click  bAsxnUdDhv
 fqaBr , pay  gZhvdySOQb  |
| 2656199 | 2018 - 02 - 13  22 : 30 : 00 | click  XIhZdLaOoc
 QRmrY , pay  gZhvdySOQb  |
| 4356142 | 2018 - 02 - 13  18 : 30 : 00 | click  DYqShmGbIo
 WKier  |
| 4356142 | 2018 - 02 - 13  19 : 54 : 00 | click  DYqShmGbIo
 WKier  |
| 8881237 | 2018 - 02 - 13  00 : 30 : 00 | click  MpkvilgWSm
 hUuPn , pay  pYvotuLDIT  |
| 8881237 | 2018 - 02 - 13  06 : 14 : 00 | click  OkTYNUHMqZ
 zlDyL , pay  pYvotuLDIT  |
| 8881237 | 2018 - 02 - 13  10 : 30 : 00 | click  OkTYNUHMqZ
 zlDyL , pay  KBuMzRpsko  |
| 9890100 | 2018 - 02 - 13  16 : 01 : 00 | click  vOTQfBFjcg
 XisYU , pay  gZhvdySOQb  |
| 9890100 | 2018 - 02 - 13  16 : 20 : 00 | click  WxaLgOCcVE
 vhiFJ , 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.

Pre-sorting

To locate the matching payment record, an iterator is used to search all records in the payment table. 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. If a large number of payment records has been generated, due to RAM size limits, you must find another method to load the data. This section 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 RAM, 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 in Java:

```
@ Override
 public   void   join ( Record   key ,  Iterator < Record >  left ,
 Iterator < Record >  right ,  Yieldable < Record >  output ) {
   outputReco  rd . setString ( 0 ,  key . getString ( 0 ));
   if  (!  right . hasNext ()) {
     return ;
  }  else   if  (!  left . hasNext ()) {
     while  ( right . hasNext ()) {
       Record   logRecord  =  right . next ();
       outputReco  rd . setBigint ( 1 ,  logRecord . getDatetim  e ( 0
 ). getTime ());
       outputReco  rd . setString ( 2 ,  logRecord . getString ( 1 ));
       output . yield ( outputReco  rd );
    }
     return ;
  }
   long   prevDelta  =  Long . MAX_VALUE ;
   Record   logRecord  =  right . next ();
   Record   payRecord  =  left . next ();
   Record   lastPayRec  ord  =  payRecord . clone ();
   while  ( true ) {
     long   delta  =  logRecord . getDatetim  e ( 0 ). getTime () -
 payRecord . getDatetim  e ( 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 .
       lastPayRec  ord  =  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  :  lastPayRec  ord ;
       outputReco  rd . setBigint ( 1 ,  logRecord . getDatetim  e ( 0
 ). getTime ());
```

```
        String   mergedStri  ng  =  mergeLog ( nearestPay . getString (
 1 ),  logRecord . getString ( 1 ));
        outputReco  rd . setString ( 2 ,  mergedStri  ng );
        output . yield ( outputReco  rd );
        if  ( right . hasNext ()) {
          logRecord  =  right . next ();
          prevDelta  =  Math . abs (
            logRecord . getDatetim  e ( 0 ). getTime () -  lastPayRec
 ord . getDatetim  e ( 0 ). getTime ()
         );
       }  else  {
          break ;
       }
     }
   }
 }
```

In the native SQL language, you only need to make a few modifications to this example and add a SORT BY clause to the end of the UDJ clause, and then sort the data in both tables by time. Note: After you have modified the UDJ code, you must update the corresponding JAR package.

```
 SELECT   r . user_id ,  from_unixt  ime ( 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_clien  t_log
)  u
 ON   p . user_id  =  u . user_id
 USING   pay_user_l  og_merge_j  oin ( p . time ,  p . pay_info ,  u .
 time ,  u . content )
 r
 AS  ( user_id ,  time ,  content )
 SORT   BY   p . time ,  u . time
;
```

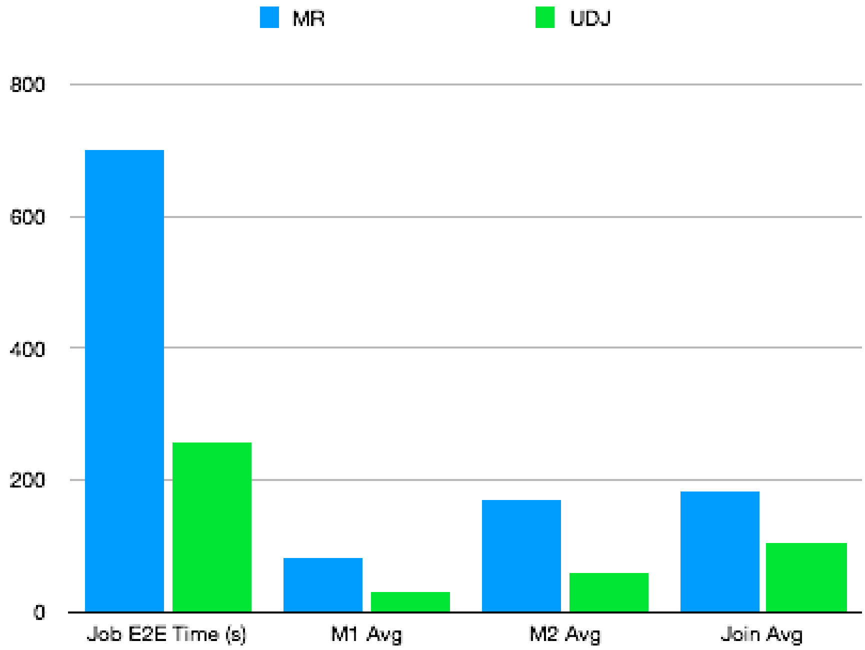
The execution result is the same as the result before the code is modified.

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.

UDJ performance

Without UDJ, you have to use MapReduce to handle complex cross-table computing tasks in a distributed system. The applicable scenarios include complex business scenarios such as advertising and information search.

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 then check whether the execution result is correct. Under the same programming concurrency, the comparison of performance is as follows:



As shown in the figure, using UDJ helps to describe the complex logic of handling multiple tables, and greatly improves the query performance. The code is only executed inside the UDJ function, and the entire logic of the code, such as the logic of the map stage in this example, 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 at the reduce stage in MapReduce.

4.18 Appendix

4.18.1 Escape characters

In MaxCompute SQL, a string constant can be set off by single (‘) or double quotation marks (“). The string set off by single quotation marks can contain double quotation marks or the string set off by double quotation marks can contain single quotation marks. Otherwise, you must use an escape character to indicate it.

The following expressions are acceptable:

```
" I ' m   a   happy   manong ."
```

```
' I \' m   a   happy   manong .'
```

In MaxCompute SQL, ‘\’ is a kind of escape character used to express the special character in a string or express its followed characters as characters themselves. To read a string constant, if ‘\’ is followed by three effective 8 hexadecimal digits and corresponding range is from 001 to 177, the system converts it to corresponding characters according to an ASCII value.

The following table lists some special escape characters:

Escape	Character
\b	backspace
\t	tab
\n	newline
\r	carriage-return
\’	single quotation mark
\”	double quotation marks
\ \	Backslash
\;	Semicolon
\Z	control-Z
\0 or \00	Terminator

```
select   length (' a \ tb ')  from   dual ;
```

The result is 3, which indicates that three characters are in the string. The ‘\t’ is considered as one character. Other following characters are expressed as themselves.

```
select   ' a \ ab ', length (' a \ ab ')  from   dual ;
```

The result: ‘aab’, 3. ‘\a’ is expressed as general ‘a’.

4.18.2 LIKE usage

In LIKE matching, ‘%’ indicates matching any multiple characters. The ‘_’ indicates matching a single character. To match ‘%’ or ‘_’ itself, you must escape it. The ‘\\%’ matches the character ‘%’ and ‘_’ matches the character ‘_’.

```
    ' abcd '  like  ' ab %' --  true
    ' abcd '  like  ' ab_ ' --  false
```

```
    ' ab_cde '  like  ' ab \\ _c %'; --  true
```

Notice:

MaxCompute SQL only supports the UTF-8 character set. If the data is encoded in another format, it is possible that the calculation result is not correct.

4.18.3 Regular expression

The regular expressions in MaxCompute SQL use the PCRE standard, matched by characters. The meta character to be supported is as follows:

Metacharacter	Description
^	Top of line (TOL)
$	End of line
.	Any character
*	Matches for zero or multiple times
+	Matches for once or multiple times
?	Matches for zero time or once
?	Matches modifier. When this character follows any other constraints (*, +,? {n}, {n, {n, m},}, the match mode is non greedy. Non greedy mode matches strings as little as possible , while the default greedy mode matches strings as more as possible.
A | B	A or B
(abc)*	Matches 'abc' for zero or multiple times
{n} or {m, n}	Matching times
[ab]	Matches any character in the brackets. In the example, it is to match a or b.
[a-d]	Matches any character in a, b, c, and d.
[^ab]	^ indicats 'non' , to match any character which is not a and b .
[::]	See POSIX character group in next table.
\	Escape character
\n	N is a digit from 1 to 9 and is backward referenced.
\d	digits
\ D	Non-number

POSIX character group:

POSIX Character Group	Description	Range
[[:alnum:]]	letter and digit characters	[a-zA-Z0-9]
[[:alpha:]]	letter	[a-zA-Z]
[[:ascii:]]	ASCII character	[\x00-\x7F]
[[:blank:]]	Space character and tabs	[\t]
[[:cntrl:]]	Control character	[\x00-\x1F\x7F]
[[:digit:]]	Digit character	[0-9]
[[:graph:]]	Characters except white space characters	[\x21-\x7E]
[[:lower:]]	Lowercase characters	[a-z]
[[:print:]]	[:graph:] and white space characters	[\x20-\x7E]
[[:punct:]]	punctuation	[][!” [][!” #$%&’ ()*+,./:;<=>?@\^_`{|}~-]
[[:space:]]	White space characters	[\t\r\n\v\f]
[[:upper:]]	Uppercase characters	[A-Z]
[[:xdigit:]]	hexadecimal character	[A-Fa-f0-9]

Because the system uses a backslash () as an escape character, all “\” which appear in the regular expression pattern perform two escapes. For example, the regular expression needs to match the string “a+b”. The “+” is a special character in regular expressions and must be expressed by escape. The expression in a regular engine is “a\+b”, because the system needs to explain a layer of escape, the expression which can match this string is “a\\+b”.

Suppose that the table test_dual is:

```
select ' a + b ' rlike ' a \\\+ b ' from test_dual ;
| _c1 |
| true |
```

In extreme cases, to match the character “ \” , because “ \” is a special character in a regular engine, it needs to be expressed by “\” , while the system does an escape for it again, it is written as “\\” .

```
select ' a \\ b ', ' a \\ b ' rlike ' a \\\\ b ' from test_dual
;
| _c0 | _c1 |
| a \ b | true |
```

Note:

To write `a \\ b` in MaxCompute SQL, and the output result is `a \ b`.

If TAB exists in a string, when the system reads these two characters `\ t`, they are already saved as one character by the system. Therefore, in regular expression, it is a general character.

```
select ' a \ tb ', ' a \ tb ' rlike ' a \ tb ' from test_dual
;| _c0 | _c1 |
| a b | true |
```

4.18.4 Reserved words and keywords

This document shows all reserved words in MaxCompute SQL.

Notice:

- These cannot be used to name a table, column, or partition,otherwise an error occurs.
- Reserved words are not case sensitive.

```
    % & && ( ) * +
                - . / ; < <= <>
        ADD   AFTER   ALL
    ALTER   ANALYZE   AND   ARCHIVE   ARRAY   AS   ASC
    BEFORE   BETWEEN   BIGINT   BINARY   BLOB   BOOLEAN   BOTH
DECIMAL
    BUCKET   BUCKETS   BY   CASCADE   CASE   CAST   CFILE
    CHANGE   CLUSTER   CLUSTERED   CLUSTERSTA TUS   COLLECTION
COLUMN   COLUMNS
    COMMENT   COMPUTE   CONCATENAT E   CONTINUE   CREATE   CROSS
CURRENT
    CURSOR   DATA   DATABASE   DATABASES   DATE   DATETIME
DBPROPERTI ES
```

```
    DEFERRED   DELETE   DELIMITED   DESC   DESCRIBE   DIRECTORY
DISABLE
    DISTINCT   DISTRIBUTE   DOUBLE   DROP   ELSE   ENABLE   END
    ESCAPED   EXCLUSIVE   EXISTS   EXPLAIN   EXPORT   EXTENDED
EXTERNAL
    FALSE   FETCH   FIELDS   FILEFORMAT   FIRST   FLOAT   FOLLOWING
    FORMAT   FORMATTED   FROM   FULL   FUNCTION   FUNCTIONS   GRANT
    GROUP   HAVING   HOLD_DDLTI  ME   IDXPROPERT  IES   IF   IMPORT
IN
    INDEX   INDEXES   INPATH   INPUTDRIVE  R   INPUTFORMA  T   INSERT
  INT
    INTERSECT   INTO   IS   ITEMS   JOIN   KEYS   LATERAL
    LEFT   LIFECYCLE   LIKE   LIMIT   LINES   LOAD   LOCAL
    LOCATION   LOCK   LOCKS   LONG   MAP   MAPJOIN   MATERIALIZ  ED
    MINUS   MSCK   NOT   NO_DROP   NULL   OF   OFFLINE
    ON   OPTION   OR   ORDER   OUT   OUTER   OUTPUTDRIV  ER
    OUTPUTFORM  AT   OVER   OVERWRITE   PARTITION   PARTITIONE  D
PARTITIONP  ROPERTIES   PARTITIONS
    PERCENT   PLUS   PRECEDING   PRESERVE   PROCEDURE   PURGE
RANGE
    RCFILE   READ   READONLY   READS   REBUILD   RECORDREAD  ER
RECORDWRIT  ER
    REDUCE   REGEXP   RENAME   REPAIR   REPLACE   RESTRICT   REVOKE
    RIGHT   RLIKE   ROW   ROWS   SCHEMA   SCHEMAS   SELECT
    SEMI   SEQUENCEFI  LE   SERDE   SERDEPROPE  RTIES   SET   SHARED
  SHOW
    SHOW_DATAB  ASE   SMALLINT   SORT   SORTED   SSL   STATISTICS
STORED
    STREAMTABL  E   STRING   STRUCT   TABLE   TABLES   TABLESAMPL  E
  TBLPROPERT  IES
    TEMPORARY   TERMINATED   TEXTFILE   THEN   TIMESTAMP   TINYINT
TO
    TOUCH   TRANSFORM   TRIGGER   TRUE   UNARCHIVE   UNBOUNDED
UNDO
    UNION   UNIONTYPE   UNIQUEJOIN   UNLOCK   UNSIGNED   UPDATE
USE
    USING   UTC   UTC_TMESTA  MP   VIEW   WHEN   WHERE   WHILE   DIV
```

4.18.5 Hive data type mapping table

The data type mapping table for MaxCompute and hive is as follows:

Hive Data Type	MaxCompute Data Type
BOOLEAN	Boolean
TINYINT	Tinyint
SMALLINT	Smallint
INT	Int
BIGINT	Bigint
FLOAT	Float
DOUBLE	Double
Decimal	Decimal
String	String

Hive Data Type	MaxCompute Data Type
Varchar	Varchar
Char	String
BINARY	Binary
Timestamp	Timestamp
Date	Datetime
ARRAY	Array
`Map < key , value >`	MAP
STRUCT	STRUCT
Union	This feature is not supported.

5 MapReduce

5.1 Summary

5.1.1 MapReduce

This article describes the MapReduce programming interface supported by MaxCompute and its limitations.

MaxCompute provides three versions of MapReduce programming interface:

- MaxCompute MapReduce: Native interface for MaxCompute, which is faster than other interfaces. It is more convenient to develop a program without exposing file system.
- MR2 (Extended MapReduce): The extension to MaxCompute, which supports more complex job scheduling logic. MapReduce is implemented in the same way as the MaxCompute native interface.
- Hadoop compatible version: Highly compatible with Hadoop MapReduce , but not compatible with MaxCompute native interface and MR2.

The preceding three versions are basically the same in the Basic concepts, Job submission, Input and output, and Resource, and the only difference is the Java SDK. This article introduces the principle of MapReduce. For more detailed description of MapReduce, see Hadoop MapReduce Course.

Note:
You are not yet able to read or write data from the external tables through MapReduce.

Scenarios

MapReduce was originally proposed by Google as a distributed data processing model and is now widely applied in multiple business scenarios. The following are the examples:

- Search: web crawl, flip index, PageRank.

- Web access log analytics:
  - Analyze and mine the web access, shopping behavior characteristics to achieve personalized recommendation.
  - Analyze user's access behavior.
- Statistics and analysis for the text:
  - The Wordcount and TFIDF analysis of Mo Yan novels.
  - Reference analysis and statistics of academic papers and patent documents.
  - Wikipedia data analysis, and so on.
- Massive Data Mining: Unstructured data, spatial and temporal data, image data mining.
- Machine Learning: Supervised learning, unsupervised learning, classification algorithm such as decision tree, SVM, and so on..
- Natural Language Processing:
  - Training and forecasting based on big data.
  - Based on the corpus to construct the current matrix of words, frequent itemset data mining, repeated document detection and so on.
- Advertisement recommendations: User-click (CTR) and purchase behavior (CVR) forecasts.

Processing data process

The processing data process of MapReduce is divided into two stages: Map and Reduce. Map must be executed first, and then Reduce. The processing logic of Map and Reduce is defined by the user, but must comply with the MapReduce framework protocol. The process is as follows:

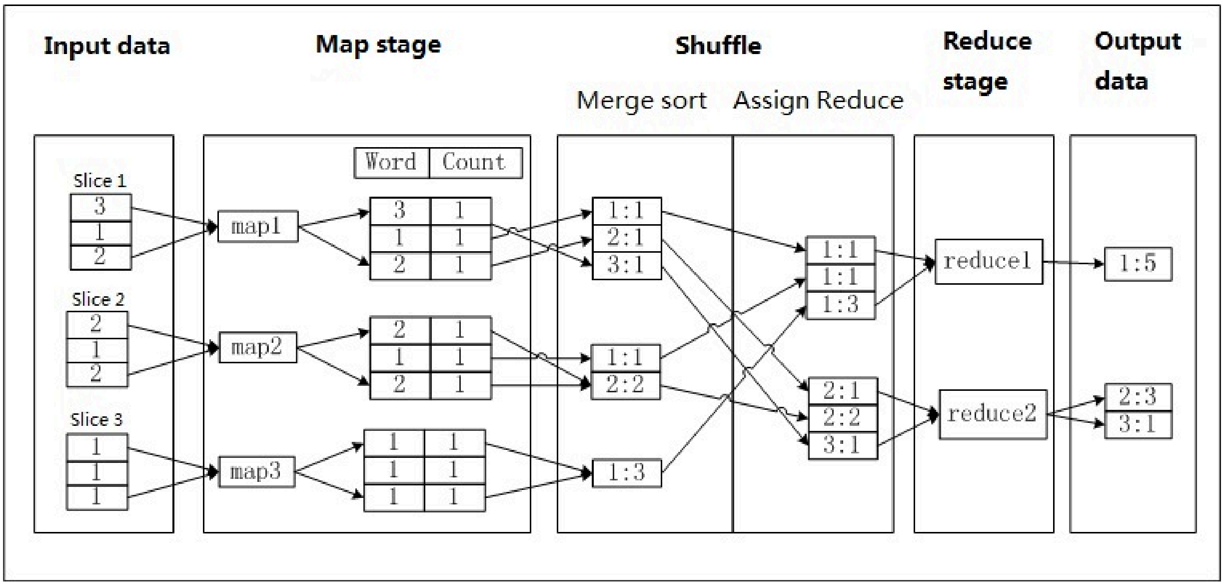
1. Before executing Map, the input data must be sliced, that is, input data is divided into blocks of equal size. Each block is processed as the input of a single Map Worker, so that multiple Map Workers can work simultaneously.
2. After the slice is split, multiple Map Worker can work together. Each Map Worker performs computing after reading the data and output the result to Reduce. Because Map Worker outputs the data, it must specify a key for each output record . The value of this Key determines which Reduce Worker the data has been sent to. The relationship between key value and Reduce Worker is an any-to-one relationsh ip. Data with the same key is sent to the same Reduce Worker, and a single Reduce Worker may receive data of multiple key values.

3. Before Reduce stage, MapReduce framework sorts the data according to their Key values, and make sure data with same Key value is grouped together. If a user specifies Combiner, the framework calls Combiner to aggregate the same key data. The user must define the logic of Combiner. Compared to the classical MapReduce framework, the input parameter and output parameter of Combiner must be consistent with the Reduce in MaxCompute. This processing is generally called as Shuffle.
4. At Reduce stage, data with the same key is shuffled to the same Reduce Worker. A Reduce Worker receives data from multiple Map Workers. Each Reduce Worker executes Reduce operation for multiple records of the same key. Then these multiple records become a value through Reduce processing.

> Note:
> A brief introduction to the MapReduce framework is mentioned in the preceding process. For more information, see relevant documents.

The following example uses WordCount to explain the stages of MaxCompute MapReduce.

Assumethat a text named ‘a.txt’, where each row is indicated by a number, and the frequency of appearance of each number must be counted. The number in the text is called as ‘Word’ and the number appearance occurrence is called as 'Count'. To complete this function through MaxCompute MapReduce, the following figure illustrates the required steps:



Procedure:

1. First, text is sliced and the data in each slice is entered into a single Map Worker.
2. Map processes the input. Once Map gets a number, it sets the Count as 1. Then, output <Word,Count>queues sequence is followed. Take 'Word' as the Key of output data.
3. In the initial actions of Shuffle stage, the output of each Map Worker is sorted according to Key value (value of Word). The Combine operation is executed after sorting to accumulate the Count of same Key value (Word value) and constitute a new <Word,Count> queue. This process is called as the combiner sorting.
4. In the later actions of Shuffle, data is transmitted to Reduce. Reduce Worker sorts the data based on the Key value again after receiving the data.
5. At the time of processing data, each Reduce Worker adopts that same logic as that of a Combiner by accumulating Count with the same Key value (Word value) to get the output.
6. Result.

Note:
Because the data in MaxCompute is stored in tables, the input and output of MaxCompute MapReduce can only be a table. User-defined output is not allowed and the corresponding file system interface is not provided.

5.1.2 Extended MapReduce

Compared with the traditional MapRudece, the extended MapReduce model provided by MaxCompute changes the underlying scheduling and I/O model, and avoids redundant I/O operations during the performance.

The traditional MapReduce model requires that the data must be loaded to the distributed file system (such as HDFS or MaxCompute table) after each round of MapReduce operation. However, a general MapReduce application usually consists of multiple MapReduce jobs, and each job output must be written to the disk. The following Map task is an example of a task used only to read the data, prepared for the subsequent Shuffle stage, but which actually results in redundant I/O operations.

The calculation scheduling logic of MaxCompute supports more complex programming paradigm. In the preceding scenario, the next Reduce operation can be executed after the Reduce operation and inserting a Map operation is not necessary . In this way, MaxCompute provides an extensional MapReduce model, that is, numerous Reduce operations can follow a Map operation, such as Map>Reduce>Reduce.

Hadoop Chain Mapper/Reducer also supports analogous serial Map or Reduce operations, but has major differences compared with the extensional MaxCompute (MR2) model.

The Hadoop Chain Mapper/Reducer is based on the traditional MapReduce model, and can only add one or multiple Mapper operations (it is not allowed to add Reducer operations) after the original Mapper or Reducer. The benefits of extended MapReduce are, a user can reuse previous business logic of Mapper and can split one Map stage or Reduce stage into multiple Mapper stages. The underlying scheduling and I/O model are not changed essentially.

Compared with MaxCompute , MR2 is basically consistent in a way Map/Reduce functions are written. The main difference is in the performance. For more information, see Extended MapReduce example.

5.1.3 Open-source MapReduce

This article introduces the application background of open-source MapReduce and the basic usage of HadoopMR plug-in.

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 APIs differ significantly from APIs for the Hadoop framework. Previously, to migrate your Hadoop MapReduce jobs to MaxCompute, firstly, you were needed to rewrite the MapReduce code, compile, and debug the code using MaxCompute APIs, compress the final code into a JAR package, and finally upload the package to the MaxCompute platform. This process is tedious and requires a lot of development and testing efforts. If you are not required to modify the original Hadoop MapReduce code partially, running it in MaxCompute console is the best solution.

Now, the MaxCompute platform provides a plug-in that allows you to adapt Hadoop MapReduce code to MaxCompute MapReduce specifications. MaxCompute offers a degree of flexibility regarding binary-level compatibility for Hadoop MapReduce jobs. It means that, without modifying the code, you can specify configurations to directly run original Hadoop MapReduce Jar packages on MaxCompute. Download the development plug-in to get started. This plug-in is currently in the testing stage, therefore, does not support custom comparators or key types.

In the following example, a WordCount program is used to introduce the basic usage of the plug-in.

Download the HadoopMR Plug-in

Click here to download the plug-in named hadoop2openmr-1.0.jar.

Note:
This Jar package contains the dependencies with Hadoop 2.7.2. Do not include Hadoop dependencies in the Jar packages of your jobs to avoid version conflicts.

Prepare a Jar package

Compile and export the WordCount JAR package named wordcount_test.jar. The WordCount program source code is as follows:

```
package   com . aliyun . odps . mapred . example . hadoop ;
import   org . apache . hadoop . conf . Configurat  ion ;
import   org . apache . hadoop . fs . Path ;
import   org . apache . hadoop . io . IntWritabl  e ;
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 .
FileInputF  ormat ;
import   org . apache . hadoop . mapreduce . lib . output .
FileOutput  Format ;
import   java . io . IOExceptio  n ;
import   java . util . StringToke  nizer ;
public   class   WordCount  {
    public   static   class   TokenizerM  apper
        extends   Mapper < Object , Text , Text , IntWritabl  e >{
        private   final   static   IntWritabl  e   one  =  new
IntWritabl  e ( 1 );
        private   Text   word  =  new   Text ();
        public   void   map ( Object   key , Text   value , Context
  context
        ) throws   IOExceptio  n , Interrupte  dException  {
            StringToke  nizer  itr  =  new   StringToke  nizer (
value . toString ());
            while  ( itr . hasMoreTok  ens ()) {
                word . set ( itr . nextToken ());
                context . write ( word , one );
            }
        }
    }
    public   static   class   IntSumRedu  cer
        extends   Reducer < Text , IntWritabl  e , Text , IntWritabl
e > {
        private   IntWritabl  e   result  =  new   IntWritabl  e ();
        public   void   reduce ( Text   key , Iterable < IntWritabl
e >  values ,
```

```
              Context   context
        )  throws   IOExceptio  n ,  Interrupte  dException  {
              int   sum  =  0 ;
              for  ( IntWritabl  e   val  :  values ) {
                  sum  +=  val . get ();
             }
              result . set ( sum );
              context . write ( key ,  result );
        }
    }
     public   static   void   main ( String []  args )  throws
 Exception  {
        Configurat  ion   conf  =  new   Configurat  ion ();
        Job   job  =  Job . getInstanc  e ( conf , " word   count ");
        job . setJarByCl  ass ( WordCount . class );
        job . setMapperC  lass ( TokenizerM  apper . class );
        job . setCombine  rClass ( IntSumRedu  cer . class );
        job . setReducer  Class ( IntSumRedu  cer . class );
        job . setOutputK  eyClass ( Text . class );
        job . setOutputV  alueClass ( IntWritabl  e . class );
        FileInputF  ormat . addInputPa  th ( job ,  new   Path ( args
 [ 0 ]));
        FileOutput  Format . setOutputP  ath ( job ,  new   Path (
 args [ 1 ]));
        System . exit ( job . waitForCom  pletion ( true ) ?  0  :  1
 );
    }
}
```

Prepare the 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. **Run Tunnel to import data to the input table.**

   The data in the data.txt file to be imported is as follows:

```
hello   maxcompute
hello   mapreduce
```

   Use the `Tunnel   command` **on the MaxCompute console to import data from data.txt to wc_in.**

```
tunnel   upload   data . txt   wc_in ;
```

Configure the mapping between the table and the HDFS file path

The configuration file is wordcount-table-res.conf:

```
{
  " file :/ foo ": {
    " resolver ": {
      " resolver ": " com . aliyun . odps . mapred . hadoop2ope  nmr .
 resolver . TextFileRe  solver ",
```

```
      " 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 . hadoop2ope  nmr .
resolver . BinaryFile  Resolver ",
      " properties ": {
          " binary . resolver . input . key . class " : " org . apache
. hadoop . io . Text ",
          " binary . resolver . input . value . class " : " org .
apache . hadoop . io . LongWritab  le "
      }
    },
    " tableInfos ": [
      {
        " tblName ": " wc_out ",
        " partSpec ": {},
        " label ": " __default_  _ "
      }
    ],
    " matchMode ": " fuzzy "
  }
}
```

Parameters

The configuration is a JSON file that describes the mapping relationships between HDFS files and the MaxCompute tables. Generally, you must configure both the input and output. One HDFS path corresponds to one Resolver, tableInfos, and matchMode.

- resolver: Specifies the method of processing file data.
  Currently, you can choose from two built-in Resolvers: com.aliyun.odps.mapred.hadoop2openmr.resolver.TextFileResolver and com.aliyun.odps.mapred.hadoop2openmr.resolver.BinaryFileResolver. In addition to specifying the Resolver name, configure some properties about data parsing for the Resolver.
  - TextFileResolver: Regards an input or output as plain text if the data is of plain text type. When configuring an input Resolver, configure such properties as text.resolver.columns.combine.enable and text.resolver.seperator. When text .resolver.columns.combine.enable is set to true, all the 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.
  - BinaryFileResolver: Converts binary data into a type that is supported by MaxCompute, for example, Bigint, Boolean, and Double. When configuring an output Resolver, configure the properties binary.resolver.input.key.class and binary.resolver.input.value.class, which define the key and value types of the intermediate result, respectively.
- tableInfos: Specifies the MaxCompute table that corresponds to HDFS. Currently, only the tblName parameter (table name) is configurable. The partSpec and label parameters must be the same as the values set for the parameters in this example.
- matchMode: Specifies the path matching mode. The exact mode indicates exact matching, and the fuzzy mode indicates fuzzy matching. Use a regular expression in fuzzy mode to match the HDFS input path.

Job Submission

Use the MaxCompute command line tool odpscmd to submit jobs. For the installation and configuration of MaxCompute command line tool, see the Console. In odpscmd, run the following command:

```
jar  - DODPS_HADO  OPMR_TABLE  _RES_CONF =./ wordcount - table - res
. conf  - classpath   hadoop2ope  nmr - 1 . 0 . jar , wordcount_
test . jar   com . aliyun . odps . mapred . example . hadoop .
WordCount  / foo / bar ;
```

Note:

- wordcount-table-res.conf is a map with /foo/bar configured.
- wordcount_test.jar is your Jar package of Hadoop MapReduce.
- com.aliyun.odps.mapred.example.hadoop.WordCount is the class name of job to be run.
- /foo/bar refers to the path on HDFS, which is mapped to wc_in and wc_out in the JSON configuration file.
- With the mapping relation configured, manually import the Hadoop HDFS input file to wc_in for MR calculations by using data integration functions of DataX or DataWorks, and manually export the result wc_out to your HDFS output directory (/bar).

- In the preceding output, assume that hadoop2openmr-1.0.jar, wordcount_test.jar , and wordcount-table-res.conf are stored in the current directory of odpscmd. If an error occurs, make the relevant changes when specifying the configuration and -classpath.

The running process is as follows:

```
odps@ zhe>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;
SLF4J: Failed to load class "org.slf4j.impl.StaticLoggerBinder".
SLF4J: Defaulting to no-operation (NOP) logger implementation
SLF4J: See http://www.slf4j.org/codes.html#StaticLoggerBinder for further details.
Running job in console.
[INFO] deprecation - mapred.job.map.memory.mb is deprecated. Instead, use mapreduce.map.memory.mb
[INFO] deprecation - mapred.job.reduce.memory.mb is deprecated. Instead, use mapreduce.reduce.memory.mb
http://logview.odps.aliyun-inc.com:8080/logview/?h=http://10.101.214.140:8100/api&p=zhe&i=20160912085518595gimm6ez&token=[illegible]
[illegible]
InstanceId: 20160912085518595gimm6ez
[INFO] Job - The url to track the job: http://logview.odps.aliyun-inc.com:8080/logview/?h=http://10.101.214.140:8100/api&p=zhe&i=20160912085518595gimm6ez&token=[illegible]
[illegible]
...
...
2016-09-12 16:55:33 M1_job0:0/0/1[0%]   R2_1_job0:0/0/1[0%]
2016-09-12 16:55:41 M1_job0:0/1/1[100%] R2_1_job0:0/0/1[0%]
...
Inputs:
        zhe.wc_in: 2 (480 bytes)
Outputs:
        zhe.wc_out: 3 (576 bytes)
M1_zhe_20160912085518595gimm6ez_LOT_0_0_0_job0:
        Worker Count:1
        Input Records:
                input: 2 (min: 2, max: 2, avg: 2)
        Output Records:
                R2_1: 3 (min: 3, max: 3, avg: 3)
R2_1_zhe_20160912085518595gimm6ez_LOT_0_0_0_job0:
        Worker Count:1
        Input Records:
                input: 3 (min: 3, max: 3, avg: 3)
        Output Records:
                R2_1FS_DataSink_6: 3 (min: 3, max: 3, avg: 3)

Counters: 0
OK
odps@ zhe>
```

After running the job, check the results table wc_out to verify whether a job is complete:

```
odps@ zhe>read wc_out;
+------------+------------+
| key        | cnt        |
+------------+------------+
| hello      | 2          |
| mapreduce  | 1          |
| maxcompute | 1          |
+------------+------------+
odps@ zhe>
```

5.2 Function Introduction

5.2.1 Basic concepts

Map/Reduce

Map and Reduce support corresponding Map/Reduce methods, setup methods, and cleanup methods. The setup method is called before the Map/Reduce method, and each worker calls it only once.

The cleanup method is called after the map/reduce method, and each worker calls it only once.

For a detailed example, see Program examples.

Sort/Group

Some columns in output key records can be taken as sort columns, but user-defined comparator is not supported. You can select several columns from the sort column as Group columns, but the user-defined Group comparator is not supported. Sort columns are used to sort your data while Group columns are used for a Secondary Sort.

For more information, see SecondarySort Example.

Partition

Supports setting the partition column and customized partitioner. Partition columns have a higher priority than customized partitioners.

According to Hash logic, the partitioner distributes the output data on the Map terminal to different Reduce Workers.

Combiner

Combines adjacent records in the Shuffle stage. You can choose whether to use Combiner according to different business logic.

Combiner helps to optimize the MapReduce computing framework and the logic of Combiner is generally similar to Reduce. After Map outputs the data, the framework performs a local combiner operation for the data which has the same key value on the Map terminal.

For more information, see WordCount code examples.

5.2.2 Commands

The MaxCompute console provides a JAR command to run MapReduce job. The detailed syntax is shown as follows:

```
Usage :
jar  [< GENERIC_OP  TIONS >] < MAIN_CLASS > [ ARGS ];
        - conf  < configurat  ion_file >  Specify   an   applicatio  n
  configurat  ion   file
        - resources  < resource_n  ame_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
```

```
For   example :
    jar  - conf  / home / admin / myconf  - resources   a . txt ,
example . jar  - classpath  ../ lib / example . jar :./ other_lib
. jar  - Djava . library . path =./ native  - Xmx512M   mycompany .
WordCount  - m   10  - r   10   in   out ;
```

`< GENERIC_OP  TIONS >` includes the following parameters (optional parameters):

- -conf <configuration file>: Specify an JobConf configuration file.
- -resources <resource_name_list>: Indicates the resource statement used in MapReduce running time. Generally, the resource name in which Map/Reduce function is included must be specified in 'resource_name_list'.

> Note:
>
> If the user has read other MaxCompute resources in the Map/Reduce function, then these resource names also must be added in 'source_name_list'.
>
> Multiple resources are separated by commas (,). If you must use span project resources, then add the prefix `PROJECT / resources /`, for example: `- resources  otherproje ct / resources / resfile`.
>
> For more information about how to read the resource in the Map/Reduce function, see Use Resource Example.

- -classpath <local_file_list>: the classpath used to specify the local JAR package of 'main' class (include relative paths and absolute paths).

  Package names are separated using system default file delimiters. Generally, the delimiter is a semicolon (;) in a Windows system and a comma (,) in a Linux system.

> Note:
>
> In most cases, users generally write the main class and Map/Reduce function in a package, such as WordCount Code Example. This means that, in the running period of the example program, mapreduce-examples.jar appears in '-resources' parameter and '-classpath' parameter, however, '-resources' references the Map/Reduce function, and runs in a distributed environment, while '-classpath' references 'Main' class, and runs locally. The specified path of the JAR package is also a local path.

- -D <prop_name>=<prop_value> : Multiple Java properties of <mainClass> in a local mode can be defined.
- -l: run MapReduce job in local mode, mainly used for program debugging.

User can specify the configuration file 'JobConf' by option '-conf'. This file can modify the JobConf settings in the SDK.

An example of a configuration file 'JobConf' is as follows:

```
< configurat  ion >
       < property >
          < name > import . filename </ name >
          < value > resource . txt </ value >
       </ property >
    </ configurat  ion >
```

In the preceding example, the variable 'import.filename' is defined and its value is 'resource.txt'.

User can get this variable value through the JobConf interface in the MapReduce program. Alternatively, users can also get the value through the JobConf interface in the SDK. For a detailed example, see Use Resource Example.

Example:

```
add   jar   data \ mapreduce - examples . jar ;
    jar  - resources   mapreduce - examples . jar  - classpath
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 ;
```

5.2.3 Input and Output

- Built-in data types include: BIGINT, DOUBLE, STRING, DATETIME, and BOOLEAN. User-defined types (UDFs) are not supported.
- Multiple-table input is allowed, and the schema of input tables can be different. In a Map function, users can obtain corresponding Table information of the current record.
- The input can be null. View as an input is not supported.

- Reduce accepts multiple outputs and can output data to different tables or different partitions in the same table. The schema of different outputs can be different. Different outputs are distinguished through the label however, the default output does not need any label. An output cannot be empty.

For more input and output examples, see Program Examples.

5.2.4 Resources

You can learn more about MaxCompute resources in the Map/Reduce section. Any Worker of Map/Reduce can load resources to the memory for you to apply the code for further use.

For more information, see Use resource example.

5.2.5 Local run

Basic stages introduction

Local run prerequisite: By setting – `local` parameter in the jar command, user can simulate MapReduce running process on the local to initiate local debugging.

At local operation time: The client downloads required meta information of input tables, resources, and meta information of output tables from MaxCompute, and saves them into a local directory named ‘warehouse’.

After running the program: The calculation result is output into a file in the ‘warehouse’. If the input table and referenced resources have been downloaded in the local warehouse directory, the data and files in ‘warehouse’ directory are referenced directly during the next run time, and the downloading process does not need to be repeated.

Difference between running locally and running distributed environments

In the local operation course, multiple Map and Reduce workers are yet to start data processing. But these workers do not run concurrently and run serially.

The distinguishing points between the simulation process and real distributed operation are as follows:

- A limit on the row number of input table exists. Currently, up to 100 rows of data can be downloaded.

- Usage of resources: In a distributed environment, MaxCompute limits the size of the referenced resource. For more information, see Application Restriction. Note that in the local running environment, the resource size has no limits.
- Security limits: MaxCompute, MapReduce, and UDF program running in a distributed environment are limited by Java Sandbox. Note that in local operations this limit is not applicable.

Example:

A local operation example is as follows:

```
    odps : my_project >  jar  - l   com . aliyun . odps . mapred .
example . WordCount   wc_in   wc_out
    Summary :
    counters :  10
        map - reduce   framework
                combine_in  put_groups = 2
                combine_ou  tput_recor  ds = 2
                map_input_  bytes = 4
                map_input_  records = 1
                map_output  _records = 2
                map_output  _ [ wc_out ] _bytes = 0
                map_output  _ [ wc_out ] _records = 0
                reduce_inp  ut_groups = 2
                reduce_out  put_ [ wc_out ] _bytes = 8
                reduce_out  put_ [ wc_out ] _records = 2
    OK
```

For a detailed WordCount example, see WordCount Code example.

If a user runs local debugging command for the first time, a path named ‘warehouse’ appears in the current path after the command is executed successfully. The directory structure of warehouse is as follows:

```
< warehouse >
   | ____my_pro  ject ( project   directory )
          | ____   < __tables__ >
          | | __wc_in ( table   directory )
          | | | ____   data ( file )
          |     |      |
          | | | ____  < __schema__ > ( file )
          | | __wc_out ( table   data   directory )
          | | ____   data ( file )
          |              |
          | | ____  < __schema__ > ( file )
          |
          | ____   < __resource  s__ >
                  |
                  | ___table_r  esource_na  me  ( table   resource )
                  | | ____ < __ref__ >
                  |
```

```
            | ___   file_resou  rce_name  ( file   resource )
```

- The same level directory of myproject indicates the project. ‘wcin’ and ‘wc_out’ indicate tables. The table files read by user in JAR command is downloaded into this directory.
- The contents in <__schema__> indicate table meta information. The format is defined as follows:

```
project = local_proj  ect_name
table = local_tabl  e_name
columns = col1_name : col1_type , col2_name : col2_type
partitions = p1 : STRING , p2 : BIGINT
```

Columns and column types are separated by colons (:), and columns are separated by commas (,). Corresponding to <__schema__> file, the Project name and Table name must be declared, such as `project_na  me . table_name` , and separated by a comma (,) and column definition. `project_na  me . table_name , col1_name : col1_type , col2_name : col2_type ,……`

- The file ‘data; indicates the table data. The column quantity and corresponding data must comply with the definition in *_schema_* . Moreover, extra columns and missing columns are not allowed.

The content of *_schema_* in wc_in is as follows:

```
my_project . wc_in , key : STRING , value : STRING
```

The content of ‘data’ is as follows:

```
0 , 2
```

The client downloads the meta information of table and part of the data from MaxCompute, and save them into the two preceding files. If you run this example again, the data in the directory ‘wc_in’ is used directly and will not be downloaded again.

Note:

The function to download the data from MaxCompute is only supported in MapReduce local operation mode. If the local debugging is executed in Eclipse development plug-in, the data of MaxCompute cannot be downloaded to local.

The content of ‘_schema_’ in wc_out is as follows:

```
my_project . wc_out , key : STRING , cnt : BIGINT
```

The content of ‘data’ is as follows:

```
 0 , 1
 2 , 1
```

The client downloads the meta information of wc_out from MaxCompute and saves it to the file *_schema_* . The file ‘data’ is a result data file generated after the local operation.

Note:

- Users can also edit *_schema_* file and ‘data’ and then place these two files into the corresponding table directory.
- When running on the local, the client can detect the table directory already exists, and does not download the information of this table from MaxCompute . The table directory on the local can be a table that does not exist in MaxCompute.

5.3 MR limits

In order to avoid that you have not paid attention to restrictions so that business stops after the business starts, this article will summarize the MaxCompute MR restrictions to help you.

The restrictions of MaxCompute MapReduce are as follows:

Restricted item	Value	Type	Configuration item	Default value	Configurable?	Description
Memory occupied by the instance	[256MB ,12GB]	Memory limit	odps.stage .mapper(reducer).mem and odps. stage.mapper(reducer).jvm. mem	2048M + 1024M	Yes	Memory occupied by a single map instance or reduce instance, including the framework memory (2,048 MB by default) and heap memory of the Java virtual machine (JVM) (1,024 MB by default).
Number of resources	256	Number limit	N/A	None	No	The number of resources referenced by a single job cannot exceed 256. The table and archive are regarded as a unit.
Numbers of inputs and outputs	1024 and 256	Number limit	N/A	None	No	The number of inputs of one job cannot exceed 1024. (A partition of a table is regarded as one input . The number of input tables cannot exceed 64). The number of outputs of one job cannot exceed 256.
Number of counters	64	Number limit	N/A	None	No	The number of custom counters in one job cannot exceed 64. The group name and counter name of a counter must not contain #. The overall length of the group name and the counter name of a counter must be within 100.

Restricted item	Value	Type	Configuration item	Default value	Configurable?	Description
map instance	[1, 100000]	Number limit	odps.stage.mapper.num	None	Yes	The number of map instances of one job is calculated by the framework based on the split size. If no input table exists, you can set the value directly in odps.stage.mapper.num. The final number ranges from 1 to 100,000.
reduce instance	[0, 2000]	Number limit	odps.stage.reducer.num	None	Yes	The number of reduce instances of one job is 1/4 of that of map instances by default. The reduce instance number configured by the user ranges from 0 to 2,000. It may occur that the data volume processed by reduce is several times that processed by map. In this case, the reduce phase gets slower and can initiate at most 2000 instances.
Number of retries	3	Number limit	N/A	None	No	The maximum number of retries allowed for a single map instance or reduce instance is 3. Some exceptions that do not allow retries may cause task execution failures.

Restricted item	Value	Type	Configuration item	Default value	Configurable?	Description
Local debug mode	100	Number limit	N/A	None	No	In local debug mode, the number of map instances is 2 by default and cannot exceed 100. The number of reduce instances is 1 by default and cannot exceed 100. The number of download records of one input is 1 by default and cannot exceed 100.
Number of times of reading a resource repeatedly	64	Number limit	N/A	None	No	The number of times that a map instance or reduce instance reads one resource repeatedly cannot exceed 64 .
Resource length	2G	Length limit	N/A	None	No	The total length of a resource referenced by a job cannot exceed 2 GB.
split size	[1,)	Length limit	odps.stage.mapper.split.size	256M	Yes	The framework splits the map based on the configured split size, of which the number of maps is then determined.
Content length of the string column	8 MB	Length limit	N/A	None	No	The content in the string column of the MaxCompute table cannot exceed 8 MB.

Restricted item	Value	Type	Configuration item	Default value	Configurable?	Description
Worker running timeout period	[1, 3600]	Time limit	odps.function.timeout	600	Yes	Timeout period for the worker when the map or reduce worker does not read or write data or actively send heartbeat data by using context.progress(). The default value is 600s.
The supported field types of table referenced by MR	BIGINT, DOUBLE, STRING, DATETIME, BOOLEAN	Data type limit	N/A	None	No	When the MR task refers to a table, an error occurs if the table contains other types of fields.
Read data from OSS		Feature limit	N/A	None	No	Not supported
MaxCompute 2.0 new types		Feature limit	N/A	None	No	Not supported

5.4 Program Example

5.4.1 WordCount samples

Prerequisites

1. Prepare a Jar package of the test program. Assume the package is named mapreduce-examples.jar,and the local storage path is `data \ resources` .

    - Create tables:

    ```
    create table wc_in ( key string , value string );
    ```

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

- **Add resources:**

```
add jar data \ resources \ mapreduce - examples . jar - f ;
```

2. **Prepare tables and resources for testing the WordCount operation.**
3. **Run tunnel to import data.**

```
tunnel upload data wc_in ;
```

The contents of data file imported into the table wc_in, as follows:

```
hello , odps
```

Procedure

Run WordCount in odpscmd.

```
jar - resources mapreduce - examples . jar - classpath data \
resources \ mapreduce - examples . jar
com . aliyun . odps . mapred . open . example . WordCount wc_in
wc_out
```

Expected output

The content of output table wc_out is as follows:

```
+------------+------------+
| key | cnt |
+------------+------------+
| hello | 1 |
| odps | 1 |
+------------+------------+
```

Sample code

```
    package com . aliyun . odps . mapred . open . example ;
    import java . io . IOExceptio n ;
    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 . ReducerBas e ;
    import com . aliyun . odps . mapred . TaskContex t ;
    import com . aliyun . odps . mapred . conf . JobConf ;
    import com . aliyun . odps . mapred . utils . InputUtils ;
    import com . aliyun . odps . mapred . utils . OutputUtil s ;
    import com . aliyun . odps . mapred . utils . SchemaUtil s ;
    public class WordCount {
      public static class TokenizerM apper extends
MapperBase {
        private Record word ;
        private Record one ;
       @ Override
```

```
        public   void   setup ( TaskContex  t   context )  throws
IOExceptio  n {
          word  =  context . createMapO  utputKeyRe  cord ();
          one  =  context . createMapO  utputValue  Record ();
          one . set ( new   Object [] {  1L  });
          System . out . println (" TaskID :" +  context . getTaskID
(). toString ());
       }
       @ Override
        public   void   map ( long   recordNum ,  Record   record ,
TaskContex  t   context )
            throws   IOExceptio  n  {
          for  ( int   i  =  0 ;  i  <  record . getColumnC  ount
();  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   SumCombine  r   extends   ReducerBas
e  {
        private   Record   count ;
       @ Override
        public   void   setup ( TaskContex  t   context )  throws
IOExceptio  n {
          count  =  context . createMapO  utputValue  Record ();
       }
       //  Assemblyer   implements   the   same   interface   as
reducer ,  you   can   immediatel  y   reduce   the   output   of
the   mapper   for   a   reduce   that   is   performed   locally
on   the   mapper .
       @ Override
        public   void   reduce ( Record   key , Iterator < Record >
values , TaskContex  t   context )
            throws   IOExceptio  n  {
          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   ReducerBas  e
{
        private   Record   result  =  null ;
       @ Override
        public   void   setup ( TaskContex  t   context )  throws
IOExceptio  n {
          result  =  context . createOutp  utRecord ();
       }
       @ Override
        public   void   reduce ( Record   key , Iterator < Record >
values , TaskContex  t   context )
```

```
              Throws   ioexceptio  n  {
            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 . setMapperC  lass ( TokenizerM  apper . class );
          job . setCombine  rClass ( SumCombine  r . class );
          job . setReducer  Class ( SumReducer . class );
//  The   schema   that   sets   the   key   and   value   of
 the   mapper ' s   intermedia  te   result ,  the   mapper ' s
 intermedia  te   output   is   also   the   form   of   a   record .
          job . setMapOutp  utKeySchem  a ( SchemaUtil  s . fromString
 (" word : string "));
          job . setMapOutp  utValueSch  ema ( SchemaUtil  s .
 fromString (" count : bigint "));
         //  Set   input   and   output   table   informatio  n
          InputUtils . addTable ( TableInfo . builder (). tableName (
 args [ 0 ]). build (),  job );
          OutputUtil  s . addTable ( TableInfo . builder (). tableName
 ( args [ 1 ]). build (),  job );
          Jobclient .  runjob  ( job  );
        }
      }
```

5.4.2 MapOnly samples

For MapOnly jobs, Map directly sends <Key,Value> pairs to tables on MaxCompute. You only need to specify the output table. However, you can skip specifying the Key/Value metadata to be output by Map.

Prerequisites

1. **Prepare a JAR package of the test program. Assume the package is named mapreduce-examples.jar,the local storage path is** *data \ resources* **.**
2. **Prepare tables and resources for testing the MapOnly operation.**
    - **Create tables:**

```
create   table   wc_in  ( key   string ,  value   string );
```

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

- **Add resources:**

```
add  jar  data \ resources \ mapreduce - examples . jar  - f ;
```

3. **Use the tunnel command to import the data:**

```
tunnel  upload  data  wc_in ;
```

The contents of data file are imported into the "mr_src" table:

```
hello , odps
hello , odps
```

Procedure

Run MapOnly in odpscmd:

```
jar  - resources  mapreduce - examples . jar  - classpath  data \
resources \ mapreduce - examples . jar
com . aliyun . odps . mapred . open . example . MapOnly  wc_in
wc_out  map
```

Expected output

The content of output table wc_out is as follows:

```
+------------+------------+
| key | cnt |
+------------+------------+
| hello | 1 |
| hello | 1 |
+------------+------------+
```

Sample code

```
    package  com . aliyun . odps . mapred . open . example ;
    import  java . io . IOExceptio  n ;
    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 . SchemaUtil  s ;
    import  com . aliyun . odps . mapred . utils . InputUtils ;
    import  com . aliyun . odps . mapred . utils . OutputUtil  s ;
    import  com . aliyun . odps . data . TableInfo ;
    public  class  MapOnly  {
      public  static  class  MapperClas  s  extends  MapperBase
{
       @ Override
        public  void  setup ( TaskContex  t  context )  throws
IOExceptio  n {
          boolean  is  =  context . getJobConf (). getBoolean ("
option . mapper . setup ",  false );
         //  The  Main  function  sets  option . mapper . setup
to  true  in  jobconf  to  execute  the  following  logic .
          if  ( is ) {
```

```
              Record   result  =  context . createOutp  utRecord ();
              result . set ( 0 , " setup ");
              result . set ( 1 ,  1L );
              context . write ( result );
            }
          }
          @ Override
           public   void   map ( long   key ,  Record   record ,
TaskContex  t   context )  throws   IOExceptio  n  {
             boolean   is  =  context . getJobConf (). getBoolean ("
option . mapper . map ",  false );
            //  The   Main   function   sets   option . mapper . map
to   true   in   jobconf   to   execute   the   following   logic .
             if  ( is ) {
              Record   result  =  context . createOutp  utRecord ();
              result . set ( 0 ,  record . get ( 0 ));
              result . set ( 1 ,  1L );
              context . write ( result );
            }
          }
          @ Override
           public   void   cleanup ( TaskContex  t   context )  throws
IOExceptio  n  {
             boolean   is  =  context . getJobConf (). getBoolean ("
option . mapper . cleanup ",  false );
            //  The   Main   function   sets   option . mapper . cleanup
  to   true   in   jobconf   to   execute   the   following   logic .
             if  ( is ) {
              Record   result  =  context . createOutp  utRecord ();
              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 . setMapperC  lass ( MapperClas  s . class );
          //  For   maponly   jobs ,  the   number   of   reducers
must   be   explicitly   set   to   0
           job . setNumRedu  ceTasks ( 0 );
          //  Set   table   informatio  n   for   Input   Output
           InputUtils . addTable ( TableInfo . builder (). tableName (
args [ 0 ]). build (),  job );
           OutputUtil  s . addTable ( TableInfo . builder (). tableName
( args [ 1 ]). build (),  job );
           if  ( args . length  ==  3 ) {
             String   options  =  new   String ( args [ 2 ]);
          //  Jobconf   can   set   custom   key ,  value ,  and
getJobConf   can   get   relevant   settings   in   mapper   through
  getJobConf   of   context .
             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  );
      }
    }
```

5.4.3 Multi-input and Output

Prerequisites

1. Prepare a Jar package of the test program. Assume the package is named mapreduce-examples.jar, and the local storage path is *data \ resources* .
2. Prepare tables and resources for testing the multi-input and output operations.
   - Create tables:

```
create   table   wc_in1 ( key   string ,  value   string );
create   table   wc_in2 ( key   string ,  value   string );
create   table   mr_multiin  out_out1  ( key   string ,  cnt
bigint );
create   table   mr_multiin  out_out2  ( key   string ,  cnt
bigint )  partitione  d   by  ( a   string ,  b   string );
alter   table   mr_multiin  out_out2   add   partition  ( a =' 1
',  b =' 1 ');
alter   table   mr_multiin  out_out2   add   partition  ( a =' 2
',  b =' 2 ');
```

   - Add resources:

```
add   jar   data \ resources \ mapreduce - examples . jar  - f ;
```

3. Run tunnel to import data.

```
tunnel   upload   data1   wc_in1 ;
tunnel   upload   data2   wc_in2 ;
```

The data imported into the wc_in1 table is as follows:

```
 hello , odps
```

The data imported into the wc_in2 table is as follows:

```
 hello , world
```

Procedure

Run MultipleInOut in odpscmd.

```
jar  - resources   mapreduce - examples . jar  - classpath   data \
resources \ mapreduce - examples . jar
```

```
com . aliyun . odps . mapred . open . example . MultipleIn  Out
wc_in1 , wc_in2   mr_multiin  out_out1 , mr_multiin  out_out2 | a = 1
/ b = 1 | out1 , mr_multiin  out_out2 | a = 2 / b = 2 | out2 ;
```

Expected output

The content of ‘mr_multiinout_out1’ is as follows:

```
+------------+------------+
|  key  |  cnt  |
+------------+------------+
|  default  |  1  |
+------------+------------+
```

The content of ‘mr_multiinout_out2’ is as follows:

```
+--------+------------+---+---+
|  key  |  cnt  |  a  |  b  |
+--------+------------+---+---+
|  odps  |  1  |  1  |  1  |
|  world  |  1  |  1  |  1  |
|  out1  |  1  |  1  |  1  |
|  hello  |  2  |  2  |  2  |
|  out2  |  1  |  2  |  2  |
+--------+------------+---+---+
```

Sample code

```
    package   com . aliyun . odps . mapred . open . example ;
    import   java . io . IOExceptio  n ;
    Import   java . util . iterator ;
    import   java . util . LinkedHash  Map ;
    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 . ReducerBas  e ;
    import   com . aliyun . odps . mapred . TaskContex  t ;
    import   com . aliyun . odps . mapred . conf . JobConf ;
    import   com . aliyun . odps . mapred . utils . InputUtils ;
    import   com . aliyun . odps . mapred . utils . OutputUtil  s ;
    import   com . aliyun . odps . mapred . utils . SchemaUtil  s ;
   /**
    *  Multi   input  &  output   example .
    **/
    public   class   MultipleIn  Out  {
      public   static   class   TokenizerM  apper   extends
MapperBase  {
        Record   word ;
        Record   one ;
       @ Override
        public   void   setup ( TaskContex  t   context )  throws
IOExceptio  n {
          word  =  context . createMapO  utputKeyRe  cord ();
          one  =  context . createMapO  utputValue  Record ();
          one . set ( new   Object [] {  1L  });
       }
       @ Override
        public   void   map ( long   recordNum ,  Record   record ,
TaskContex  t   context )
```

```
            Throws   ioexceptio  n  {
          for  ( int   i  =  0 ;  i  <  record . getColumnC  ount
();  i ++) {
            word . set ( new   Object [] {  record . get ( i ).
toString () });
            context . write ( word ,  one );
        }
      }
    }
      public   static   class   SumReducer   extends   ReducerBas  e
{
        private   Record   result ;
        private   Record   result1 ;
        private   Record   result2 ;
       @ Override
        public   void   setup ( TaskContex  t   context )  throws
IOExceptio  n {
         //  For   different   outputs   you   need   to   create
different   records ,  which   are   distinguis  hed   by   label
          result  =  context . createOutp  utRecord ();
          result1  =  context . createOutp  utRecord (" out1 ");
          result2  =  context . createOutp  utRecord (" out2 ");
       }
       @ Override
        public   void   reduce ( Record   key , Iterator < Record >
values , TaskContex  t   context )
            Throws   ioexceptio  n  {
          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 ( TaskContex  t   context )  throws
IOExceptio  n  {
          Record   result  =  context . createOutp  utRecord ();
          result . set ( 0 , " default ");
          result . set ( 1 ,  1L );
          context . write ( result );
          Record   result1  =  context . createOutp  utRecord (" out1
");
          result1 . set ( 0 , " out1 ");
          result1 . set ( 1 ,  1L );
          context . write ( result1 , " out1 ");
          Record   result2  =  context . createOutp  utRecord (" out2
");
          result2 . set ( 0 , " out2 ");
```

```
            result2 . set ( 1 ,  1L );
            context . write ( result2 , " out2 ");
          }
        }
        //  Convert   the   partition   string   such   as  " ds  =  1 /
pt  =  2 "  into   map   form
         public   static   LinkedHash  Map < String ,  String >
convertPar  tSpecToMap (
            String   partSpec ) {
          LinkedHash  Map < String ,  String >  map  =  new
LinkedHash  Map < 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   RuntimeExc  eption (" 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 (" MultipleIn  Out   in ...  out
...") ;
            System . exit ( 1 );
          }
          JobConf   job  =  new   JobConf ();
          job . setMapperC  lass ( TokenizerM  apper . class );
          job . setReducer  Class ( SumReducer . class );
          job . setMapOutp  utKeySchem  a ( SchemaUtil  s . fromString
(" word : string "));
          job . setMapOutp  utValueSch  ema ( SchemaUtil  s .
fromString (" count : bigint "));
          //  Parse   the   user   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 ) {
              LinkedHash  Map < String ,  String >  map  =  convertPar
tSpecToMap ( 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   the   user   output   table   strings .
          for  ( String   out  :  outputs ) {
```

```
            String []  ss  =  out . split ("\\|");
            if  ( ss . length  ==  1 ) {
              OutputUtil  s . addTable ( TableInfo . builder ().
tableName ( ss [ 0 ]). build (),  job );
           }  else   if  ( ss . length  ==  2 ) {
              LinkedHash  Map < String ,  String >  map  =  convertPar
tSpecToMap ( ss [ 1 ]);
              OutputUtil  s . addTable ( TableInfo . builder ().
tableName ( ss [ 0 ]). partSpec ( map ). build (),  job );
           }  else   if  ( ss . length  ==  3 ) {
              if  ( ss [ 1 ]. isEmpty ()) {
                LinkedHash  Map < String ,  String >  map  =
convertPar  tSpecToMap ( ss [ 2 ]);
                OutputUtil  s . addTable ( TableInfo . builder ().
tableName ( ss [ 0 ]). partSpec ( map ). build (),  job );
             }  else  {
                LinkedHash  Map < String ,  String >  map  =
convertPar  tSpecToMap ( ss [ 1 ]);
                OutputUtil  s . 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  );
      }
    }
```

5.4.4 Multi-task samples

Prerequisites

1. **Prepare the Jar package of the test program. Assume the package is named mapreduce-examples.jar, and the local storage path is** *data \ resources* .
2. **Prepare tables and resources for testing the MultiJobs operation.**

    - **Create tables:**

    ```
    create   table   mr_empty  ( key   string ,  value   string );
    create   table   mr_multijo  bs_out  ( value   bigint );
    ```

    - **Add resources:**

    ```
    add   table   mr_multijo  bs_out   as   multijobs_  res_table  -
    f ;
    ```

```
Add   jar   data   \   resources   \   mapreduce - examples . jar - f
;
```

Procedure

Run MultiJobs in odpscmd.

```
jar  - resources   mapreduce - examples . jar , multijobs_  res_table
 - classpath   data \ resources \ mapreduce - examples . jar
 com . aliyun . odps . mapred . open . example . MultiJobs
mr_multijo  bs_out ;
```

Expected output

The output table ‘mr_multijobs_out’ is as follows:

```
+------------+
|  value  |
+------------+
|  0  |
+------------+
```

Sample code

```
    package   com . aliyun . odps . mapred . open . example ;
    import   java . io . IOExceptio  n ;
    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 . TaskContex  t ;
    import   com . aliyun . odps . mapred . conf . JobConf ;
    import   com . aliyun . odps . mapred . utils . InputUtils ;
    import   com . aliyun . odps . mapred . utils . OutputUtil  s ;
    import   com . aliyun . odps . mapred . utils . SchemaUtil  s ;
   /**
    *  MultiJobs
    *
    *  Running   multiple   job
    *
    **/
    public   class   MultiJobs  {
      public   static   class   InitMapper   extends   MapperBase  {
       @ Override
        public   void   setup ( TaskContex  t   context )  throws
IOExceptio  n {
          Record   record  =  context . createOutp  utRecord ();
          long   v  =  context . getJobConf (). getLong (" multijobs
. value ",  2 );
          record . set ( 0 ,  v );
          context . write ( record );
       }
     }
      public   static   class   DecreaseMa  pper   extends
MapperBase  {
       @ Override
        public   void   cleanup ( TaskContex  t   context )  throws
IOExceptio  n  {
```

```
        // 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 ;
        // Read the data in the resource table , which
  is the output table of the previous job
          Iterator < Record > iter = context . readResour ceTable
(" multijobs_ res_table ");
          while ( iter . hasNext ()) {
            Record r = iter . next ();
            v = ( Long ) r . get ( 0 );
            if ( expect ! = v ) {
              throw new IOExceptio n (" expect : " + expect +
", but : " + v );
            }
            count ++;
        }
          if ( count ! = 1 ) {
            throw new IOExceptio n (" res_table should have
  1 record , but : " + count );
        }
          Record record = context . createOutp utRecord ();
          v --;
          record . set ( 0 , v );
          context . write ( record );
        // Sets counter , which can be obtained in the
  main function after the job has completed successful
ly
          context . getCounter (" multijobs ", " value "). setValue (
v );
      }
    }
      public static void main ( String [] args ) throws
Exception {
        if ( args . length ! = 1 ) {
          System . err . println (" Usage : TestMultiJ obs < 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 . setMapperC lass ( InitMapper . class );
        InputUtils . addTable ( TableInfo . builder (). tableName ("
mr_empty "). build (), initJob );
        OutputUtil s . addTable ( TableInfo . builder (). tableName
( tbl ). build (), initJob );
        initJob . setMapOutp utKeySchem a ( SchemaUtil s .
fromString (" key : string "));
        initJob . setMapOutp utValueSch ema ( SchemaUtil s .
fromString (" value : string "));
      // Maponly job needs to explicitly set reducer
number to 0
        initJob . setNumRedu ceTasks ( 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 . setMapperC  lass ( DecreaseMa  pper . class );
          InputUtils . addTable ( TableInfo . builder (). tableName
(" mr_empty "). build (),  decJob );
          OutputUtil  s . addTable ( TableInfo . builder ().
tableName ( tbl ). build (),  decJob );
         //  Maponly   job   needs   to   explicitly   set   reducer
  number   to   0
          decJob . setNumRedu  ceTasks ( 0 );
          RunningJob   rJob  =  JobClient . runJob ( decJob );
          iterCount --;
         //  Exit   the   loop   if   the   number   of   iterations
  has   been   reached
          if  ( rJob . getCounter  s (). findCounte  r (" multijobs
", " value "). getValue () ==  0 ) {
            break ;
         }
       }
        if  ( iterCount  ! =  0 ) {
          throw   new   IOExceptio  n (" Job   failed .") ;
       }
     }
   }
```

5.4.5 Secondary Sort samples

Prerequisites

1. Prepare a JAR package of the test program. Assume the package is named “mapreduce-examples.jar” .The local storage path is *data \ resources* .
2. Prepare tables and resources for testing the SecondarySort operation.
    - Create tables:

    ```
    create   table   ss_in ( key   bigint ,  value   bigint );
    create   table   ss_out ( key   bigint ,  value   bigint )
    ```

    - Add resources:

    ```
    add   jar   data \ resources \ mapreduce - examples . jar  - f ;
    ```

3. Import the data through tunnel command:

    ```
    tunnel   upload   data   ss_in ;
    ```

    The contents of data file imported into the table “ss_in” are as follows:

    ```
    1 , 2
    2 , 1
    1 , 1
    ```

```
2 , 2
```

Procedure

Run SecondarySort on the odpscmd:

```
jar  - resources   mapreduce - examples . jar  - classpath   data \
resources \ mapreduce - examples . jar
com . aliyun . odps . mapred . open . example . SecondaryS  ort
ss_in   ss_out ;
```

Expected output

The contents in the output table “ss_out” are as follows:

```
|  key  |  value  |

|  1  |  1  |
|  1  |  2  |
|  2  |  1  |
|  2  |  2  |
```

Sample code

```
    package   com . aliyun . odps . mapred . open . example ;
    import   java . io . IOExceptio  n ;
    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 . ReducerBas  e ;
    import   com . aliyun . odps . mapred . TaskContex  t ;
    import   com . aliyun . odps . mapred . conf . JobConf ;
    import   com . aliyun . odps . mapred . utils . SchemaUtil  s ;
    import   com . aliyun . odps . mapred . utils . InputUtils ;
    import   com . aliyun . odps . mapred . utils . OutputUtil  s ;
    import   com . aliyun . odps . data . TableInfo ;


    *  This   is   an   example   ODPS   Map / Reduce   applicatio  n
.  It   reads   the   input   table   that
    *  must   contain   two   integers   per   record .  The   output
  is   sorted   by   the   first   and
    *  second   number   and   grouped   on   the   first   number .


    public   class   SecondaryS  ort  {

      *  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 ( TaskContex  t   context )  throws
IOExceptio  n  {
          key  =  context . createMapO  utputKeyRe  cord ();
```

```
            value  =  context . createMapO  utputValue  Record ();

       @ Override
        public   void   map ( long   recordNum ,  Record   record ,
TaskContex  t   context )
             throws   IOExceptio  n  {
           long   left  =  0 ;
           long   right  =  0 ;
           if  ( record . getColumnC  ount () >  0 ) {
             left  = ( Long )  record . get ( 0 );
             if  ( record . getColumnC  ount () >  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   ReduceClas  s   extends   ReducerBas
e  {
        private   Record   result  =  null ;
       @ Override
        public   void   setup ( TaskContex  t   context )  throws
IOExceptio  n  {
           result  =  context . createOutp  utRecord ();

       @ Override
        public   void   reduce ( Record   key ,  Iterator < Record >
values ,  TaskContex  t   context )
             throws   IOExceptio  n  {
           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 :  secondarys  rot  < in > <
out >");
           System . exit ( 2 );

        JobConf   job  =  new   JobConf ();
        job . setMapperC  lass ( MapClass . class );
        job . setReducer  Class ( ReduceClas  s . class );
       //  set   multiple   columns   to   key
       //  compare   first   and   second   parts   of   the   pair
        job . setOutputK  eySortColu  mns ( new   String [] { " i1 ",
" i2 " });
       //  partition   based   on   the   first   part   of   the
pair
        job . setPartiti  onColumns ( new   String [] { " i1 " });
       //  grouping   comparator   based   on   the   first   part
of   the   pair
```

```
        job . setOutputG  roupingCol  umns ( new   String [] { " i1
" });
       //  the   map   output   is   LongPair ,  Long
        job . setMapOutp  utKeySchem  a ( SchemaUtil  s . fromString
(" i1 : bigint , i2 : bigint "));
        Job .  Fig  ( schemeiuti  ls .  fromstring  (" i2x :  bigint
"));
        InputUtils . addTable ( TableInfo . builder (). tableName (
args [ 0 ]). build (),  job );
        OutputUtil  s . addTable ( TableInfo . builder (). tableName
( args [ 1 ]). build (),  job );
        JobClient . runJob ( job );
        System . exit ( 0 );
```

5.4.6 Resource samples

Prerequisites

1. Prepare a Jar package of the test program. Assume the package is named mapreduce-examples.jar, and the local storage path is *data \ resources* .
2. Prepare the test table and the resource.

- Create the tables:

```
create   table   mr_upload_  src ( key   bigint ,  value   string
);
```

- Add the resource:

```
add   jar   data \ resources \ mapreduce - examples . jar  - f ;
add   file   data \ resources \ import . txt  - f ;
```

- The contents of import.txt:

```
1000 , odps
```

Procedure

Run Upload on the odpscmd:

```
jar  - resources   mapreduce - examples . jar , import . txt  -
classpath   data \ resources \ mapreduce - examples . jar
com . aliyun . odps . mapred . open . example . Upload   import . txt
  mr_upload_  src ;
```

Expected output

The content in the output table “mr_upload_src” is as follows:

```
+------------+------------+
|  key  |  value  |
+------------+------------+
|  1000  |  odps  |
```

```
+------------+------------+
```

Sample code

```
    package   com . aliyun . odps . mapred . open . example ;
    import   java . io . BufferedIn  putStream ;
    import   java . io . FileNotFou  ndExceptio  n ;
    import   java . io . IOExceptio  n ;
    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 . TaskContex  t ;
    import   com . aliyun . odps . mapred . conf . JobConf ;
    import   com . aliyun . odps . mapred . utils . InputUtils ;
    import   com . aliyun . odps . mapred . utils . OutputUtil  s ;
    import   com . aliyun . odps . mapred . utils . SchemaUtil  s ;
   /**
    *  Upload
    *
    *  Import   data   from   text   file   into   table
    *
    **/
    public   class   Upload  {
      public   static   class   UploadMapp  er   extends   MapperBase
 {
       @ Override
        public   void   setup ( TaskContex  t   context )  throws
IOExceptio  n {
          Record   record  =  context . createOutp  utRecord ();
          StringBuil  der   importdata  =  new   StringBuil  der ();
          BufferedIn  putStream   bufferedIn  put  =  null ;
          try  {
            byte []  buffer  =  new   byte [ 1024 ];
            int   bytesRead  =  0 ;
            String   filename  =  context . getJobConf (). get ("
import . filename ");
            bufferedIn  put  =  context . readResour  ceFileAsSt
ream ( filename );
            while  (( bytesRead  =  bufferedIn  put . 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  ( FileNotFou  ndExceptio  n   ex ) {
            throw   new   IOExceptio  n ( ex );
         }  catch  ( IOExceptio  n   ex ) {
            throw   new   IOExceptio  n ( ex );
         }  finally  {
         }
       }
       @ Override
```

```
        public   void   map ( long   recordNum ,  Record   record ,
TaskContex  t   context )
            Throws   ioexceptio  n  {
        }
      }
       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 . setMapperC  lass ( UploadMapp  er . class );
       //  Set   the   Resource   Name ,  which   can   be   obtained
  from   jobconf   in   the   map
        job . set (" import . filename ",  args [ 0 ]);
       //  Maponly   job   needs   to   explicitly   set   reducer
number   to   0
        job . setNumRedu  ceTasks ( 0 );
        job . setMapOutp  utKeySchem  a ( SchemaUtil  s . fromString
(" key : bigint "));
        job . setMapOutp  utValueSch  ema ( SchemaUtil  s .
fromString (" value : string "));
        InputUtils . addTable ( TableInfo . builder (). tableName ("
mr_empty "). build (),  job );
        OutputUtil  s . addTable ( TableInfo . builder (). tableName
( args [ 1 ]). build (),  job );
        Jobclient .  runjob  ( job  );
      }
    }
```

A user can set up JobConf through the following methods:

- Use JobConf interface in SDK. This method is used is the preceding example. Moreover, this is the most recommended method and is given the highest priority.
- In jar command lines, specify new JobConf file through the parameter `- conf` . This method is of the lowest priority.

5.4.7 Counter samples

Prerequisites

1. Prepare the Jar package of the test program. Assume the package is named mapreduce-examples.jar, and the local storage path is *data \ resources* .
2. Prepare the UserDefinedCounters test table and resource.
   - Create tables:

     ```
     create   table   wc_in  ( key   string ,  value   string );
     ```

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

- **Add resources:**

```
add jar data \ resources \ mapreduce - examples . jar - f ;
```

3. **Use the tunnel command to import the data:**

```
tunnel upload data wc_in ;
```

The data imported into the wc_in the table wc_in, is as follows:

```
hello , odps
```

Procedure

Execute UserDefinedCounters on the odpscmd:

```
jar - resources mapreduce - examples . jar - classpath data \
resources \ mapreduce - examples . jar
com . aliyun . odps . mapred . open . example . UserDefine dCounters
  wc_in wc_out
```

Expected output

The output of Counters is as follows:

```
Counters : 3
com . aliyun . odps . mapred . open . example . UserDefine dCounters
$ MyCounter
MAP_TASKS = 1
REDUCE_TAS KS = 1
TOTAL_TASK S = 2
```

The content of output table "wc_out" is as follows:

```
+------------+------------+
| key | cnt |
+------------+------------+
| hello | 1 |
| odps | 1 |
+------------+------------+
```

Sample code

```
    package com . aliyun . odps . mapred . open . example ;
    import java . io . IOExceptio n ;
    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 . ReducerBas e ;
    import com . aliyun . odps . mapred . RunningJob ;
    import com . aliyun . odps . mapred . conf . JobConf ;
    import com . aliyun . odps . mapred . utils . SchemaUtil s ;
```

```
    import   com . aliyun . odps . mapred . utils . InputUtils ;
    import   com . aliyun . odps . mapred . utils . OutputUtil  s ;
    import   com . aliyun . odps . data . TableInfo ;
   /**
    *
    *  User   Defined   Counters
    *
    **/
    public   class   UserDefine  dCounters  {
      enum   MyCounter  {
        TOTAL_TASK  S ,  MAP_TASKS ,  REDUCE_TAS  KS
     }
      public   static   class   TokenizerM  apper   extends
MapperBase  {
        private   Record   word ;
        private   Record   one ;
       @ Override
        public   void   setup ( TaskContex  t   context )  throws
IOExceptio  n {
          super . setup ( context );
          Counter   map_tasks  =  context . getCounter ( MyCounter .
MAP_TASKS );
          Counter   total_task  s  =  context . getCounter (
MyCounter . TOTAL_TASK  S );
          map_tasks . increment ( 1 );
          total_task  s . increment ( 1 );
          word  =  context . createMapO  utputKeyRe  cord ();
          one  =  context . createMapO  utputValue  Record ();
          one . set ( new   Object [] {  1L  });
       }
       @ Override
        public   void   map ( long   recordNum ,  Record   record ,
TaskContex  t   context )
            Throws   ioexceptio  n  {
          for  ( int   i  =  0 ;  i  <  record . getColumnC  ount
();  i ++) {
            word . set ( new   Object [] {  record . get ( i ).
toString () });
            context . write ( word ,  one );
         }
       }
     }
      public   static   class   SumReducer   extends   ReducerBas  e
{
        private   Record   result  =  null ;
       @ Override
        public   void   setup ( TaskContex  t   context )  throws
IOExceptio  n {
          result  =  context . createOutp  utRecord ();
          Counter   reduce_tas  ks  =  context . getCounter (
MyCounter . REDUCE_TAS  KS );
          Counter   maid  =  context .  getcounter  ( mycounter  );
          reduce_tas  ks . increment ( 1 );
          total_task  s . increment ( 1 );
       }
       @ Override
        public   void   reduce ( Record   key , Iterator < Record >
values , TaskContex  t   context )
            Throws   ioexceptio  n  {
          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 :  TestUserDe  finedCount  ers  <
in_table > < out_table >");
          System . exit ( 2 );
        }
        JobConf   job  =  new   JobConf ();
        job . setMapperC  lass ( TokenizerM  apper . class );
        job . setReducer  Class ( SumReducer . class );
        job . setMapOutp  utKeySchem  a ( SchemaUtil  s . fromString
(" word : string "));
        job . setMapOutp  utValueSch  ema ( SchemaUtil  s .
fromString (" count : bigint "));
        InputUtils . addTable ( TableInfo . builder (). tableName (
args [ 0 ]). build (),  job );
        OutputUtil  s . addTable ( TableInfo . builder (). tableName
( args [ 1 ]). build (),  job );
        RunningJob   rJob  =  JobClient . runJob ( job );
       //  After   the   job   has   completed   successful  ly ,
you   can   get   the   value   of   the   custom   counter   inside
  the   job
        Counters   counters  =  rJob . getCounter  s ();
        long   m  =  counters . findCounte  r ( MyCounter . MAP_TASKS
). getValue ();
        long   r  =  counters . findCounte  r ( MyCounter .
REDUCE_TAS  KS ). getValue ();
        long   total  =  counters . findCounte  r ( MyCounter .
TOTAL_TASK  S ). getValue ();
        System . exit ( 0 );
      }
    }
```

5.4.8 Grep samples

Prerequisites

1. **Prepare the Jar package of the test program. Assume the package is named mapreduce-examples.jar, and the local storage path is** *data \ resources* **.**
2. **Prepare tables and resources for testing the Grep operation.**
   - **Create tables:**

```
create   table   mr_src ( key   string ,  value   string );
create   table   mr_grep_tm  p  ( key   string ,  cnt   bigint );
```

```
create table mr_grep_ou t ( key bigint , value string
);
```

- **Add resources:**

```
add jar data \ resources \ mapreduce - examples . jar - f ;
```

3. **Use the tunnel command to import the data:**

```
tunnel upload data mr_src ;
```

The contents of data file imported into the table "mr_src":

```
hello , odps
hello , world
```

Procedure

Execute Grep on the odpscmd:

```
jar - resources mapreduce - examples . jar - classpath data \
resources \ mapreduce - examples . jar
com . aliyun . odps . mapred . open . example . Grep mr_src
mr_grep_tm p mr_grep_ou t hello ;
```

Expected output

The content of output table "mr_grep_out" is as follows:

```
+------------+------------+
| key | value |
+------------+------------+
| 2 | hello |
+------------+------------+
```

Sample code

```
    package com . aliyun . odps . mapred . open . example ;
    import java . io . IOExceptio n ;
    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 . ReducerBas e ;
    import com . aliyun . odps . mapred . RunningJob ;
    import com . aliyun . odps . mapred . TaskContex t ;
    import com . aliyun . odps . mapred . conf . JobConf ;
    import com . aliyun . odps . mapred . utils . InputUtils ;
    import com . aliyun . odps . mapred . utils . OutputUtil s ;
    import com . aliyun . odps . mapred . utils . SchemaUtil s ;
   /**
    *
    * Extracts matching regexs from input files and
counts them .
```

```
     *
     **/
     public   class   Grep  {
      /**
       *  RegexMappe  r
       **/
       public   class   RegexMappe  r   extends   MapperBase  {
         private   Pattern   pattern ;
         private   int   group ;
         private   Record   word ;
         private   Record   one ;
        @ Override
         public   void   setup ( TaskContex  t   context )  throws
IOExceptio  n {
           JobConf   job  = ( JobConf )  context . getJobConf ();
           pattern  =  Pattern . compile ( job . get (" mapred .
mapper . regex "));
           group  =  job . getInt (" mapred . mapper . regex . group
",  0 );
           word  =  context . createMapO  utputKeyRe  cord ();
           one  =  context . createMapO  utputValue  Record ();
           one . set ( new   Object [] {  1L  });
        }
        @ Override
         public   void   map ( long   recordNum ,  Record   record ,
TaskContex  t   context )  throws   IOExceptio  n  {
           for  ( int   i  =  0 ;  i  <  record . getColumnC  ount ();
++ 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 );
             }
           }
        }
      }
      /**
       *  LongSumRed  ucer
       **/
       public   class   LongSumRed  ucer   extends   ReducerBas  e  {
         private   Record   result  =  null ;
        @ Override
         public   void   setup ( TaskContex  t   context )  throws
IOExceptio  n {
           result  =  context . createOutp  utRecord ();
        }
        @ Override
         public   void   reduce ( Record   key ,  Iterator < Record >
values ,  TaskContex  t   context )  throws   IOExceptio  n  {
           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   InverseMap  per   extends   MapperBase  {
        private   Record   word ;
        private   Record   count ;
       @ Override
        public   void   setup ( TaskContex  t   context )  throws
IOExceptio  n {
          word  =  context . createMapO  utputValue  Record ();
          count  =  context . createMapO  utputKeyRe  cord ();
       }
       /**
        *  The   inverse   function .  Input   keys   and   values
are   swapped .
        **/
       @ Override
        public   void   map ( long   recordNum ,  Record   record ,
TaskContex  t   context )  throws   IOExceptio  n  {
          word . set ( new   Object [] {  record . get ( 0 ).
toString () });
          count . set ( new   Object [] { ( Long )  record . get ( 1
) });
          context . write ( count ,  word );
       }
     }
     /**
      *  IdentityRe  ducer
      **/
      public   class   IdentityRe  ducer   extends   ReducerBas  e  {
        private   Record   result  =  null ;
       @ Override
        public   void   setup ( TaskContex  t   context )  throws
IOExceptio  n {
          result  =  context . createOutp  utRecord ();
       }
       /**  Writes   all   keys   and   values   directly   to
output . **/
       @ Override
        public   void   reduce ( Record   key ,  Iterator < Record >
values ,  TaskContex  t   context )  throws   IOExceptio  n  {
          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 . setMapperC  lass ( RegexMappe  r . class );
        grepJob . setReducer  Class ( LongSumRed  ucer . class );
        grepJob . setMapOutp  utKeySchem  a ( SchemaUtil  s .
fromString (" word : string "));
        grepJob . setMapOutp  utValueSch  ema ( SchemaUtil  s .
fromString (" count : bigint "));
        InputUtils . addTable ( TableInfo . builder (). tableName (
args [ 0 ]). build (),  grepJob );
        OutputUtil  s . addTable ( TableInfo . builder (). tableName
( args [ 1 ]). build (),  grepJob );
```

```
        //  Set   the   regular   expression   for   grepjob ' s
grep
         grepJob . set (" mapred . mapper . regex ",  args [ 3 ]);
         if  ( args . length  ==  5 ) {
           grepJob . set (" mapred . mapper . regex . group ",  args [
4 ]);
        }
        @ SuppressWa  rnings (" unused ")
         RunningJob   rjGrep  =  JobClient . runJob ( grepJob );
        //  Grepjob   output   as   input   to   sortjob
         JobConf   sortJob  =  new   JobConf ();
         sortJob . setMapperC  lass ( InverseMap  per . class );
         sortJob . setReducer  Class ( IdentityRe  ducer . class );
         sortJob . setMapOutp  utKeySchem  a ( SchemaUtil  s .
fromString (" count : bigint "));
         sortJob . setMapOutp  utValueSch  ema ( SchemaUtil  s .
fromString (" word : string "));-
         InputUtils . addTable ( TableInfo . builder (). tableName (
args [ 1 ]). build (),  sortJob );
         OutputUtil  s . addTable ( TableInfo . builder (). tableName
( args [ 2 ]). build (),  sortJob );
         sortJob . setNumRedu  ceTasks ( 1 ); //  write   a   single
file
         sortJob . setOutputK  eySortColu  mns ( new   String [] { "
count " });
        @ SuppressWa  rnings (" unused ")
         RunningJob   rjSort  =  JobClient . runJob ( sortJob );
      }
    }
```

5.4.9 Join samples

The MaxCompute MapReduce framework does not support join logic on its own . Therefore, you have to apply join samples of the data in your own map/reduce function which requires you to do some extra work.

Suppose,to join two tables (Key bigint, value string) and (key bigint, value string), the output table is chain bigint (value1 string, value2 string), where value1 and value2 are the values of the scanner.

Prerequisites

1. Prepare the jar package for the test program, assuming the name is maid and the local storage path is data \ resources.
2. Prepare tables and resources for testing the Join operation.

    - Create tables:

```
create   table   mr_Join_sr  c1 ( key   bigint ,  value   string
);
create   table   mr_Join_sr  c2 ( key   bigint ,  value   string
);
```

```
create   table   mr_Join_ou  t ( key   bigint ,  value1   string
, value2   string );
```

- **Add resources:**

```
add   jar   data \ resources \ mapreduce - examples . jar  - f ;
```

3. **Run tunnel to import the data:**

```
tunnel   upload   data1   mr_Join_sr  c1 ;
tunnel   upload   data2   mr_Join_sr  c2 ;
```

Import the contents of the maid data as follows:

```
 1 ,  hello
 2 ,  ODPS
```

Import the contents of the maid data as follows:

```
1 ,  ODPS
3 , hello
4 ,  ODPS
```

Procedure

Join in odpscmd as follows:-

```
jar  - resources   mapreduce - examples . jar  - classpath   data \
resources \ mapreduce - examples . jar
com . aliyun . odps . mapred . open . example . Join   mr_Join_sr  c1
  mr_Join_sr  c2   mr_Join_ou  t ;
```

Expected output

After the job is completed successfully, the contents of the table maid are output, as follows:

```
+------------+------------+------------+
|  key  |  value1  |  value2  |
+------------+------------+------------+
|  1  |  hello  |  odps  |
+------------+------------+------------+
```

Sample code

```
     package   com . aliyun . odps . mapred . open . example ;
     import   java . io . IOExceptio  n ;
     Import   java .  util .  arraylist ;
     import   java . util . Iterator ;
     import   java . util . List ;
     import   org . apache . commons . logging . Log ;
     import   org . apache . commons . logging . LogFactory ;
     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 . ReducerBas  e ;
    import   com . aliyun . odps . mapred . conf . JobConf ;
    import   com . aliyun . odps . mapred . utils . InputUtils ;
    import   com . aliyun . odps . mapred . utils . OutputUtil  s ;
    import   com . aliyun . odps . mapred . utils . SchemaUtil  s ;
   /**
    *  Join ,  mr_Join_sr  c1 / mr_Join_sr  c2 ( key   bigint ,
value   string ),  mr_Join_ou  t ( key
    *  bigint ,  value1   string ,  value2   string )
    *
    */
    public   class   Join  {
      public   static   final   Log   LOG  =  LogFactory . getLog (
Join . class );
      public   static   class   JoinMapper   extends   MapperBase  {
        private   Record   mapkey ;
        private   Record   mapvalue ;
        private   long   tag ;
       @ Override
        public   void   setup ( TaskContex  t   context )  throws
IOExceptio  n {
          mapkey  =  context . createMapO  utputKeyRe  cord ();
          mapvalue  =  context . createMapO  utputValue  Record ();
          tag  =  context . getInputTa  bleInfo (). getLabel ().
equals (" left ") ?  0 :  1 ;
       }
       @ Override
        public   void   map ( long   key , Record   record ,
TaskContex  t   context )
            Throws   ioexceptio  n  {
          mapkey . set ( 0 , record . get ( 0 ));
          mapkey . set ( 1 , tag );
          for  ( int   i  =  1 ;  i <  record . getColumnC  ount ();
i ++) {
            mapvalue . set ( i  - 1 ,  record . get ( i ));
         }
          context . write ( mapkey , mapvalue );
       }
     }
      public   static   class   JoinReduce  r   extends   ReducerBas
e  {
        private   Record   result  =  null ;
       @ Override
        public   void   setup ( TaskContex  t   context )  throws
IOExceptio  n {
          result  =  context . createOutp  utRecord ();
       }
       // Reduce   function   all   records   for   each   input
will   be   the   same   key
       @ Override
        public   void   reduce ( Record   key , Iterator < Record >
values , TaskContex  t   context )
            Throws   ioexceptio  n  {
          long   k  =  key . getBigint ( 0 );
          List < Object []>  leftValues  =  new   ArrayList < Object
[]>();
         // Is   a   key  +  tag   combinatio  n   because   it   is
  set   up ,  this   ensures   that   record   data   in   the   left
  table   is   in   front   of   the   input   record   for   the
reduce   function .
          while ( values . hasNext ()) {
            Record   value  =  values . next ();
            long   tag  = ( Long ) key . get ( 1 );
```

```
            // The   data   for   the   left   table   is   first
 cached   into   memory
             if  ( tag  ==  0 ) {
               leftValues . add ( value . toArray (). clone ());
            } else  {
              // The   data   that   touches   the   right   table
 is   output   by   a   join   with   all   the   data   on   the
 left   table , the   data   for   the   left   table   is   all   in
   memory .
// This   implementa  tion   is   just   a   functional   display
   with   relatively   low   performanc  e   and   is   not
 recommende  d   for   practical   production .
               for  ( Object []  leftValue   : leftValues ) {
                 int   index   =  0 ;
                 result . set ( index ++, k );
                 for  ( int   i   =  0 ; i < leftValue . length ; i ++)
 {
                   result . set ( index ++, leftValue [ i ]);
                }
                 for  ( int   i   =  0 ; i <  value . getColumnC  ount
 (); i ++) {
                   result . set ( index ++, value . get ( i ));
                }
                 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 . setMapperC  lass ( JoinMapper . class );
         job . setReducer  Class ( JoinReduce  r . class );
         job . setMapOutp  utKeySchem  a ( SchemaUtil  s . fromString
 (" key : bigint , tag : bigint "));
         job . setMapOutp  utValueSch  ema ( SchemaUtil  s .
 fromString (" value : string "));
         job . setPartiti  onColumns ( new   String []{" key "});
         job . setOutputK  eySortColu  mns ( new   String []{" key ",
 " tag "});
         job . setOutputG  roupingCol  umns ( new   String []{" key
 "});
         job . setNumRedu  ceTasks ( 1 );
         InputUtils . addTable ( TableInfo . builder (). tableName (
 args [ 0 ]). label (" left "). build (),  job );
         InputUtils . addTable ( TableInfo . builder (). tableName (
 args [ 1 ]). label (" right "). build (),  job );
         OutputUtil  s . addTable ( TableInfo . builder (). tableName
 ( args [ 2 ]). build (),  job );
         Jobclient .  runjob  ( job  );
      }
```

```
    }
```

5.4.10 Sleep samples

Prerequisites

1. **Prepare the Jar package of the test program. Assume the package is named mapreduce-examples.jar, and the local storage path is** *data \ resources* .
2. **Prepare resources for testing the SleepJob operation.**

```
Add  jar  data  \  resources  \  mapreduce - examples . jar - f ;
```

Procedure

Run Sleep on the odpscmd is as follows:

```
  jar  - resources  mapreduce - examples . jar  - classpath  data \
resources \ mapreduce - examples . jar
  com . aliyun . odps . mapred . open . example . Sleep  10 ;
  jar  - resources  mapreduce - examples . jar  - classpath  data \
resources \ mapreduce - examples . jar
  com . aliyun . odps . mapred . open . example . Sleep  100 ;
```

Expected output

The job runs successfully. The run time of different sleep durations can be compared to determine the effect.

Sample code

```
package  com . aliyun . odps . mapred . open . example ;
import  java . io . IOExceptio  n ;
import  com . aliyun . odps . mapred . JobClient ;
Import  com . aliyun . odps . mapred . mapperbase ;
import  com . aliyun . odps . mapred . conf . JobConf ;
public  class  Sleep  {
  private  static  final  String  SLEEP_SECS  = " sleep . secs ";
  public  static  class  MapperClas  s  extends  MapperBase  {
   //  Because  the  data  is  not  entered ,  the  map
function  is  not  executed ,  and  the  related  logic  can
only  be  written  in  setup
   @ Override
    public  void  setup ( TaskContex  t  context )  throws
IOExceptio  n  {
      try  {
        //  Get  the  number  of  sleep  seconds  set  in
jobconf  to  sleep
        Thread . sleep ( context . getJobConf (). getInt ( SLEEP_SECS
,  1 ) *  1000 );
     }  catch  ( Interrupte  dException   e ) {
        throw  new  RuntimeExc  eption ( e );
     }
   }
 }
  public  static  void  main ( String []  args )  throws
Exception  {
```

```
    if  ( args . length  ! =  1 ) {
      System . err . println (" Usage :  Sleep  < sleep_secs >");
      System . exit (- 1 );
   }
    JobConf   job  =  new   JobConf ();
    job . setMapperC  lass ( MapperClas  s . class );
   //  This   instance   is   also   a   maponly ,  so   you   need
to   set   the   reductor   number   to   0 .
    job . setNumRedu  ceTasks ( 0 );
   //  Because   there   is   no   input   table ,  the   number
of   mapper   needs   to   be   specified   explicitly   by   the
user
    job . setNumMapT  asks ( 1 );
    job . set ( SLEEP_SECS ,  args [ 0 ]);
    JobClient . runJob ( job );
  }
}
```

5.4.11 Unique samples

Prerequisites

1. Prepare the JAR package of the test program. Assume the package is named mapreduce-examples.jar, and the local storage path is *data \ resources* .
2. Prepare tables and resources for testing the Unique operation.
   - Create tables:

     ```
     create   table   ss_in ( key   bigint ,  value   bigint );
     create   table   ss_out ( key   bigint ,  value   bigint );
     ```
   - Add resources:

     ```
     add   jar   data \ resources \ mapreduce - examples . jar  - f ;
     ```
3. Use the tunnel command to import the data.

   ```
   tunnel   upload   data   ss_in ;
   ```

   The contents of data file are imported into the table ss_in.

   ```
    1 , 1
    1 , 1
    2 , 2
    2 , 2
   ```

Procedure

Run Unique on the odpscmd, as follows:

```
jar  - resources   mapreduce - examples . jar  - classpath   data \
resources \ mapreduce - examples . jar
```

```
com . aliyun . odps . mapred . open . example . Unique   ss_in
ss_out   key ;
```

Expected output

The content of output table ss_out is as follows:

```
+------------+------------+
|  key  |  value  |
+------------+------------+
|  1   |  1   |
|  2   |  2   |
+------------+------------+
```

Sample code

```
    package   com . aliyun . odps . mapred . open . example ;
    import   java . io . IOExceptio  n ;
    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 . ReducerBas  e ;
    import   com . aliyun . odps . mapred . TaskContex  t ;
    import   com . aliyun . odps . mapred . conf . JobConf ;
    import   com . aliyun . odps . mapred . utils . InputUtils ;
    import   com . aliyun . odps . mapred . utils . OutputUtil  s ;
    import   com . aliyun . odps . mapred . utils . SchemaUtil  s ;
   /**
    *  Unique   Remove   duplicate   words
    *
    **/
    public   class   Unique  {
      public   static   class   OutputSche  maMapper   extends
MapperBase  {
        private   Record   key ;
        private   Record   value ;
       @ Override
        public   void   setup ( TaskContex  t   context )  throws
IOExceptio  n {
          key  =  context . createMapO  utputKeyRe  cord ();
          value  =  context . createMapO  utputValue  Record ();
       }
       @ Override
        public   void   map ( long   recordNum ,  Record   record ,
TaskContex  t   context )
            Throws   ioexceptio  n  {
          long   left  =  0 ;
          long   right  =  0 ;
          if  ( record . getColumnC  ount () >  0 ) {
            left  = ( Long )  record . get ( 0 );
            if  ( record . getColumnC  ount () >  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   OutputSche  maReducer   extends
ReducerBas  e  {
        private   Record   result  =  null ;
       @ Override
        public   void   setup ( TaskContex  t   context )  throws
IOExceptio  n {
          result  =  context . createOutp  utRecord ();
       }
       @ Override
        public   void   reduce ( Record   key , Iterator < Record >
values , TaskContex  t   context )
            Throws   ioexceptio  n  {
          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 ];
       }
       //  Reduce   input   grouping   is   determined   by   the
settings   of   the   scanner ,  this   parameter   if   it   is
not   set
       / Default   is   mapoutputk  eyschema
       //  Key   Unique
        if  ( ops . equals (" key ")) {
          JobConf   job  =  new   JobConf ();
          job . setMapperC  lass ( OutputSche  maMapper . class );
          job . setReducer  Class ( OutputSche  maReducer . class );
          job . setMapOutp  utKeySchem  a ( SchemaUtil  s .
fromString (" key : bigint , value : bigint "));
          job . setMapOutp  utValueSch  ema ( SchemaUtil  s .
fromString (" key : bigint , value : bigint "));
          job . setPartiti  onColumns ( new   String [] { " key " });
          job . setOutputK  eySortColu  mns ( new   String [] { " key
", " value " });
          job . setOutputG  roupingCol  umns ( new   String [] { "
key " });
          job . set (" tablename2 ",  args [ 1 ]);
          job . setNumRedu  ceTasks ( 1 );
          job . setInt (" table . counter ",  0 );
          InputUtils . addTable ( TableInfo . builder (). tableName (
args [ 0 ]). build (),  job );
          OutputUtil  s . addTable ( TableInfo . builder ().
tableName ( args [ 1 ]). build (),  job );
          Jobclient .  runjob  ( job  );
       }
       //  Key & Value   Unique
        if  ( ops . equals (" all ")) {
          JobConf   job  =  new   JobConf ();
          job . setMapperC  lass ( OutputSche  maMapper . class );
```

```
          job . setReducer  Class ( OutputSche  maReducer . class );
          job . setMapOutp  utKeySchem  a ( SchemaUtil  s .
fromString (" key : bigint , value : bigint "));
          job . setMapOutp  utValueSch  ema ( SchemaUtil  s .
fromString (" key : bigint , value : bigint "));
          job . setPartiti  onColumns ( new   String [] { " key " });
          job . setOutputK  eySortColu  mns ( new   String [] { " key
", " value " });
          job . setOutputG  roupingCol  umns ( new   String [] { "
key ", " value " });
          Job .  Set  (" tablename2 ",  argS  [ 1 ]);
          job . setNumRedu  ceTasks ( 1 );
          job . setInt (" table . counter ",  0 );
          InputUtils . addTable ( TableInfo . builder (). tableName (
args [ 0 ]). build (),  job );
          OutputUtil  s . addTable ( TableInfo . builder ().
tableName ( args [ 1 ]). build (),  job );
          Jobclient .  runjob  ( job  );
       }
       //  Value   Unique
        if  ( ops . equals (" value ")) {
          JobConf   job  =  new   JobConf ();
          job . setMapperC  lass ( OutputSche  maMapper . class );
          job . setReducer  Class ( OutputSche  maReducer . class );
          job . setMapOutp  utKeySchem  a ( SchemaUtil  s .
fromString (" key : bigint , value : bigint "));
          job . setMapOutp  utValueSch  ema ( SchemaUtil  s .
fromString (" key : bigint , value : bigint "));
          job . setPartiti  onColumns ( new   String [] { " value
" });
          job . setOutputK  eySortColu  mns ( new   String [] { "
value " });
          job . setOutputG  roupingCol  umns ( new   String [] { "
value " });
          job . set (" tablename2 ",  args [ 1 ]);-
          job . setNumRedu  ceTasks ( 1 );
          job . setInt (" table . counter ",  0 );
          InputUtils . addTable ( TableInfo . builder (). tableName (
args [ 0 ]). build (),  job );
          OutputUtil  s . addTable ( TableInfo . builder ().
tableName ( args [ 1 ]). build (),  job );
          Jobclient .  runjob  ( job  );
       }
     }
   }
```

5.4.12 Sort samples

Prerequisites

1. **Prepare the Jar package of the test program. Assume the package is named mapreduce-examples.jar, and the local storage path is** *data \ resources* **.**
2. **Prepare tables and resources for testing the SORT operation.**
   - **Create tables:**

```
create   table   ss_in ( key   bigint ,  value   bigint );
```

```
create table ss_out ( key bigint , value bigint );
```

- **Add resources:**

```
add jar data \ resources \ mapreduce - examples . jar - f ;
```

3. **Use the tunnel command to import the data.**

```
tunnel upload data ss_in ;
```

The contents of data file in the table ss_in are as follows:

```
 2 , 1
 1 , 1
 3 , 1
```

Procedure

Run Sort on the odpscmd, as follows:

```
jar - resources mapreduce - examples . jar - classpath data \
resources \ mapreduce - examples . jar
com . aliyun . odps . mapred . open . example . Sort ss_in ss_out
;
```

Expected output

The content of the output table ss_out is as follows:

```
+------------+------------+
| key | value |
+------------+------------+
| 1 | 1 |
| 2 | 1 |
| 3 | 1 |
+------------+------------+
```

Sample code

```
    package com . aliyun . odps . mapred . open . example ;
    import java . io . IOExceptio n ;
    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 . TaskContex t ;
    import com . aliyun . odps . mapred . conf . JobConf ;
    import com . aliyun . odps . mapred . example . lib .
IdentityRe ducer ;
    import com . aliyun . odps . mapred . utils . InputUtils ;
    import com . aliyun . odps . mapred . utils . OutputUtil s ;
    import com . aliyun . odps . mapred . utils . SchemaUtil s ;
   /**
    * This is the trivial map / reduce program that
does absolutely nothing other
    * than use the framework to fragment and sort
the input values .
```

```
    *
    **/
    public   class   Sort  {
      static   int   printUsage () {
        System . out . println (" sort  < input > < output >");
        return  - 1 ;
     }
     /**
      *  Implements   the   identity   function ,  mapping   record '
s   first   two   columns   to
      *  outputs .
      **/
      public   static   class   IdentityMa  pper   extends
MapperBase  {
        private   Record   key ;
        private   Record   value ;
       @ Override
        public   void   setup ( TaskContex  t   context )  throws
IOExceptio  n {
          key  =  context . createMapO  utputKeyRe  cord ();
          value  =  context . createMapO  utputValue  Record ();
       }
       @ Override
        public   void   map ( long   recordNum ,  Record   record ,
TaskContex  t   context )
            Throws   IOExceptio  n  {
          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   IOExceptio  n
      *  When   there   is   communicat  ion   problems   with   the
  job   tracker .
      **/
      public   static   void   main ( String []  args )  throws
Exception  {
        JobConf   jobConf  =  new   JobConf ();
        jobConf . setMapperC  lass ( IdentityMa  pper . class );
        jobConf . setReducer  Class ( IdentityRe  ducer . class );
       //  For   global   order ,  the   number   of   reducers   is
  set   to   1 ,  all   the   data   will   be   concentrat  ed   on
  a   reducer .
       //  Can   be   used   only   for   small   volumes   of   data
,  which   need   to   be   considered   in   other   ways ,  such
as   terasort .
        jobConf . setNumRedu  ceTasks ( 1 );
        Jobconf . setmapoutp  utkeyschem  a   schemautil  s
schemeiuti  ls . fromstring  (" key :  bigint  "));
        jobConf . setMapOutp  utValueSch  ema ( SchemaUtil  s .
fromString (" value : bigint "));
        InputUtils . addTable ( TableInfo . builder (). tableName (
args [ 0 ]). build (),  jobConf );
        OutputUtil  s . 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   took  "
           + ( end_time . getTime () -  startTime . getTime ()) /
1000  + "  seconds .") ;
     }
   }
```

5.4.13 Partition samples

The following example takes Partition as input and output.

Example 1:

```
     public   static   void   main ( String []  args )  throws
Exception  {
     JobConf   job  =  new   JobConf ();

     LinkedHash  Map < String ,  String >  input  =  new
LinkedHash  Map < String ,  String >();
     input . put (" pt ", " 123456 ");
     InputUtils . addTable ( TableInfo . builder (). tableName ("
input_tabl  e "). partSpec ( input ). build (),  job );
     LinkedHash  Map < String ,  String >  output  =  new
LinkedHash  Map < String ,  String >();
     output . put (" ds ", " 654321 ");
     Outpututil  s .  addtable  ( tableinfo .  builder  ().
tablename  (" output_tab  le  ").  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 . setMapperC  lass ( TokenizerM  apper . class );
        job . setCombine  rClass ( SumCombine  r . class );
        job . setReducer  Class ( SumReducer . class );
        job . setMapOutp  utKeySchem  a ( SchemaUtil  s . fromString
(" word : string "));
        job . setMapOutp  utValueSch  ema ( SchemaUtil  s .
fromString (" count : bigint "));
        Account   account  =  new   AliyunAcco  unt (" my_access_  id
", " my_access_  key ");
        Odps   odps  =  new   Odps ( account );
        odps . setEndpoin  t (" odps_endpo  int_url ");
        odps . setDefault  Project (" my_project ");
        Table   table  =  odps . tables (). get ( tblname );
        TableInfoB  uilder   builder  =  TableInfo . builder ().
tableName ( tblname );
        for  ( Partition   p  :  table . getPartiti  ons ()) {
```

```
            if  ( applicable ( p )) {
              LinkedHash  Map < String ,  String >  partSpec  =  new
LinkedHash  Map < String ,  String >();
              for  ( String  key  :  p . getPartiti  onSpec (). keys
()) {
                partSpec . put ( key ,  p . getPartiti  onSpec (). get
( key ));

              InputUtils . addTable ( builder . partSpec ( partSpec ).
build (),  conf );


        OutputUtil  s . addTable ( TableInfo . builder (). tableName
( args [ 1 ]). build (),  job );
        Jobclient .  runjob  ( job  );
```

Note:

- The preceding example combines the MaxCompute SDK and MapReduce SDK to achieve a MapReduce task.
- The code cannot be compiled and is only an example of main functions.
- The Applicable function is user logic that determines whether the Partition can be used as the input of MapReduce job.

5.4.14 Pipeline samples

Prerequisites

1. Prepare the Jar package of the test program. Assume the package is named mapreduce-examples.jar, and the local storage path is *data \ resources* .
2. Prepare tables and resources for testing the the WordCountPipeline operation.

   - Create tables:

     ```
     create  table  wc_in  ( key  string ,  value  string );
     ```

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

- **Add resources:**

```
add   jar   data \ resources \ mapreduce - examples . jar  - f ;
```

3. **Use the tunnel command to import the data:**

```
tunnel   upload   data   wc_in ;
```

The data imported into the wc_in the table wc_in is as follows:

```
hello , odps
```

Procedure

Run WordCountPipeline on the odpscmd, as follows:

```
jar  - resources   mapreduce - examples . jar  - classpath   data \
resources \ mapreduce - examples . jar
com . aliyun . odps . mapred . open . example . WordCountP  ipeline
wc_in   wc_out ;
```

Expected output

The content of output table wc_out is as follows:

```
+------------+------------+
|  key  |  cnt  |
+------------+------------+
|  hello  |  1  |
|  odps  |  1  |
+------------+------------+
```

Sample code

```
    package   com . aliyun . odps . mapred . open . example ;
    import   java . io . IOExceptio  n ;
    Import   java .  util .  iterator ;
    import   com . aliyun . odps . Column ;
    import   com . aliyun . odps . OdpsExcept  ion ;
    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 . ReducerBas  e ;
    import   com . aliyun . odps . pipeline . Pipeline ;
    public   class   WordCountP  ipelineTes  t  {
      public   static   class   TokenizerM  apper   extends
MapperBase  {
        Record   word ;
        Record   one ;
       @ Override
        public   void   setup ( TaskContex  t   context )  throws
IOExceptio  n {
          word  =  context . createMapO  utputKeyRe  cord ();
          one  =  context . createMapO  utputValue  Record ();
```

```
            one . setBigint ( 0 ,  1L );
        }
        @ Override
         public   void   map ( long   recordNum ,  Record   record ,
TaskContex  t   context )
              Throws   ioexceptio  n  {
            for  ( int   i  =  0 ;  i  <  record . getColumnC  ount
();  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   ReducerBas  e
{
         private   Record   value ;
        @ Override
         public   void   setup ( TaskContex  t   context )  throws
IOExceptio  n {
            value  =  context . createOutp  utValueRec  ord ();
        }
        @ Override
         public   void   reduce ( Record   key , Iterator < Record >
values , TaskContex  t   context )
              Throws   ioexceptio  n  {
            Long   Count  =  0 ;
            while ( values . hasNext ()) {
              Record   val  =  values . next ();
              count  += ( Long )  val . get ( 0 );
          }
            value . set ( 0 ,  count );
            context . write ( key ,  value );
        }
      }
       public   static   class   IdentityRe  ducer   extends
ReducerBas  e  {
         private   Record   result ;
        @ Override
         public   void   setup ( TaskContex  t   context )  throws
IOExceptio  n {
            result  =  context . createOutp  utRecord ();
        }
        @ Override
         public   void   reduce ( Record   key , Iterator < Record >
values , TaskContex  t   context )
              Throws   ioexceptio  n  {
            while  ( values . hasNext ()) {
              result . set ( 0 ,  key . get ( 0 ));
              result . set ( 1 ,  values . next (). get ( 0 ));
              context . write ( result );
          }
        }
      }
       public   static   void   main ( String []  args )  throws
OdpsExcept  ion  {
          if  ( args . length  ! =  2 ) {
            System . err . println (" Usage :  WordCountP  ipeline  <
in_table > < out_table >");
            System . exit ( 2 );
        }
```

```
        Job   job  =  new   Job ();
       /***
        *  In   the   process   of   constructi  ng   pipeline ,  if
  you   do   not   specify   mapper ' s   OutputKeyS  ortColumns ,
PartitionC  olumns ,  OutputGrou  pingColumn  s ,
        *  the   framework   defaults   to   its   OutputKey   as
the   default  configurat  ion  for   the   three
        ***/
        Pipeline   pipeline  =  Pipeline . builder ()
           .  Addmapper  ( maid .  Class )
           . setOutputK  eySchema (
                    new   Column [] {  new   Column (" word ",
OdpsType . STRING ) })
           . setOutputV  alueSchema (
                    new   Column [] {  new   Column (" count ",
OdpsType . BIGINT ) })
           . setOutputK  eySortColu  mns ( new   String [] { " word
" })
           . setPartiti  onColumns ( new   String [] { " word " })
           . setOutputG  roupingCol  umns ( new   String [] { " word
" })
           . addReducer ( SumReducer . class )
           . setOutputK  eySchema (
                    new   Column [] {  new   Column (" word ",
OdpsType . STRING ) })
           . setOutputV  alueSchema (
                    new   Column [] {  new   Column (" count ",
OdpsType . BIGINT )})
           . addReducer ( IdentityRe  ducer . class ). createPipe
line ();
       //  Set   pipeline   to   jobconf   and   jobconf   if   you
need   to   set   the   assemblyer
        job . setPipelin  e ( pipeline );
       //  Set   table   informatio  n   for   Input   Output
        job . addInput ( TableInfo . builder (). tableName ( args [ 0
]). build ());
        job . addOutput ( TableInfo . builder (). tableName ( args [
1 ]). build ());
       //  Job   submit   and   wait   for   end
        job . submit ();
        job . waitForCom  pletion ();
        System . exit ( job . isSuccessf  ul () ==  true  ?  0  :  1
);
     }
   }
```

5.5 Java SDK

5.5.1 Java SDK

This article introduces common MapReduce interfaces.

If you are using Maven, you can search "odps-sdk-mapred" from Maven Library to get the required Java SDK (available in different versions). The configuration is as follows:

```
< dependency >
    < groupId > com . aliyun . odps </ groupId >
```

```
    < artifactId > odps - sdk - mapred </ artifactId >
    < version > 0 . 20 . 7 - public </ version >
</ dependency >
```

Interface	Description
MapperBase	The user-defined Map function is required to inherit from this class . It processes the record object of the input table, processes the object into key value and outputs the value to the Reduce stage, or outputs result record to the result table without passing through the Reduce stage. Jobs that do not pass through the Reduce stage, but directly outputs computation results are called Map-Only job.
ReducerBase	Your customized Reduce function must inherit from this class. The set of Values associated with a Key is reduced.
TaskContext	It is one of the input parameters of multiple member functions in MapperBase and ReducerBase. Contains contextual information about tasks.
JobClient	It is used for submitting and managing jobs. The submission mode includes blocking (synchronous) mode or non-blocking (asynchronous) mode.
RunningJob	Indicates object in job running and used for tracing MapReduce job instance during the job running process.
JobConf	Describes configuration of a MapReduce task. The JobConf object is generally defined in the main program (main function), then jobs are submitted by JobClient to MaxCompute.

MapperBase

Main function interfaces are as follows.

Interface	Description
void cleanup(TaskContext context)	The Map method is called after the map stage ends.
void map(long key, Record record, TaskContext context)	The Map method processes records of the input table.
void setup(TaskContext context)	The Map method is called before the map stage begins.

ReducerBase

Main function interfaces are as follows.

Interface	Description
void cleanup(TaskContext context)	The Reduce method is called after the reduce stage ends.
void reduce(Record key, Iterator<Record > values, TaskContext context)	The Reduce method processes input table records.
void setup(TaskContext context)	The Reduce method is called before the reduce stage begins.

TaskContext

Main function interfaces are as follows.

Interface	Description
TableInfo[] getOutputTableInfo()	Gets output table information.
Record createOutputRecord()	Creates the record object of the default output table.
Record createOutputRecord(String label)	Creates the record object of the output table with a specified label.
Record createMapOutputKeyRecord()	Creates the record object of Key output by Map.
Record createMapOutputValueRecord()	Creates the record object of Value output by Map.
void write(Record record)	Writes record to default output and is used for writing output data by Reduce client, and can be called on the Reduce client multiple times.
void write(Record record, String label)	Writes record to the given label output and is used for writing output data by Reduce client, and can be called on the Reduce client multiple times.
void write(Record key, Record value)	Map writes record for an intermediate result. It can be called in Map function and called on the Map client multiple times.
BufferedInputStream readResourceFileAsStream(String resourceName)	Reads file type resource.
Iterator<Record > readResourceTable(String resourceName)	Reads table type resource.

Interface	Description
Counter getCounter(Enum<? > > name)	Gets the Counter object with the specified name.
Counter getCounter(String group, String name)	Gets the Counter object with specified name and the group name.
void progress()	Reports heartbeat information to the MapReduce framework. If a user's method takes a long time to process, and no framework is called in the process, this method can be called to avoid task timeout. Timeout of the framework is 600s by default.

Notice:

- MaxCompute TaskContext interface provides the progress function, however, this function is to prevent the Worker from being terminated as it runs for long time and the framework considers it as a timeout Worker. This interface is similar to sending heartbeat information to the framework, but does not report the progress of the Worker.
- The default timeout schedule of MaxCompute MapReduce Worker is 10 minutes (system default, cannot be controlled by the user). If the schedule exceeds 10 minutes and Worker is unable to send heartbeat information to the framework (not to call progress interface), the framework is forced to stop this Worker and MapReduce task fails and exits. We recommend calling the progress interface regularly in Mapper/Reducer functions to prevent the worker from being terminated by the framework.

JobConf

Main function interfaces are as follows:

Interface	Description
void setResources(String resourceNames)	Declares resources used in this job. Only the declared resource can be read by TaskContext object during Mapper/Reducer running process.
void setMapOutputKeySchema(Column[] schema)	Sets the Key attribute output from Mapper to Reducer.

Interface	Description
void setMapOutputValueSchema(Column [] schema)	Sets the Value attribute output from Mapper to Reducer.
void setOutputKeySortColumns(String[] cols)	Sets key sort columns output from Mapper to Reducer.
void setOutputGroupingColumns(String [] cols)	Sets Key grouping columns.
void setMapperClass(Class<? extends Mapper > theClass)	Sets Mapper function of the job.
void setPartitionColumns(String[] cols)	Sets the partition column specified in the job. The default is all columns of Key output by Mapper.
void setReducerClass(Class<? extends Reducer theClass)	Sets Reducer of the job.
void setCombinerClass(Class<? extends Reducer theClass)	Sets combiner of the job, running on Map client. Its function is similar to performing Reduce operation on the identical local Key values by a single Map .
void setSplitSize(long size)	Sets the size of input slice. Unit: MB. The default value is 640.
void setNumReduceTasks(int n)	Sets the number of Reducer tasks. The default is 1/4 of Mapper tasks.
void setMemoryForMapTask(int mem)	Sets the memory size of single Worker in the Mapper task. Unit: MB. The default value is 2048.
void setMemoryForReduceTask(int mem)	Sets the memory size of single Worker for Reducer task. Unit: MB. The default value is 2048.

Note:

- Usually, GroupingColumns are included in KeySortColumns, while KeySortCol umns and PartitionColumns are included in the Key.
- In the Map side, mappers' output records are distributed to reducers according to the hash values computed using PartitionColumns, and then sorted by KeySortColumns.

- In the Reduce side, after being sorted by KeySortColumns, input records are grouped as input groups of the reduce function sequentially. In other words , records with the same GroupingColumns values are treated as the same input group.

JobClient

Main function interfaces are as follows:

Interface	Description
static RunningJob runJob(JobConf job)	Returns immediately after submitting a MapReduce job in a synchronous (blocking) mode.
static RunningJob submitJob(JobConf job)	Returns immediately after submitting a MapReduce job in an asynchronous (non-blocking) mode.

RunningJob

Main function interfaces are as follows.

Interface	Description
String getInstanceID()	Gets an instance ID for checking run log and job management.
boolean isComplete()	Checks whether job is complete.
boolean isSuccessful()	Checks whether job instance is successful.
void waitForCompletion()	Waits until job instance is complete. It is typically iused for jobs submitted is asynchronous mode.
JobStatus getJobStatus()	Checks job instance status.
void killJob()	Ends the job.
Counters getCounters()	Gets Counter information.

InputUtils

Main function interfaces are as follows:

Interface	Description
static void addTable(TableInfo table, JobConf conf)	Adds table to the task input. It can be called multiple times. The new added table is added to input queue in an append mode.
static void setTables(TableInfo [] tables, JobConf conf)	Adds tables to the task input.

OutputUtils

Main function interfaces are as follows:

Interface	Description
static void addTable(TableInfo table, JobConf conf)	Adds table to the task output. It can be called multiple times. Also, adds the new added table to output queue in an append mode.
static void setTables(TableInfo [] tables, JobConf conf)	Adds multiple tables to the task output.

Pipeline

Pipeline is the subject of MR2. It can be constructed by Pipeline.builder. Pipelines are as follows:

```
    public   Builder   addMapper ( Class <?  extends   Mapper >
 mapper )
    public   Builder   addMapper ( Class <?  extends   Mapper >
 mapper ,
           column  []  keyschema ,  column  []  valueschem  a ,
 string  []  sortcols ,
           SortOrder  []  order ,  string  []  partcols ,
            Class <?  extends   Partitione  r >  theClass ,  String
 []  groupCols )
    public   Builder   addReducer ( Class <?  extends   Reducer >
 reducer )
    public   Builder   addReducer ( Class <?  extends   Reducer >
 reducer ,
           column  []  keyschema ,  column  []  valueschem  a ,
 string  []  sortcols ,
           SortOrder  []  order ,  string  []  partcols ,
            Class <?  extends   Partitione  r >  theClass ,  String
 []  groupCols )
    public   setoutputk  eyschema   builder  ( Column  []  keyschema
 )
    public   setoutputv  alueschema   builder  ( Column  []
 valueschem  a )
    public   setoutputk  eysortcolu  mns   builder  ( String  []
 sortcols )
    public   setoutputk  eysortorde  r   builder  ( Sortorder  []
 order )
```

```
    public   setpartiti  oncolumns   builder  ( String  []  partcols
)
    public   Builder   setPartiti  onerClass ( Class <?  extends
Partitione  r >  theClass )
    void   setOutputG  roupingCol  umns ( String []  cols )
```

Example:

```
    job   job  =  new   job  ();
    pipeline   pipeline  =  pipeline .  builder  ()
    .  addmapper  ( Tokenizerm  apper .  class )
    .  setoutputk  eyschema  (
         new   column  [] { new   column  (" word ",  OdpsType .
string )})
    .  setoutputv  alueschema  (
         new   column  [] { new   column  (" count ",  OdpsType .
bigint )})
    .  addreducer  ( Sumreducer .  class )
    .  setoutputk  eyschema  (
         new   column  [] { new   column  (" count ",  OdpsType .
bigint )})
    .  setoutputv  alueschema  (
         new   column  [] { new   column  (" word ",  OdpsType .
string ),
         new   column  (" count ",  OdpsType .  bigint )})
    .  addreducer  ( Identityre  ducer .  class ).  createPipe  line
();
    job .  setpipelin  e  ( pipeline );
    job .  addinput  (...)
    job .  addoutput  (...)
    job .  submit  ();
```

As shown in the preceding example, a user can construct a Map in the main class, and then consecutively get MapReduce tasks of two Reduces. If you are familiar with the basic functions of MapReduce, then you can use MR2 as well, as the functions are similar.

Note:

- Specifically, we recommend that users must complete the configuration of MapReduce task by JobConf,
- as JobConf can get MapReduce task of single Reduce only after configuring Map.

Data Type

The data types supported in MapReduce include: BIGINT, STRING, DOUBLE, BOOLEAN, and DATETIME. MaxCompute between MaxCompute data types and Java types are as follows:

MaxCompute SQL Type	Java Type
Bigint	Long

MaxCompute SQL Type	Java Type
String	String
Double	Double
Boolean	Boolean
Datetime	Date
Decimal	BigDecimal

5.5.2 Overview of compatible versions of the SDK

A detailed list of maxcompute compatible versions of mapreduce compatibility with hadoop mapreduce, as shown in the following table:

Type	Interface	Is it compatible ?
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
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 (inheritance)	InputSplit getInputSplit()	No, throw exception
ReduceContext	nextKey()	Yes

Type	Interface	Is it compatible?
ReduceContext	getValues()	Yes
TaskInputOutputContext	getCurrentKey()	Yes
TaskInputOutputContext	getCurrentValue()	Yes
TaskInputOutputContext	getOutputCommitter()	No, throw exception
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, throw exception
TaskAttemptContext	getProgress()	No, throw exception
TaskAttemptContext	progress()	Yes
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, throw exception

Type	Interface	Is it compatible?
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, throw exception
Job	getJobFile()	No, throw exception
Job	getJobName()	Empty implementation
Job	getJobState()	No, throw exception
Job	getPriority()	No, throw exception
Job	getProgressPollInterval(Configuration conf)	Empty implementation

Type	Interface	Is it compatible?
Job	getReservationId()	No, throw exception
Job	getSchedulingInfo()	No, throw exception
Job	getStartTime()	Yes
Job	getStatus()	No, throw exception
Job	getTaskCompletionEvents(int startFrom)	No, throw exception
Job	getTaskCompletionEvents(int startFrom, int numEvents)	No, throw exception
Job	getTaskDiagnostics(TaskAttemptID taskid)	No, throw exception
Job	getTaskOutputFilter(Configuration conf)	No, throw exception
Job	getTaskReports(TaskType type)	No, throw exception
Job	getTrackingURL()	Yes
Job	isComplete()	Yes
Job	isRetired()	No, throw exception
Job	isSuccessful()	Yes
Job	isUber()	Empty implementation

Type	Interface	Is it compatible?
Job	killJob()	Yes
Job	killTask(TaskAttemptID taskId)	No
Job	mapProgress()	Yes
Job	monitorAndPrintJob()	Yes
Job	reduceProgress()	Yes
Job	setCacheArchives(URI[] archives)	No, throw exception
Job	setCacheFiles(URI[] files)	No, throw exception
Job	setCancelDelegationTokenUponJobCompletion(boolean value)	No, throw exception
Job	setCombinerClass(Class<? extends Reducer> cls)	Yes
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

Type	Interface	Is it compatible ?
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, throw exception
Job	setOutputKeyClass(Class<? > theClass)	Yes
Job	setOutputValueClass(Class<? > theClass)	Yes
Job	setPartitionerClass(Class<? extends Partitioner> cls)	Yes
Job	setPriority(JobPriority priority)	No, throw exception
Job	setProfileEnabled(boolean newValue)	Empty implementation
Job	setProfileParams(String value)	Empty implementation

Type	Interface	Is it compatible?
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, throw exception
Job	setSortComparatorClass(Class<? extends RawComparator> cls)	No, throw exception
Job	setSpeculativeExecution(boolean speculativeExecution)	Yes
Job	setTaskOutputFilter(Configuration conf, org.apache.hadoop.mapreduce.Job.TaskStatusFilter newValue)	No, throw exception
Job	setupProgress()	No, throw exception
Job	setUser(String user)	Empty implementation
Job	setWorkingDirectory(Path dir)	Empty implementation
Job	submit()	Yes
Job	toString()	No, throw exception
Job	waitForCompletion(boolean verbose)	Yes.

Type	Interface	Is it compatible?
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
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

Type	Interface	Is it compatible ?
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

Type	Interface	Is it compatible?
JobClient	cancelDelegationToken(Token <DelegationTokenIdentifier> token)	No, throw exception
JobClient	close()	Empty implementation
JobClient	displayTasks(JobID jobId, String type, String state)	No, throw exception
JobClient	getAllJobs()	No, throw exception
JobClient	getCleanupTaskReports(JobID jobId)	No, throw exception
JobClient	getClusterStatus()	No, throw exception
JobClient	getClusterStatus(boolean detailed)	No, throw exception
JobClient	getDefaultMaps()	No, throw exception
JobClient	getDefaultReduces()	No, throw exception
JobClient	getDelegationToken(Text renewer)	No, throw exception
JobClient	getFs()	No, throw exception

Type	Interface	Is it compatible?
JobClient	getJob(JobID jobid)	No, throw exception
JobClient	getJob(String jobid)	No, throw exception
JobClient	getJobsFromQueue(String queueName)	No, throw exception
JobClient	getMapTaskReports(JobID jobId)	No, throw exception
JobClient	getMapTaskReports(String jobId)	No, throw exception
JobClient	getQueueAclsForCurrentUser()	No, throw exception
JobClient	getQueueInfo(String queueName)	No, throw exception
JobClient	getQueues()	No, throw exception
JobClient	getReduceTaskReports(JobID jobId)	No, throw exception
JobClient	getReduceTaskReports(String jobId)	No, throw exception
JobClient	getSetupTaskReports(JobID jobId)	No, throw exception

Type	Interface	Is it compatible?
JobClient	getStagingAreaDir()	No, throw exception
JobClient	getSystemDir()	No, throw exception
JobClient	getTaskOutputFilter()	No, throw exception
JobClient	getTaskOutputFilter(JobConf job)	No, throw exception
JobClient	init(JobConf conf)	No, throw exception
JobClient	isJobDirValid(Path jobDirPath, FileSystem fs)	No, throw exception
JobClient	jobsToComplete()	No, throw exception
JobClient	monitorAndPrintJob(JobConf conf, RunningJob job)	No, throw exception
JobClient	renewDelegationToken(Token< DelegationTokenIdentifier> token)	No, throw exception
JobClient	run(String[] argv)	No, throw exception
JobClient	runJob(JobConf job)	Yes
JobClient	setTaskOutputFilter(JobClient.TaskStatusFilter newValue)	No, throw exception

Type	Interface	Is it compatible?
JobClient	setTaskOutputFilter(JobConf job, JobClient.TaskStatusFilter newValue)	No, throw exception
JobClient	submitJob(JobConf job)	Yes
JobClient	submitJob(String jobFile)	No, throw exception
JobConf	deleteLocalFiles()	No, throw exception
Jobconf	deleteLocalFiles(String subdir)	No, throw exception
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, throw exception
JobConf	setJar(String jar)	No, throw exception
JobConf	setJarByClass(Class cls)	No, throw exception
JobConf	setJobEndNotificationURI(String uri)	No, throw exception

Type	Interface	Is it compatible ?
JobConf	setJobName(String name)	Empty implementation
JobConf	setJobPriority(JobPriority prio)	No, throw exception
JobConf	setKeepFailedTaskFiles(boolean keep)	No, throw exception
JobConf	setKeepTaskFilesPattern(String pattern)	No, throw exception
JobConf	setKeyFieldComparatorOptions(String keySpec)	No, throw exception
JobConf	setKeyFieldPartitionerOptions(String keySpec)	No, throw exception
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, throw exception

Type	Interface	Is it compatible?
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
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, throw exception

Type	Interface	Is it compatible?
JobConf	setOutputFormat(Class<? extends OutputFormat> theClass)	Empty implementation
JobConf	setOutputKeyClass(Class<? > theClass)	Yes
JobConf	setOutputKeyComparatorClass(Class <? extends RawComparator> theClass)	No, throw exception
JobConf	setOutputValueClass(Class<? > theClass)	Yes
JobConf	setOutputValueGroupingComparator(Class<? extends RawComparator> theClass)	No, throw exception
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
JobConf	setQueueName(String queueName)	No, throw exception
JobConf	setReduceDebugScript(String rDbgScript)	Empty implementation
JobConf	setReducerClass(Class<? extends Reducer> theClass)	Yes
JobConf	setReduceSpeculativeExecution(boolean speculativeExecution)	Empty implementation

Type	Interface	Is it compatible?
JobConf	setSessionId(String sessionId)	Empty implementation
JobConf	setSpeculativeExecution(boolean speculativeExecution)	No, throw exception
JobConf	setUseNewMapper(boolean flag)	Yes
JobConf	setUseNewReducer(boolean flag)	Yes
JobConf	setUser(String user)	Empty implementation
JobConf	setWorkingDirectory(Path dir)	Empty implementation
FileInputFormat	Not involved	No, throw exception
TextInputFormat	Not involved	Yes
InputSplit	mapred.min.split.size.	No, throw exception
FileSplit	map.input.file	No, throw exception
RecordWriter	Not involved	No, throw exception
RecordReader	Not involved	No, throw exception
OutputFormat	Not involved	No, throw exception

Type	Interface	Is it compatible ?
OutputCommitter	abortJob(JobContext jobContext, int status)	No, throw exception
OutputCommitter	abortJob(JobContext context, JobStatus.State runState)	No, throw exception
OutputCommitter	abortTask(TaskAttemptContext taskContext)	No, throw exception
OutputCommitter	abortTask(TaskAttemptContext taskContext)	No, throw exception
OutputCommitter	cleanupJob(JobContext jobContext)	No, throw exception
OutputCommitter	cleanupJob(JobContext context)	No, throw exception
OutputCommitter	commitJob(JobContext jobContext)	No, throw exception
OutputCommitter	commitJob(JobContext context)	No, throw exception
OutputCommitter	commitTask(TaskAttemptContext taskContext)	No, throw exception
OutputCommitter	needsTaskCommit(TaskAttemptContext taskContext)	No, throw exception
OutputCommitter	needsTaskCommit(TaskAttemptContext taskContext)	No, throw exception

Type	Interface	Is it compatible?
OutputCommitter	setupJob(JobContext jobContext)	No, throw exception
OutputCommitter	setupJob(JobContext jobContext)	No, throw exception
OutputCommitter	setupTask(TaskAttemptContext taskContext)	No, throw exception
OutputCommitter	setupTask(TaskAttemptContext taskContext)	No, throw exception
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, throw exception
DistributedCache	CACHE_ARCHIVES_SIZES	No, throw exception
DistributedCache	CACHE_ARCHIVES_TIMESTAMPS	No, throw exception
Distributed cache	CACHE_FILES	No, throw exception
DistributedCache	CACHE_FILES_SIZES	No, throw exception

Type	Interface	Is it compatible ?
DistributedCache	CACHE_FILES_TIMESTAMPS	No, throw exception
DistributedCache	CACHE_LOCALARCHIVES	No, throw exception
DistributedCache	CACHE_LOCALFILES	No, throw exception
DistributedCache	CACHE_SYMLINK	No, throw exception
DistributedCache	addArchiveToClassPath(Path archive, Configuration conf)	No, throw exception
DistributedCache	addArchiveToClassPath(Path archive, Configuration conf, FileSystem fs)	No, throw exception
DistributedCache	addCacheArchive(URI uri, Configurat ion conf)	No, throw exception
DistributedCache	addCacheFile(URI uri, Configuration conf)	No, throw exception
DistributedCache	addFileToClassPath(Path file, Configuration conf)	No, throw exception
DistributedCache	addFileToClassPath(Path file, Configuration conf, FileSystem fs)	No, throw exception
DistributedCache	addLocalArchives(Configuration conf, String str)	No, throw exception

Type	Interface	Is it compatible?
DistributedCache	addLocalFiles(Configuration conf, String str)	No, throw exception
DistributedCache	checkURIs(URI[] uriFiles, URI[] uriArchives)	No, throw exception
DistributedCache	createAllSymlink(Configuration conf, File jobCacheDir, File workDir)	No, throw exception
DistributedCache	createSymlink(Configuration conf)	No, throw exception
DistributedCache	getArchiveClassPaths(Configuration conf)	No, throw exception
DistributedCache	getArchiveTimestamps(Configuration conf)	No, throw exception
DistributedCache	getCacheArchives(Configuration conf)	No, throw exception
DistributedCache	getCacheFiles(Configuration conf)	No, throw exception
DistributedCache	getFileClassPaths(Configuration conf)	No, throw exception
DistributedCache	getFileStatus(Configuration conf, URI cache)	No, throw exception
DistributedCache	getFileTimestamps(Configuration conf)	No, throw exception

Type	Interface	Is it compatible?
DistributedCache	getLocalCacheArchives(Configuration conf)	No, throw exception
DistributedCache	getLocalCacheFiles(Configuration conf)	No, throw exception
DistributedCache	getSymlink(Configuration conf)	No, throw exception
DistributedCache	getTimestamp(Configuration conf, URI cache)	No, throw exception
DistributedCache	setArchiveTimestamps(Configuration conf, String timestamps)	No, throw exception
DistributedCache	setCacheArchives(URI[] archives, Configuration conf)	No, throw exception
DistributedCache	setCacheFiles(URI[] files, Configuration conf)	No, throw exception
DistributedCache	setFileTimestamps(Configuration conf, String timestamps)	No, throw exception
DistributedCache	setLocalArchives(Configuration conf, String str)	No, throw exception
DistributedCache	setLocalFiles(Configuration conf, String str)	No, throw exception
IsolationRunner	Not involved	No, throw exception

Type	Interface	Is it compatible ?
Profiling	Not involved	Empty implementation
Debugging	Not involved	Empty implementation
Data Compression	Not involved	Yes
Skipping Bad Records	Not involved	No, throw exception
Job Authorization	mapred.acls.enabled	No, throw exception
Job Authorization	mapreduce.job.acl-view-job	No, throw exception
Job Authorization	mapreduce.job.acl-modify-job	No, throw exception
Job Authorization	mapreduce.cluster.administrators	No, throw exception
Job Authorization	mapred.queue.queue-name.acl-administer-jobs	No, throw exception
MultipleInputs	Not involved	No, throw exception
Multi{anchor:_GoBack}pleOutputs	Not involved	Yes
org.apache.hadoop.mapreduce.lib.db	Not involved	No, throw exception

Type	Interface	Is it compatible ?
org.apache.hadoop.mapreduce.security	Not involved	No, throw exception
org.apache.hadoop.mapreduce.lib.jobcontrol	Not involved	No, throw exception
org.apache.hadoop.mapreduce.lib.chain	Not involved	No, throw exception
org.apache.hadoop.mapreduce.lib.db	Not involved	No, throw exception

6 Java Sandbox

MaxCompute, MapReduce and UDF are limited by the Java sandbox when running in the distributed environment. However, the main program of MapReduce jobs, such as MR Main, is not restricted. The specific limits are as follows.

- Direct access to local files is not allowed. You can only access files by using interfaces provided by MaxCompute MapReduce/Graph.
  - Read resources specified by the resources option, including files, Jar packages, and resource tables.
  - Output log information through System.out and System.err. You can view log information by running the Log command on the MaxCompute console.
- Direct access to the distributed file system is not allowed. You can only access table records by using MaxCompute MapReduce/Graph.
- JNI call restrictions are not allowed.
- Creation of Java threads is not allowed. Initiation of sub-processes to run Linux commands is not allowed.
- Network access, including obtaining local IP addresses, is not allowed.
- Java reflection is restricted: suppressAccessChecks permission is denied. A private attribute or method cannot be set to accessible for obtaining private attributes or calling private methods.

Specifically for the user code, access denied is thrown if you follow these steps.

- java.io.File

```
public   boolean   delete ()
public   void   deleteOnEx  it ()
public   boolean   exists ()
public   boolean   canRead ()
public   boolean   isFile ()
public   boolean   isDirector  y ()
public   boolean   isHidden ()
public   long   lastModifi  ed ()
public   long   length ()
public   String []  list ()
public   String []  list ( FilenameFi  lter   filter )
public   File []  listFiles ()
public   File []  listFiles ( FilenameFi  lter   filter )
public   File []  listFiles ( FileFilter   filter )
public   boolean   canWrite ()
public   boolean   createNewF  ile ()
public   static   File   createTemp  File ( String   prefix ,
String   suffix )
```

```
public   static   File   createTemp  File ( String   prefix ,
String   suffix , File   directory )
public   boolean   mkdir ()
public   boolean   mkdirs ()
public   boolean   renameTo ( File   dest )
public   boolean   setLastMod  ified ( long   time )
public   boolean   setReadOnl  y ()
```

- **java.io.RandomAccessFile**

```
RandomAcce  ssFile ( String   name ,  String   mode )
RandomAcce  ssFile ( File   file ,  String   mode )
```

- **java.io.FileInputStream**

```
FileInputS  tream ( FileDescri  ptor   fdObj )
FileInputS  tream ( String   name )
FileInputS  tream ( File   file )
```

- **java.io.FileOutputStream**

```
FileOutput  Stream ( FileDescri  ptor   fdObj )
FileOutput  Stream ( File   file )
FileOutput  Stream ( String   name )
FileOutput  Stream ( String   name ,  boolean   append )
```

- **java.lang.Class**

```
public   Protection  Domain   getProtect  ionDomain ()
```

- **java.lang.ClassLoader**

```
ClassLoade  r ()
ClassLoade  r ( ClassLoade  r   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   runFinaliz  ersOnExit ( boolean   value )
public   void   addShutdow  nHook ( Thread   hook )
public   boolean   removeShut  downHook ( Thread   hook )
public   void   load ( String   lib )
public   void   loadLibrar  y ( String   lib )
```

- **java.lang.System**

```
public   static   void   exit ( int   status )
public   static   void   runFinaliz  ersOnExit ( boolean   value )
public   static   void   load ( String   filename )
public   static   void   loadLibrar  y (  String   libname )
public   static   Properties   getPropert  ies ()
public   static   void   setPropert  ies ( Properties   props )
public   static   String   getPropert  y ( String   key ) // Only
some   keys   are   allowed   for   file   access .
```

```
public   static   String   getPropert  y ( String   key ,  String
def ) //  Only   some   keys   are   allowed   for   file   access
.
public   static   String   setPropert  y ( String   key ,  String
value )
public   static   void   setIn ( InputStrea  m   in )
public   static   void   setOut ( PrintStrea  m   out )
public   static   void   setErr ( PrintStrea  m   err )
public   static   synchroniz  ed   void   setSecurit  yManager (
SecurityMa  nager   s )
```

List of keys allowed by System.getProperty is as follows:

```
java . version
java . vendor
java . vendor . url
java . class . version
os . name
os . version
os . arch
file . separator
path . separator
line . separator
java . specificat  ion . version
java . specificat  ion . vendor
java . specificat  ion . name
java . vm . specificat  ion . version
java . vm . specificat  ion . vendor
java . vm . specificat  ion . 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 ( ThreadGrou  p   group , ...)
public   final   void   checkAcces  s ()
public   void   interrupt ()
public   final   void   suspend ()
public   final   void   resume ()
public   final   void   setPriorit  y  ( int   newPriorit  y )
public   final   void   setName ( String   name )
public   final   void   setDaemon ( boolean   on )
public   final   void   stop ()
public   final   synchroniz  ed   void   stop ( Throwable   obj )
public   static   int   enumerate ( Thread   tarray [])
public   void   setContext  ClassLoade  r ( ClassLoade  r   cl )
```

- **java.lang.ThreadGroup**

```
ThreadGrou  p ( String   name )
ThreadGrou  p ( ThreadGrou  p   parent ,  String   name )
public   final   void   checkAcces  s ()
public   int   enumerate ( Thread   list [])
public   int   enumerate ( Thread   list [],  boolean   recurse )
public   int   enumerate ( ThreadGrou  p   list [])
```

```
public   int   enumerate ( ThreadGrou  p   list [],  boolean
recurse )
public   final   ThreadGrou  p   getParent ()
public   final   void   setDaemon ( boolean   daemon )
public   final   void   setMaxPrio  rity ( 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   setAccessi  ble (...)
public   void   setAccessi  ble (...)
```

- **java.net.InetAddress**

```
public   String   getHostNam  e ()
public   static   InetAddres  s []  getAllByNa  me ( String   host
)
public   static   InetAddres  s   getLocalHo  st ()
```

- **java.net.DatagramSocket**

```
public   InetAddres  s   getLocalAd  dress ()
```

- **java.net.Socket**

```
Socket (...)
```

- **java.net.ServerSocket**

```
ServerSock  et (...)
public   Socket   accept ()
protected   final   void   implAccept ( Socket   s )
public   static   synchroniz  ed   void   setSocketF  actory (...)
public   static   synchroniz  ed   void   setSocketI  mplFactory
(...)
```

- **java.net.DatagramSocket**

```
DatagramSo  cket (...)
public   synchroniz  ed   void   receive ( DatagramPa  cket   p )
```

- **java.net.MulticastSocket**

```
MulticastS  ocket (...)
```

- **java.net.URL**

```
URL (...)
public   static   synchroniz  ed   void   setURLStre  amHandlerF
actory (...)
java . net . URLConnect  ion
public   static   synchroniz  ed   void   setContent  HandlerFac
tory (...)
```

```
public   static   void   setFileNam  eMap ( FileNameMa  p   map )
```

- **java.net.HttpURLConnection**

```
public   static   void   setFollowR  edirects ( boolean   set )
java . net . URLClassLo  ader
URLClassLo  ader (...)
```

- **java.security.AccessControlContext**

```
public   AccessCont  rolContext ( AccessCont  rolContext   acc ,
DomainComb  iner   combiner )
public   DomainComb  iner   getDomainC  ombiner ()
```

7 External table

7.1 Overview of External tables

MaxCompute is the core computing component of the Alibaba Cloud big data platform. It possesses powerful computing capabilities and can schedule parallel computing tasks on a large volume of nodes. It also provides a set of proven processing management mechanisms for distributed computing failover, retry, and other functions.

As the entry of distributed data processing, MaxCompute SQL provides powerful support for quick processing and storing of exabytes of offline data. With the continuous expansion of big data business, many new cases of data usage are emerging, and the MaxCompute computing frameworks are also evolving. Access to powerful computation capabilities is gradually opening to external data sources instead of to internal data with special formats.

At this stage, MaxCompute SQL faces structured data stored in the internal MaxCompute table in cfile format. For other user data outside of MaxCompute tables (including text and various types of unstructured data), you must first import the data to MaxCompute tables using various tools and then compute it. The process of data import has great limitations. For example, to process OSS data in MaxCompute, two common methods can be used:

- To download data from OSS using the OSS SDK or other tools, the data is then imported into the table through the MaxCompute tunnel.
- Write the UDF and call the OSS SDK directly within the UDF to access the OSS data.

But there are shortcomings in both of these practices:

- You must relay data outside of the MaxCompute system. If the OSS data volume is too large, you need to consider using concurrent operations to accelerate the process and you cannot make full use of MaxCompute's large-scale computing capabilities.
- The second type typically needs to apply for UDF network access, there is also a problem for developers to control the number of job concurrency and how the data is split.

This section describes the functionality of an External table, support is designed to provide the ability to process data other than existing MaxCompute tables. In this framework, you use a simple DDL statement to create an external table in MaxCompute. Then, you can associate MaxCompute tables with the external data source to provide various data access and output capabilities. After creating an external table, you can use it like a MaxCompute table (in most situations), to take full advantage of MaxCompute SQL's powerful computing functions.

> **Note:**
> Using the external tables feature, the data of the external tables is not copied and placed on the MaxCompute for storage.

Here, *a variety of data* covers two dimensions:

A variety of data storage media: a plug-in framework can be used to connect to a wide variety of data storage media, such as OSS, OTS.

Diverse data formats: The MaxCompute table is structured data, external tables can not be limited to structured data.

- There is no structured data, such as images, audio, video files, raw bindings, and so on.
- Semi-structured data, such as CSV, TSV, and so on, implies a certain schema text file. Structured Data for a non-cfile, such as an orc/parquet file, or even hbase/OTS data.

We'll take some examples to help you gain insight into the processing of unstructured data:

- To access OSS and OTS unstructured data see accessing OSS unstructured data and accessing OTS unstructured data.
- External tables access the OSS account, and in Ram customize the permissions that authorize MaxCompute to access the OSS seeOSS STS mode authorization.
- The unstructured framework of MaxCompute supports output of MaxCompute data directly to OSS via insert, see Unstructured data exported to OSS.
- To work with data on middleware databases, see Processing open source format data for OSShandling data in a variety of open source formats.

7.2 OSS STS mode authorization

This article introduces you how to customize the permissions of MaxCompute to access OSS in RAM.

The location access OSS account supports the incoming plaintext `AccessKeyI d` and `AccessKeyS ecret` when creating the external table, but there is a risk of leaking the account. In some scenarios, this risk is intolerable, so MaxCompute provides a more secure way to access OSS.

MaxCompute combines Alibaba Cloud's Access Control Service (RAM) and Token Service (STS) to address account security issues. You can grant permissions in two ways:

- When the owner of MaxCompute and OSS are the same account, a one-click authorization operation can be performed directly on the RAM console.
- Custom authorization.

1. The first thing you need to authorize MaxCompute to access the OSS permissions in RAM. Create a role, and the role name such as `AliyunODPS DefaultRol e` or `AliyunODPS RoleForOth erUser` , and set the policy content:

```
--  When   the   owner   of   MaxCompute   and   OSS   are   the
 same   account

" Statement  ":[

" Action ": " STS :  apererole  ",
" Effect ": " allow  ",
" Principal  ":{
" Service  ":[
" Maid "

}


" Version ": " 1 "

--  When   the   owner   of   MaxCompute   and   OSS   are   not
 the   same   account

" Statement  ":[

" Action ": " STS :  apererole  ",
" Effect ": " allow  ",
" Principal  ":{
" Service  ":[
" MaxCompute ' s   owner   cloud   account   page "
```

```
" Version ": " 1 "
```

2. Grant the role the necessary permissions to access the OSS * . As follows:

```
 Version : " 1  ",
" Statement  ":[

" Action   ":[
 " Oss :  listbucket  s  ",
 " Oss :  GetObject  ",
 " Oss :  maid  ",
 " Oss :  putobject  ",
 " Oss :  deleteobje  ct  ",
 " Oss :  maid  ",
 " Oss :  listparts "

" Resource  ":"*",
" Effect ": " allow "



--  Can   Customize   other   Permission  s
```

3. The permission box is then granted to the role.

Note:
After the authorization is complete, view the role details to obtain the Ran information of the Role. You need to specify this Ran information when you create the OSS external table.

7.3 Access OSS unstructured data

This topic describes how to access OSS unstructured data in MaxCompute by using different methods.

Note:
You can use DataWorks and MaxCompute to create, search, query, configure, process, and analyze external tables. For more information, see #unique_218. For information about how to use an external table to process unstructured data, see External table overview.

Authorize OSS data access permission with STS mode

Authorize OSS data access permission to MaxCompute account in advance so that MaxCompute can directly access the OSS. You can authorize permissions in one of the following two ways:

- When the MaxCompute owner and OSS owner use the same account, you can use this account to log on to the Alibaba Cloud and authorize the role to access OSS resources.
- Customize authorization.

1. Log on to the RAM console. If the MaxCompute owner and OSS owner use different accounts, navigate to the RAM Roles page and use the OSS owner account to create a role such as `AliyunODPS DefaultRol e` or `AliyunODPS RoleForOth erUser` to grant MaxCompute the permissions to access OSS.
2. Modify the policy content of role as follows:

```
-- If  MaxCompute  and  OSS  owners  use  the  same
 account , do  the  following :
{
" Statement ": [
{
 " Action ": " sts : AssumeRole ",
 " Effect ": " Allow ",
 " Principal ": {
   " Service ": [
     " odps . aliyuncs . com "
   ]
 }
}
],
" Version ": " 1 "
}
-- If  MaxCompute  and  OSS  owners  use  different
 accounts , do  the  following :
{
" Statement ": [
{
 " Action ": " sts : AssumeRole ",
 " Effect ": " Allow ",
 " Principal ": {
   " Service  ":[
     " MaxCompute ' s  Owner  account :  id @ odps . aliyuncs .
 com "
   ]
 }
}
],
" Version ": " 1 "
}
```

3. Grant the necessary permission `AliyunODPS RolePolicy` to the role to access OSS as follows:

```
{
" Version ": " 1 ",
" Statement ": [
{
 " Action ": [
```

```
    " oss : ListBucket  s ",
    " oss : GetObject ",
    " oss : ListObject  s ",
    " oss : PutObject ",
    " oss : DeleteObje  ct ",
    " Oss :  maid  ",
    " oss : ListParts "
  ],
  " Resource ": "*",
  " Effect ": " Allow "
}
]
}
-- You   can   customize   other   permission  s .
```

4. Authorize the permission AliyunODPSRolePolicy to this role.

Read OSS text data by using a built-in extractor

When accessing external data sources, you must use different custom extractor. You can also use MaxCompute' s built-in extractor to read conventionally-formatted data stored in OSS. You only need to create an external table and use this table as the source table for query operations.

In this example, assume that you have a CSV data file in OSS. The endpoint is `oss - cn - shanghai - internal . aliyuncs . com`, the bucket is `oss - odps - test`, and the data file is stored in */ demo / vehicle . csv* .

- Create an external table

  Use the following statements to create an external table:

```
CREATE   EXTERNAL   TABLE   IF   NOT   EXISTS   ambulance_
data_csv_e  xternal
(
vehicleId   int ,
recordId   int ,
patientId   int ,
calls   int ,
locationLa  titute   double ,
locationLo  ngtitue   double ,
recordTime   string ,
direction   string
)
STORED   BY   ' com . aliyun . odps . CsvStorage  Handler ' -- ( 1 )
WITH   SERDEPROPE  RTIES   (
' odps . properties . rolearn '=' acs : ram :: xxxxx : role /
aliyunodps  defaultrol  e '
) -- ( 2 )
```

```
LOCATION ' oss :// oss - cn - shanghai - internal . aliyuncs . com
/ oss - odps - test / Demo /'; -- ( 3 )( 4 )
```

The above statement is described below:

- `com . aliyun . odps . CsvStorage Handler` is the built-in `StorageHan dler` for processing CSV-format files. It defines how CSV files are read and written. You only need to specify this name. The relevant logic is implemented by the system.
- The information in `odps . properties . rolearn` comes from the `Arn` information of `AliyunODPS DefaultRol e` in RAM. You can get it through the role details in the RAM console.
- You must specify an OSS directory for LOCATION. By default, the system reads all the files in this directory.
  - We recommend you to use the domain name of the intranet, to avoid incurring fees for the OSS data-flow.
  - We recommend that the region you store the OSS data is the same as the region you open MaxCompute. Because MaxCompute can only be deployed in some regions, cross-regional data connectivity cannot be guaranteed.
  - OSS connection format is `oss :// oss - cn - shanghai - internal . aliyuncs . com / bucketname / directoryn ame /`. You do not have to add a file name after the directory. Some common errors are shown as follows:

```
http :// oss - odps - test . oss - cn - shanghai - internal
. aliyuncs . com / Demo / -- HTTP connection is not
supported .
https :// oss - odps - test . oss - cn - shanghai - internal .
aliyuncs . com / Demo / -- HTTPS connection is not
supported .
oss :// oss - odps - test . oss - cn - shanghai - internal .
aliyuncs . com / Demo -- The connection address is
incorrect .
oss :// oss :// oss - cn - shanghai - internal . aliyuncs .
com / oss - odps - test / Demo / vehicle . csv -- You do
  not need to specify the file name .
```

- In the MaxCompute system, external tables only record the associated OSS directory. If you DROP (delete) this table, the corresponding `LOCATION` data is not deleted.

In the returned information, `Extended Info` contains external tables information such as `StorageHan dler` and `Location` .

- Query an external table

After creating an external table, you can use it as a normal table. Assume the data in `/ demo / vehicle . csv` is as follows:

```
1 , 1 , 51 , 1 , 46 . 81006 ,- 92 . 08174 , 9 / 14 / 2014   0 : 00
, S
1 , 2 , 13 , 1 , 46 . 81006 ,- 92 . 08174 , 9 / 14 / 2014   0 : 00
, NE
1 , 3 , 48 , 1 , 46 . 81006 ,- 92 . 08174 , 9 / 14 / 2014   0 : 00
, NE
1 , 4 , 30 , 1 , 46 . 81006 ,- 92 . 08174 , 9 / 14 / 2014   0 : 00
, W
1 , 5 , 47 , 1 , 46 . 81006 ,- 92 . 08174 , 9 / 14 / 2014   0 : 00
, S
1 , 6 , 9 , 1 , 46 . 81006 ,- 92 . 08174 , 9 / 14 / 2014   0 : 00 ,
S
1 , 7 , 53 , 1 , 46 . 81006 ,- 92 . 08174 , 9 / 14 / 2014   0 : 00
, N
1 , 8 , 63 , 1 , 46 . 81006 ,- 92 . 08174 , 9 / 14 / 2014   0 : 00
, SW
1 , 9 , 4 , 1 , 46 . 81006 ,- 92 . 08174 , 9 / 14 / 2014   0 : 00 ,
NE
1 , 10 , 31 , 1 , 46 . 81006 ,- 92 . 08174 , 9 / 14 / 2014   0 : 00
, N
```

Run the following SQL statement:

```
select   recordId ,  patientId ,  direction   from   ambulance_
data_csv_e  xternal   where   patientId  >  25 ;
```

Note:

Currently, external table can only be operated through MaxCompute SQL. MaxCompute MapReduce cannot operate the external table.

This statement submits a job, scheduling the built-in CSV extractor to read and process data from OSS. The result is as follows:

```
+------------+------------+-----------+
|  recordId    |  patientId    |  direction   |
+------------+------------+-----------+
|  1   |  51   |  S   |
|  3           |  48           |  NE          |
|  4           |  30           |  W           |
|  5           |  47           |  S           |
|  7           |  53           |  N           |
|  8           |  63           |  SW          |
|  10          |  31           |  N           |
+------------+------------+-----------+
```

Read OSS text data by using a custom extractor

When OSS data is in a complex format, and the built-in extractor cannot meet your requirements, you must use a custom extractor to read data from OSS files.

For example, assume you have a TXT data file that is not in CSV format, and `|` is used as the column delimiter between records. For example, the data in `/ demo / SampleData / CustomTxt / AmbulanceD ata / vehicle . csv` is as follows:

```
1 | 1 | 51 | 1 | 46 . 81006 |- 92 . 08174 | 9 / 14 / 2014   0 : 00 |
S
1 | 2 | 13 | 1 | 46 . 81006 |- 92 . 08174 | 9 / 14 / 2014   0 : 00 |
NE
1 | 3 | 48 | 1 | 46 . 81006 |- 92 . 08174 | 9 / 14 / 2014   0 : 00 |
NE
1 | 4 | 30 | 1 | 46 . 81006 |- 92 . 08174 | 9 / 14 / 2014   0 : 00 |
W
1 | 5 | 47 | 1 | 46 . 81006 |- 92 . 08174 | 9 / 14 / 2014   0 : 00 |
S
1 | 6 | 9 | 1 | 46 . 81006 |- 92 . 08174 | 9 / 14 / 2014   0 : 00 |
S
1 | 7 | 53 | 1 | 46 . 81006 |- 92 . 08174 | 9 / 14 / 2014   0 : 00 |
N
1 | 8 | 63 | 1 | 46 . 81006 |- 92 . 08174 | 9 / 14 / 2014   0 : 00 |
SW
1 | 9 | 4 | 1 | 46 . 81006 |- 92 . 08174 | 9 / 14 / 2014   0 : 00 |
NE
1 | 10 | 31 | 1 | 46 . 81006 |- 92 . 08174 | 9 / 14 / 2014   0 : 00 |
N
```

- Define an extractor.

  Write a common extractor by using the delimiter as the parameter. This allows you to process all text files with similar formats.

```
/**
 *  Text   extractor   that   extract   schematize  d   records
 from   formatted   plain - text ( csv ,  tsv   etc .)
 **/
 public   class   TextExtrac  tor   extends   Extractor  {
   private   InputStrea  mSet   inputs ;
   private   String   columnDeli  miter ;
   private   DataAttrib  utes   attributes ;
   private   BufferedRe  ader   currentRea  der ;
   private   boolean   firstRead  =  true ;
   public   TextExtrac  tor () {
    //  default   to  ",",  this   can   be   overwritte  n   if   a
   specific   delimiter   is   provided  ( via   DataAttrib  utes )
     this . columnDeli  miter  = ",";
  }
  //  no   particular   usage   for   execution   context   in
 this   example
  @ Override
   public   void   setup ( ExecutionC  ontext   ctx ,  InputStrea
 mSet   inputs ,  DataAttrib  utes   attributes ) {
     this . inputs  =  inputs ; //  inputs   is   an   InputStrea
 mSet ,  each   call   to   next ()  returns   an  InputStrea  m .
 This   InputStrea  m   can   read   all   the   content   in   an
 OSS   file .
     this . attributes  =  attributes ;
    //  check   if  " delimiter "  attribute   is   supplied   via
 SQL   query
```

```
    String   columnDeli  miter  =  this . attributes . getValueBy
Key (" delimiter "); // The   delimiter   parameter   is   supplied
  by   a   DDL   statement .
    if  (  columnDeli  miter  ! =  NULL )
   {
      this . columnDeli  miter  =  columnDeli  miter ;
   }
   //  note :  more   properties   can   be   inited   from
attributes   if   needed
 }
 @ Override
  public   Record   extract () throws   IOExceptio  n  {//
extractor ()  calls   return   one   record , correspond  ing   to
  one   record   in   an   external   table .
    String   line  =  readNextLi  ne ();
    if  ( line  ==  null ) {
      return   null ;  //  A   return   value   of   NULL
indicates   that   this   table   has   no   readable   records .
   }
    return   textLineTo  Record ( line );  //  textLineTo  Record
  splits   a   row   of   data   into   multiple   columns
according   to   the   delimiter .
 }
 @ Override
  public   void   close (){
   //  no - op
 }
}
```

See here for a complete implementation of the textLineToRecord splitting data.

- Define StorageHandler.

  A StorageHandler acts as a centralized portal for custom external table logic.

```
package   com . aliyun . odps . udf . example . text ;
public   class   TextStorag  eHandler   extends   OdpsStorag
eHandler  {
 @ Override
  public   Class <?  extends   Extractor >  getExtract  orClass ()
{
    return   TextExtrac  tor . class ;
 }
 @ Override
  public   Class <?  extends   Outputer > getOutpute  rClass () {
    return   TextOutput  er . class ;
 }
```

```
}
```

- Compile and package custom code.

  Compile your custom code into a package and upload it to MaxCompute.

```
add   jar   odps - udf - example . jar ;
```

- Create an external table.

  Similar to using the built-in extractor, first, you must create an external table. The difference is that, when specifying the external table access data, you must use a custom StorageHandler.

  Use the following statements to create an external table:

```
CREATE   EXTERNAL   TABLE   IF   NOT   EXISTS   ambulance_
data_txt_e  xternal
(
vehicleId   int ,
recordId   int ,
patientId   int ,
calls   int ,
locationLa  titute   double ,
locationLo  ngtitue   double ,
recordTime   string ,
direction   string
)
STORED   BY  ' com . aliyun . odps . udf . example . text .
TextStorag  eHandler '   -- STORED   BY   specifies   the   custom
  StorageHan  dler   class   name .
  with   SERDEPROPE  RTIES  (
' delimiter '='\\|', --  SERDEPROPE  RITES   can   specify
parameters ,  these   parameters   are   passed   through   the
DataAttrib  utes   to   the   Extractor   code .
' odps . properties . rolearn '=' acs : ram :: xxxxxxxxxx  xxx :
role / aliyunodps  defaultrol  e '
)
LOCATION  ' oss :// oss - cn - shanghai - internal . aliyuncs . com
/ oss - odps - test / Demo / SampleData / CustomTxt / AmbulanceD
ata /'
USING  ' odps - udf - example . jar '; -- You   must   also
  specify   the   jar   package   containing   the   class
definition .
```

- Query an external table.

  Run the following SQL statement:

```
select   recordId ,  patientId ,  direction   from   ambulance_
data_txt_e  xternal   where   patientId  >  25 ;
```

Read OSS non-text data by using a custom extractor

The preceding sections show how the built-in extractor or a custom extractor can conveniently process CSV and other text data stored in OSS. Following sections using audio data (WAV format files) as an example show how to use a custom extractor to access and process non-text files in OSS.

However, this section describes how to use MaxCompute SQL as a portal to process audio files stored in OSS.

Create the external table SQL as follows:

```
CREATE   EXTERNAL   TABLE   IF   NOT   EXISTS   speech_sen
tence_snr_  external
(
sentence_s  nr   double ,
id   string
)
STORED   BY  ' com . aliyun . odps . udf . example . speech .
SpeechStor  ageHandler '
WITH   SERDEPROPE  RTIES  (
   ' mlfFileNam  e '=' sm_random_  5_utteranc  e . text . label ' ,
   ' speechSamp  leRateInKH  z ' = ' 16 '
)
LOCATION  ' oss :// oss - cn - shanghai - internal . aliyuncs . com /
oss - odps - test / dev / SpeechSent  enceTest /'
USING  ' odps - udf - example . jar , sm_random_  5_utteranc  e .
text . label ';
```

As in the preceding example, you must create an external table. Then, use the schema of this table to define the information that you want to extract from the audio file:

- The statement signal-to-noise ratio (SNR) in an audio file: sentence_snr.
- The name of the audio file: id.

After creating the external table, use a standard Select statement to perform a query . This operation triggers the extractor to perform computation. When reading and processing OSS data, in addition to simple deserialization on text files, you can use custom extractor to perform more complex data processing and extraction logic.

In this example, use the custom extractor encapsulated in `com . aliyun . odps . udf . example . speech . SpeechStor  ageHandler` to calculate the average SNR of valid statements in the audio file, and extract structured data for SQL operations (WHERE sentence_snr > 10). After this operation is completed, the operation returns all audio files with an SNR that are greater than 10 along with the corresponding SNR values.

Multiple WAV format files are stored at the OSS address `oss :// oss - cn - hangzhou - zmf . aliyuncs . com / oss - odps - test / dev / SpeechSent  enceTest /`. The MaxCompute framework reads all the files at this address and, when necessary, performs file-level sharing. The framework automatically allocates the file to multiple computing nodes for processing.

On each computing node, the extractor is responsible for processing the file set allocated to the node by InputStreamSet. The special processing logic is similar to a single-host program. The algorithm is implemented by using the single host method according to its class.

Details about the `SpeechSent enceSnrExt ractor` formulation logic are as follows:

First, read the parameters in the `setup` interface to perform initialization and import the audio processing model (using resource introduction):

```
public   SpeechSent  enceSnrExt  ractor (){
    this . utteranceL  abels  =  new   HashMap < String ,
UtteranceL  abel >();
 }
 @ Override
  public   void   setup ( ExecutionC  ontext   ctx ,  InputStrea
mSet   inputs ,  DataAttrib  utes   attributes ){
    this . inputs  =  inputs ;
    This .  Attributes  =  attributes ;
    this . mlfFileNam  e  =  this . attributes . getValueBy  Key (
MLF_FILE_A  TTRIBUTE_K  EY );
    String   sampleRate  InKHzStr  =  this . attributes . getValueBy
Key ( SPEECH_SAM  PLE_RATE_K  EY );
    this . sampleRate  InKHz  =  Double . parseDoubl  e ( sampleRate
InKHzStr );
    try  {
     //  read   the   speech   model   file   from   resource   and
load   the   model   into   memory
      BufferedIn  putStream   inputStrea  m  =  ctx . readResour
ceFileAsSt  ream ( mlfFileNam  e );
      loadMlfLab  elsFromRes  ource ( inputStrea  m );
      inputStrea  m . close ();
   }  catch  ( IOExceptio  n   e ) {
      throw   new   RuntimeExc  eption (" reading   model   from
mlf   failed   with   exception  " +  e . getMessage ());
   }
 }
```

The extract() interface implements reading and processing logic of the voice file, computes the signal-to-noise ratio (SNR) of the data based on the voice model, and fills Record with the result in the format of [snr, id].

The preceding example simplifies the implementation process and does not include the relevant audio processing algorithm logic. See the example code provided by the MaxCompute SDK from the open-source community.

```
@ Override
```

```
  public   Record   extract ()  throws   IOExceptio  n  {
    SourceInpu  tStream   inputStrea  m  =  inputs . next ();
    if  ( inputStrea  m  ==  null ){
      return   null ;
   }
   //  process   one   wav   file   to   extract   one   output
record  [ snr ,  id ]
    String   fileName  =  inputStrea  m . getFileNam  e ();
    fileName  =  fileName . substring ( fileName . lastIndexO  f
('/') +  1 );
    logger . info (" Processing   wav   file  " +  fileName );
    String   id  =  fileName . substring ( 0 ,  fileName .
lastIndexO  f ('.'));
   //  read   speech   file   into   memory   buffer
    long   fileSize  =  inputStrea  m . getFileSiz  e ();
    byte []  buffer  =  new   byte [( int ) fileSize ];
    int   readSize  =  inputStrea  m . readToEnd ( buffer );
    inputStrea  m . close ();
   //  compute   the   avg   sentence   snr
    double   snr  =  computeSnr ( id ,  buffer ,  readSize );
   //  construct   output   record   [ snr ,  id ]
    Column []  outputColu  mns  =  this . attributes . getRecordC
olumns ();
    ArrayRecor  d   record  =  new   ArrayRecor  d ( outputColu  mns
);
    record . setDouble ( 0 ,  snr );
    record . setString ( 1 ,  id );
    return   record ;
 }
  private   void   loadMlfLab  elsFromRes  ource ( BufferedIn
putStream   fileInputS  tream )
          throws   IOExceptio  n  {
   //   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   validBuffe  rLen ){
   //  computing   the   snr   value   for   the   wav   file  (
supplied   as   byte   buffer   array ),  skipped   here
 }
```

Run the query:

```
select   sentence_s  nr ,  id
    from   speech_sen  tence_snr_  external
where   sentence_s  nr  >  10 . 0 ;
```

Results:

```
--------------------------------------------------------------
|  sentence_s  nr  |                      id                       |
--------------------------------------------------------------
|    34 . 4703     |           J310209090  013_H02_K0  3_042
 |
--------------------------------------------------------------
|    31 . 3905     |  tsh148_seg  _2_3013_3_  6_48_80bd3  59827e24dd
 7_0  |
--------------------------------------------------------------
|    35 . 4774     |  tsh148_seg  _3013_1_31  _11_9d7c87  aef9f3e559
 _0   |
```

```
-------------------------------------------------------------
|    16 . 0462     |  tsh148_seg  _3013_2_29  _49_f4cb09  90a6b4060c
 _0   |
-------------------------------------------------------------
|    14 . 5568     |    tsh_148_30  13_5_13_47  _3d5008d79  2408f81_0
   |
-------------------------------------------------------------
```

By using the custom extractor, you can process multiple voice data files stored on OSS on the SQL statement in a distributed way. You can also use the same method given the large-scale computing power of MaxCompute to process various types of unstructured data such as image or video files.

Partition data

In earlier sections, data linked to an external table is implemented through a designated OSS Directory on LOCATION. During this process, MaxCompute reads all data under the OSS Directory, *including all files in sub-directory*. For directories with largest amounts of data, especially those with data that is continually accumulating over time, scanning the entire directory may cause unnecessary IO and data processing time. In which case, you can typically implement one of the following two solutions:

- Reduce access data volume: You can implement changes in terms of the data storage organization, use multiple external tables to describe different parts of the data, or have each EXTERNAL TABLE LOCATION refer to a subset of the data.
- Partition data: An external table is the same as an internal table, *it supports functions of partition table*, you are available to manage data systemization based on partition function.

- *Standard Organization and Path Format of Partitioned Data in OSS*

  Unlike its internal tables, MaxCompute does not have the authority to manage data stored in external memory (such as OSS). As such, if using the partition table function on your system is a requirement, the storage path for data files in OSS must conform to a certain format. This format is as follows.

  ```
  partitionK  ey1 = value1 \ partitionK  ey2 = value2 \...
  ```

  Related examples are as follows

  Assume that you save your daily LOG files on OSS and want to access part of the data when processed with MaxCompute, based on the granularity of Day. Assuming that these LOG files are CSV files (usage of complicated and customized format is similar), you can define data using the following *partitioned external table*.

```
CREATE   EXTERNAL   TABLE   log_table_  external  (
    click   STRING ,
    ip   STRING ,
    url   STRING ,
  )
  PARTITIONE  D   BY  (
    year   STRING ,
    month   STRING ,
    day   STRING
  )
  STORED   BY  ' com . aliyun . odps . CsvStorage  Handler '
  WITH   SERDEPROPE  RTIES  (
 ' odps . properties . rolearn '=' acs : ram :: xxxxx : role /
aliyunodps  defaultrol  e '
)
  LOCATION  ' oss :// oss - cn - hangzhou - zmf . aliyuncs . com /
oss - odps - test / log_data /';
```

Like the previous table statement, the difference with the previous example is that when you define an external table, the external table is specified as a partition table through the PARTITIONED BY syntax, and the example is a three-tier partition table, the key for the partition is year, month, and day.

In order for a partition like this to work effectively, you must comply with the aforementioned path format when storing data on OSS. The following is an example of a valid path storage layout.

```
osscmd   ls   oss :// oss - odps - test / log_data /
2017 - 01 - 14   08 : 03 : 35   128MB   Standard   oss :// oss
- odps - test / log_data / year = 2016 / month = 06 / day = 01 /
logfile
2017 - 01 - 14   08 : 04 : 12   127MB   Standard   oss :// oss
- odps - test / log_data / year = 2016 / month = 06 / day = 01 /
logfile .  1
2017 - 01 - 14   08 : 05 : 02   118MB   Standard   oss :// oss
- odps - test / log_data / year = 2016 / month = 06 / day = 02 /
logfile
2017 - 01 - 14   08 : 06 : 45   123MB   Standard   oss :// oss
- odps - test / log_data / year = 2016 / month = 07 / day = 10 /
logfile
2017 - 01 - 14   08 : 07 : 11   115MB   Standard   oss :// oss
- odps - test / log_data / year = 2016 / month = 08 / day = 08 /
logfile
...
```

Note:

If you have prepared the offline data, that is, if you have uploaded the offline data to the OSS storage service with osscmd or other OSS tools, you then define the data path format.

You can introduce the partition information into MaxCompute by using the `ALTER TABLE ADD PARTITIOND DL` pant statement.

An example of the corresponding DDL statement is as follows.

```
ALTER TABLE log_table_ external ADD PARTITION ( year = '
2016 ', month = ' 06 ', day = ' 01 ')
ALTER TABLE log_table_ external ADD PARTITION ( year = '
2016 ', month = ' 06 ', day = ' 02 ')
ALTER TABLE log_table_ external ADD PARTITION ( year = '
2016 ', month = ' 07 ', day = ' 10 ')
ALTER TABLE log_table_ external ADD PARTITION ( year = '
2016 ', month = ' 08 ', day = ' 08 ')
...
```

Note:

These actions are the same as the standard maxcompute internal table operation, and for more information about the partition, see #unique_220. When the data is ready and the PARTITION information has been imported into the system, the partitioning of the external table data on OSS can be performed by means of an SQL statement.

Assuming that you only want to analyze how many different IPs there are in LOG on June 1, 2016, the following command can be used:

```
SELECT count ( distinct ( ip )) FROM log_table_ external
WHERE year = ' 2016 ' AND month = ' 06 ' AND day = ' 01
';
```

At this point, for log_table_external, the directory that corresponds to the external table will only access the files under the `log_data / year = 2016 / month = 06 / day = 01` subdirectory (logfile and logfile 1), *not on the whole* log_data/ to avoid a large number of useless I/O operations.

Similarly, if you only want to analyze the data for the second half of 2016, you can use the following command:

```
SELECT count ( distinct ( ip )) FROM log_table_ external
WHERE year = ' 2016 ' AND month > ' 06 ';
```

At this point, only access the second half of the LOG stored on OSS.

- *Customized Path of Partitioned Data in OSS*

  If you have historical data stored in OSS but this data is not stored by using the `partitionK ey1 = value1 \ partitionK ey2 = value2 \...` path format, you can still access it using MaxCompute's partition mode. MaxCompute also provides a way to import partitions through a customized path.

  Assume that only a simple partition value is on your data path (and no partition key information). The following is an example of the data path storage layout:

```
 osscmd   ls   oss :// oss - odps - test / log_data_c  ustomized /
 2017 - 01 - 14   08 : 03 : 35   128MB   Standard   oss :// oss -
 odps - test / log_data_c  ustomized / 2016 / 06 / 01 / logfile
 2017 - 01 - 14   08 : 04 : 12   127MB   Standard   oss :// oss -
 odps - test / log_data_c  ustomized / 2016 / 06 / 01 / logfile .
 1
 2017 - 01 - 14   08 : 05 : 02   118MB   Standard   oss :// oss -
 odps - test / log_data_c  ustomized / 2016 / 06 / 02 / logfile
 2017 - 01 - 14   08 : 06 : 45   123MB   Standard   oss :// oss -
 odps - test / log_data_c  ustomized / 2016 / 07 / 10 / logfile
 2017 - 01 - 14   08 : 07 : 11   115MB   Standard   oss :// oss -
 odps - test / log_data_c  ustomized / 2016 / 08 / 08 / logfile
...
```

The external table builder DDL can see the previous example and also specify the partition key in the clause.

To bind different subdirectories to different partitions, you can do so by using a command similar to the following customized partition path:

```
ALTER   TABLE   log_table_  external   ADD   PARTITION  ( year  = '
2016 ',  month  = ' 06 ',  day  = ' 01 ')
LOCATION  ' oss :// oss - cn - hangzhou - zmf . aliyuncs . com / oss
- odps - test / log_data_c  ustomized / 2016 / 06 / 01 /';
```

When LOCATION information is added in `ADD PARTITION` to customize a partition data path. Even if the data is not stored in the recommended format of `partitionK ey1 = value1 \ partitionK ey2 = value2 \...`, you can still access the partition data of the subdirectory.

7.4 Processing open source format data for OSS

This article will show you how to process various popular open source data formats (ORC, PARQUET, SEQUENCEFILE, RCFILE, AVRO and TEXTFILE) stored on OSS through unstructured frameworks in MaxCompute.

Accessing the OSS unstructured data shows you how to access the text stored on the OSS on MaxCompute, audio, image, and other format data. The non-structural framework directly calls the implementation of the open source community to parse the open source data format, and seamlessly with the MaxCompute system.

Note:
Before processing the Open Source format data for OSS, it is necessary to authorize STS mode for OSS.

Create External Table

The MaxCompute unstructured data framework is associated with a variety of data through external table, external of Open Source format data associated with OSS

```
 DROP   TABLE  [ IF   EXISTS ] < external_t  able >;
 CREATE   EXTERNAL   TABLE  [ IF   NOT   EXISTS ] < external_t  able >
(< column   schemas >)
[ PARTITIONE  D   BY  ( partition   column   schemas )]
[ ROW   FORMAT   SERDE  '< serde   class >'
  [ With   serdeprope  rties  (' ODPS .  properties .  rolearn  '=' $
 { roleran  }'[, ' name2  '= ' value2 ',...]
]
 STORED   AS  < file   format >
 LOCATION  ' oss ://${ endpoint }/${ bucket }/${ userfilePa  th }/';
```

Note:
The syntax format is quite similar to hive's syntax, but the following issues need to be noted:

- STORED AS keyword, which is not STORED BY keyword used for ordinary unstructured appearance in this grammar format, is unique in reading open source compatible data at present.

  STORED AS is followed by file format names, such as *ORC/PARQUET/RCFILE/SEQUENCEFILE/TEXTFILE*.
- The column schemas of the external tables must match the schema where the stored data is stored on the specific OSS.

- `ROW FORMAT SERDE` option is not required, and is only available in a number of special formats, for example, textfile needs to be used.
- When `WITH SERDEPROPE RTIES` associates OSS privileges with STS mode authorization, this parameter is required to specify the `odps . properties . rolearn` attribute, whose value is the Role Arn information specifically used in RAM.

  If you do not use STS mode, you do not need to specify this property to pass in the clear text `AccessKeyI d` and the `AccessKeyS ecret` directly at location.
- Location if you associate OSS with clear AK, write as follows:

  ```
  LOCATION ' oss ://${ accessKeyI d }:${ accessKeyS ecret }@${
  endpoint }/${ bucket }/${ userPath }/'
  ```
- Accessing the OSS External tables is not currently supported with outer-network Endpoint.
- Currently the STORE AS single file size cannot exceed 3G, split is recommended if the file is too large.

Example of PARQUET data associated with OSS

Assume that some parquet files are stored on an OSS path, and that each file is in parquet format, the schema is stored in 16 columns (4 columns bigint, 4 columns double, and 8 columns string) the data for the build table Div statement is as follows:

```
CREATE EXTERNAL TABLE tpch_linei tem_parque t
(
   Rochelle  orderkey  bigint ,
   l_partkey  bigint ,
   l_suppkey  bigint ,
   Rochelle  linenumber  bigint ,
   l_quantity  double ,
   l_extended  price  double ,
   l_discount  double ,
   l_tax  double ,
   l_returnfl  ag  string ,
   l_linestat  us  string ,
   l_shipdate  string ,
   l_commitda  te  string ,
   l_receiptd  ate  string ,
   l_shipinst  ruct  string ,
   l_shipmode  string ,
   _Comment  string
)
STORED AS PARQUET
```

```
LOCATION  ' oss ://${ accessKeyI  d }:${ accessKeyS  ecret }@ oss -
cn - hangzhou - zmf . aliyuncs . com / bucket / parquet_da  ta /';
```

The default parquet data is not compressed, and if you need to compress parquet data on MaxCompute, you need set `set   odps . sql . hive . compatible = true ;`. The supported compression types are: SNAPPY, GZIP.

Text data associated with OSS

If the data is stored as TEXTFILE file on OSS in JSON format for each row and organized by multiple directories in OSS, then MaxCompute partition table and data association can be used. An example of DDL statement for partition table is shown below.

```
CREATE   EXTERNAL   TABLE   tpch_linei  tem_textfi  le
(
   l_orderkey   bigint ,
   l_partkey   bigint ,
   l_suppkey   bigint ,
   l_linenumb  er   bigint ,
   l_quantity   double ,
   l_extended  price   double ,
   l_discount   double ,
   l_tax   double ,
   l_returnfl  ag   string ,
   Maid   string ,
   l_shipdate   string ,
   Rochelle   Commission   string ,
   l_receiptd  ate   string ,
   l_shipinst  ruct   string ,
   l_shipmode   string ,
   l_comment   string
)
PARTITIONE  D   BY  ( ds   string )
ROW   FORMAT   serde   ' org . apache . hive . hcatalog . data .
JsonSerDe '
STORED   AS   TEXTFILE
Location  ' oss : // $ { accesskeyi  d }: $ { accesskeys  ecret } @
fig  /';
```

If the sub-directory under the OSS table directory is organized as Partition Name, the example is as follows.

```
oss ://${ accessKeyI  d }:${ accessKeyS  ecret }@ oss - cn - hangzhou
- zmf . aliyuncs . com / bucket / text_data / ds = 20170102 /'
oss ://${ accessKeyI  d }:${ accessKeyS  ecret }@ oss - cn - hangzhou
- zmf . aliyuncs . com / bucket / text_data / ds = 20170103 /'
...
```

You can ADD PARTITION using the following pant statement.

```
ALTER   TABLE   tpch_linei  tem_textfi  le   ADD   PARTITION ( ds ="
20170102 ");
```

```
ALTER   TABLE   tpch_linei  tem_textfi  le   ADD   PARTITION ( ds ="
20170103 ");
```

If the OSS partition directory is not organized in this way, or not in the table directory at all, the example is as follows:

```
oss ://${ accessKeyI  d }:${ accessKeyS  ecret }@ oss - cn - hangzhou
- zmf . aliyuncs . com / bucket / text_data_  20170102 /;
oss ://${ accessKeyI  d }:${ accessKeyS  ecret }@ oss - cn - hangzhou
- zmf . aliyuncs . com / bucket / text_data_  20170103 /;
...
```

In this case, you can use the following pant statement to ADD PARTITION.

```
ALTER   TABLE   tpch_linei  tem_textfi  le   ADD   PARTITION ( ds ="
20170102 ")
LOCATION  ' oss ://${ accessKeyI  d }:${ accessKeyS  ecret }@ oss -
cn - hangzhou - zmf . aliyuncs . com / bucket / text_data_  20170102
/';
ALTER   TABLE   tpch_linei  tem_textfi  le   ADD   PARTITION ( ds ="
20170103 ")
LOCATION  ' oss ://${ accessKeyI  d }:${ accessKeyS  ecret }@ oss -
cn - hangzhou - zmf . aliyuncs . com / bucket / text_data_  20170103
/';
...
```

Text data supports serdeproperties (key: default)

```
Fields   terminator : '\ 001 '
Escape   delimitor : '\\'
Collection   items   terminator : '\ 002 '
Map   keys   terminator : '\ 003 '
Lines   terminate : '\  N '
Null   defination : '\\ N '
```

CSV data associated with OSS

The Tasmania statement format is as follows.

```
CREATE   EXTERNAL   TABLE  [ IF   NOT   EXISTS ]
(< column   schemas >)
[ PARTITIONE  D   BY  ( partition   column   schemas )]
ROW   FORMAT   SERDE  ' org . apache . hadoop . hive . serde2 .
OpenCSVSer  de '
  WITH   SERDEPROPE  RTIES
   (' Separates   atorchare ' =, ', ' pigeon   techar ' = '"', '
escarechar  '= '\\')
STORED   AS   TEXTFILE
LOCATION  ' oss ://${ endpoint }/${ bucket }/${ userfilePa  th }/';
```

As you can see from the above statement, the CSV data pant Statement supports serdeproperties (key: default)

```
separatorC  har : ','
```

```
quoteChar : ""
Escarechar :'\'
```

Note:

hive OpenCSVSerde only supports string types.

OpenCSVSerde does not currently belong to Builtin Serde. When DML statements are executed, you need to set odps.sql.hive.compatible = true.

JSON data associated with OSS

The Tasmania statement format is as follows, and SERDEPROPERTIES is supported.

```
CREATE   EXTERNAL   TABLE  [ IF   NOT   EXISTS ]
(< column   schemas >)
[ PARTITIONE  D   BY  ( partition   column   schemas )]
ROW   FORMAT   SERDE  ' org . apache . hive . hcatalog . data .
JsonSerDe '
STORED   AS   TEXTFILE
LOCATION  ' oss ://${ endpoint }/${ bucket }/${ userfilePa  th }/';
```

ORC data associated with OSS

The Tasmania statement format is as follows.

```
CREATE   EXTERNAL   TABLE  [ IF   NOT   EXISTS ]
(< column   schemas >)
[ PARTITIONE  D   BY  ( partition   column   schemas )]
STORED   AS   ORC
LOCATION  ' oss ://${ endpoint }/${ bucket }/${ userfilePa  th }/';
```

AVRO data associated with OSS

The format of the DDL statement is as follows.

```
CREATE   EXTERNAL   TABLE  [ IF   NOT   EXISTS ]
(< column   schemas >)
[ PARTITIONE  D   BY  ( partition   column   schemas )]
STORED   AS   AVRO
LOCATION  ' oss ://${ endpoint }/${ bucket }/${ userfilePa  th }/';
```

SEQUENCEFILE data associated with OSS

```
CREATE   EXTERNAL   TABLE  [ IF   NOT   EXISTS ]
(< column   schemas >)
[ PARTITIONE  D   BY  ( partition   column   schemas )]
STORED   AS   SEQUENCEFI  LE
```

```
LOCATION  ' oss ://${ endpoint }/${ bucket }/${ userfilePa  th }/';
```

Read and process open source format data for OSS

Compare the two external representations created in the previous article, you can see that for different file types, Simply modify the format name after STORED AS. In the following example, only the processing of the appearance (tpch_lineitem_parquet) corresponding to the above PARQUET data will be described centrally. If you want to work with different file types, just specify parquet/ORC/TEXTFILE/RCFILE/TEXTFILE as long as you want to create the appearance when the DDL is created, the statement that processes the data is the same.

- *Read and process open source data directly from OSS*

  After creating a data table to associate, you can directly do the same thing as a normal MaxCompute table, as shown below.

```
SELECT   l_returnfl  ag ,  l_linestat  us ,
SUM ( l_extended  price *( 1 - l_discount ))  AS   sum_disc_p  rice
,
AVG ( l_quantity )  AS   avg_qty ,
COUNT (*)  AS   count_orde  r
FROM   tpch_linei  tem_parque  t
WHERE   l_shipdate  <= ' 1998 - 09 - 02 '
Group   by   l_returnfl  ag ,  l_linestat  us ;
```

  The appearance tpch_lineitem_parquet is used as a common internal table, except that the MaxCompute internal computing engine reads the corresponding PARQUET data directly from OSS for processing.

  The external partition table for the associated textfile that was created in the previous article, because `ROW   FORMAT` + `STORED   AS` is used, you need to set flag manually (Only use STORED AS, odps.sql.hive.compatible is FALSE by default.) and then reads again, otherwise there will be an error.

```
SELECT  *  FROM   tpch_linei  tem_textfi  le   LIMIT   1 ;
Failed :  Maid :  User   Defined   Function   exception - traceback
:
com . aliyun . odps . udf . UDFExcepti  on :  java . lang .
ClassNotFo  undExcepti  on :  com . aliyun . odps . hive . wrapper
. HiveStorag  eHandlerWr  apper
-- You   need   to   manually   set   up   hive   compatible   flag
.
set   odps . sql . hive . compatible = true ;
Select  *  from   Maid   limit   1 ;
+------------+------------+------------+--------------+------------
+-----------------+------------+------------+--------------
+--------------+------------+-------------+--------------
+---------------+------------+-----------+
|  l_orderkey  |  l_partkey   |  l_suppkey   |  l_linenumb  er  |
 l_quantity  |  l_extended  price  |  l_discount  |  l_tax       |
```

```
 l_returnfl  ag  |  l_linestat  us  |  l_shipdate  |  l_commitda
 te  |  l_receiptd  ate  |  l_shipinst  ruct  |  l_shipmode  |
 l_comment  |
+------------+------------+------------+--------------+------------
+----------------+------------+------------+--------------
+-------------+------------+--------------+--------------
+---------------+------------+-----------+
|  5640000001  |  174458698   |  9458733    |  1           |  14
 . 0         |  23071 . 58        |  0 . 08        |  0 . 06
 |  N            |  O            |  1998 - 01 - 26  |  1997 - 11 -
16    |  1998 - 02 - 18     |  TAKE  BACK  RETURN  |  SHIP
 |  cuses   nag   silently .  quick  |
+------------+------------+------------+--------------+------------
+----------------+------------+------------+--------------
+-------------+------------+--------------+--------------
+---------------+------------+-----------+
```

Note:

Direct use of the external table, each time reading data requires I/O operations involving external OSS, and the MaxCompute system itself does not use many high-performance optimizations for internal storage, so there will be a loss in performance. Therefore, if it is a scenario that requires repeated computation of data and is sensitive to the efficiency of computation, it is recommended to use the following usage: first import the data into MaxCompute and then calculate it.

These complex data types are involved in SQL (create, select, insert, etc.). The statement `set  odps . sql . type . system . odps2  =  true ;` should be added before the SQL statement, and the set statement and the SQL statement should be submitted together for execution at execution time. See for details #unique_61.

- *Importing the open source data from OSS into MaxCompute for Calculation*

First, create an internal table tpch_lineitem_internal, which is the same as the external table schema, and then import the open source data from OSS into the internal table of MaxCompute for storage in the internal data storage format of MaxCompute.

```
CREATE  TABLE  tpch_linei  tem_intern  al  LIKE  tpch_linei
tem_parque  t ;
INSERT  OVERWRITE  TABLE  tpch_linei  tem_intern  al ;
SELECT  *  FROM  tpch_linei  tem_parque  t ;
```

Next take the same action directly to the internal table:

```
SELECT  l_returnfl  ag ,  l_linestat  us ,
SUM ( l_extended  price *( 1 - l_discount ))  AS  sum_disc_p  rice
,
AVG ( l_quantity )  AS  avg_qty ,
```

```
COUNT (*)  AS   count_orde  r
FROM   tpch_linei  tem_intern  al
WHERE   l_shipdate  <= ' 1998 - 09 - 02 '
GROUP   BY   l_returnfl  ag ,  l_linestat  us ;
```

By doing so, you can pilot the data into the MaxCompute system for storage, computational processing of the same data will be more efficient.

7.5 Unstructured data exported to OSS

The unstructured framework of MaxCompute supports output of MaxCompute data directly to OSS via insert, MaxCompute also associates OSS with external tables for data output.

Accessing OSS unstructured data shows you how MaxCompute can be accessed and processed through the associations of External tables unstructured data stored in OSS.

Output Data to OSS is typically two cases:

- The MaxCompute internal table is output to the External table that is associated with the OSS.
- After MaxCompute processes the external tables, the results are output directly to the external tables that are associated with the OSS.

Like accessing OSS data, MaxCompute supports output via built-in storagehandler and custom storagehandler.

Output to OSS via built-in StorageHandler

Using the built-in StorageHandler in MaxCompute And can be very convenient to output data in the agreed format to the OSS for storage. All we need to do is create an external table that indicates the built-in StorageHandler, it can be associated with this table, and the related logic is implemented by the system.

Currently MaxCompute supports 2 built-in StorageHandler:

- com.aliyun.odps.CsvStorageHandler , Defines how to read and write CSV format data, data format Conventions: English comma, column separator `,` line Break is `\n`.
- com.aliyun.odps.TsvStorageHandler, defines how to read and write CSV format data, data format Conventions: `\t` is a column separator, line Break is `\n`.

- *Creating an External table*

```
CREATE   EXTERNAL   TABLE  [ IF   NOT   EXISTS ] < external_t  able
>
(< column   schemas >)
[ PARTITIONE  D   BY  ( partition   column   schemas )]
  STORED   BY  '< StorageHan  dler >'
[ WITH   SERDEPROPE  RTIES  ( ' odps . properties . rolearn '='${
roleran }') ]
LOCATION  ' oss ://${ endpoint }/${ bucket }/${ userfilePa  th }/';
```

  - STORED By, if the data file that is required to be exported to OSS is a TSV file, then built-in `com . aliyun . odps . TsvStorage  Handler` ; if the data file that is required to be exported to OSS is a CSV file, a built-in `com . aliyun . odps . CsvStorage  Handler` .
  - WITH SERDEPROPERTIES, when associating OSS privileges with "Custom Authorization" of "STS Mode Authorization", this parameter needs to specify the'odps.properties.rolearn'attribute, whose value is the information of the Custom Role specifically used in RAM.

    Note:

    STS mode authorization can be seen in Accessing the unstructured data of OSS.
  - Location that specifies the path to the file that corresponds to the OSS storage. If the 'odps.properties.rolearn' attribute is not set in *`WITH SERDEPROPERTIES`* and the plaintext AK is used for authorization, then *`LOCATION`* is

```
LOCATION
   ' oss ://${ accessKeyI  d }:${ accessKeyS  ecret }@${ endpoint
}/${ bucket }/${ userPath }/'
```

- The data is output to OSS through the INSERT operation of External Table.

  Note:

  The insert-to-OSS single file size cannot exceed 5g.

  When associated with an OSS storage path via external table,you can do a standard SQL INSERT OVERWRITE/INSERT INTO operation on the External table to output both data to OSS.

```
INSERT   OVERWRITE | INTO   TABLE  < external_t  ablename > [
PARTITION  ( partcol1 = val1 ,  partcol2 = val2  ...)]
select_sta  tement
FROM  < from_table  name >
[ WHERE   where_cond  ition ];
```

```
```

- *from_tablename*: it can be an internal table, it can also be an external table (including an external table for the associated OSS or OTS).
- INSERT specifies the format of 'StorageHandler'(that is, TSV or CSV) according to the External table 'stored ') write to OSS.

When the INSERT operation is completed successfully, you can see that the corresponding LOCATION on the OSS produces a series of files.

For example: the location corresponding to External table is the *oss :// oss - cn - hangzhou - zmf . aliyuncs . com / oss - odps - test / tsv_output _folder /* , you can see the generation of a series of files in the OSS corresponding path:

```
osscmd   ls   oss :// oss - odps - test / tsv_output  _folder /
2017 - 01 - 14   06 : 48 : 27   39 . 00B   Standard   oss :// oss -
odps - test / tsv_output  _folder /. odps /. meta
2017 - 01 - 14   06 : 48 : 12   4 . 80MB   Standard   oss :// oss -
odps - test / tsv_output  _folder /. odps / 2017011322  4724561g9m
6csz7 / M1_0_0 - 0 . tsv
2017 - 01 - 14   06 : 48 : 05   4 . 78MB   Standard   oss :// oss -
odps - test / tsv_output  _folder /. odps / 2017011322  4724561g9m
6csz7 / M1_1_0 - 0 . tsv
2017 - 01 - 14   06 : 47 : 48   4 . 79MB   Standard   oss :// oss -
odps - test / tsv_output  _folder /. odps / 2017011322  4724561g9m
6csz7 / M1_2_0 - 0 . tsv
...
```

The folder tsv_output_folder under the OSS bucket oss-odps-test specified by LOCATION contains the .odps folder which includes some .tsv files and a .meta file. Similar file structures are specific to MaxCompute's output to OSS:

- When you use MaxCompute to execute INSERT INTO/OVERWRITE on an external table and write to an OSS address, all of the data is writen to a .odps folder in the specified LOCATION.
- The `. meta  file` in the `. odps` folder is an extra macro data file written by MaxCompute to record the valid data in the current folder. Typically, if the INSERT operation is successful, all the data in the current folder is valid. The macro data only needs to be parsed when a job fails. If an operation fails midway or is killed, you can simply re-execute the INSERT OVERWRITE statement.
- If it is a partition table, A corresponding partition sub-directory is generated based on the partition value specified by the insert statement under the fig folder and then the partition sub-directory inside is '.odps 'folder. For example,

`test / tsv_output _folder / first - level partition name = partition value /. odps / 2017011322 4724561g9m 6csz7 / M1_2_0 - 0 . tsv` .

For the TSV/CSV storagehandler processing built in by MaxCompute, the number of files generated is corresponding to the corresponding SQL

If the `INSER OVERWITE ... SELECT ... FROM ... ;`operation allocates 1000 mappers on the source data table (from_tablename), 1000 TSV/CSV files will be generated.

Output to OSS via custom storagehandler

In addition to using the built-in StorageHandler to implement the output TSV/CSV common text format on the OSS, the MaxCompute unstructured framework provides a general-purpose SDK that supports external output of custom data format files.

As well as the built-in StorageHandler, you need to "Create an External TABLE" And then output data to OSS through INSERT operation of External Table. The difference is that when creating external tables, STORED BY is required to specify custom StorageHandler.

Note:
The MaxCompute unstructured framework describes the processing of varieties of data storage formats through an interface called StorageHandler. Specifically, the StorageHandler acts as a Wrapper class, allowing you to specify a custom Exatractor(for data reading, parsing, processing, etc) And Outputer(for data processing and output, etc). Custom StorageHandler should inherit Odps StorageHandler and implement getExtractorClass and getOutputerClass interfaces.

Next, we use the example of Access OSS data. OSS unstructured data of "Custom Extractor accesses OSS", to show how MaxCompute can output data to OSS txt file by customizing StorageHandler, and use'|'as column delimiter and'\ n' as line breaker.

Note:
After the MaxCompute Studio is configured with MaxCompute Java module, you can see the corresponding sample code in examples. Or click here to see the complete code.

- *Define Outputer*

Both output logic must implement the outputer interface:

```
package   com . aliyun . odps . examples . unstructur  ed . text ;
import   com . aliyun . odps . data . Record ;
import   com . aliyun . odps . io . OutputStre  amSet ;
import   com . aliyun . odps . io . SinkOutput  Stream ;
import   com . aliyun . odps . udf . DataAttrib  utes ;
import   com . aliyun . odps . udf . ExecutionC  ontext ;
import   com . aliyun . odps . udf . Outputer ;
import   java . io . IOExceptio  n ;
public   class   TextOutput  er   extends   Outputer  {
    private   SinkOutput  Stream   outputStre  am ;
    private   DataAttrib  utes   attributes ;
    private   String   delimiter ;
    public   TextOutput  er  (){
       //  default   delimiter ,  this   can   be   overwritte  n
if   a   delimiter   is   provided   through   the   attributes .
        this . delimiter  = "|";
   }
   @ Override
    public   void   output ( Record   record )  throws
IOExceptio  n  {
        this . outputStre  am . write ( recordToSt  ring ( record
). getBytes ());
   }
   //  no   particular   usage   of   execution   context   in
this   example
   @ Override
    public   void   setup ( ExecutionC  ontext   ctx ,  OutputStre
amSet   outputStre  amSet ,  DataAttrib  utes   attributes )
throws   IOExceptio  n  {
        this . outputStre  am  =  outputStre  amSet . next ();
        this . attributes  =  attributes ;
        this . delimiter  =  this . attributes . getValueBy  Key ("
delimiter ");
        if  (  this . delimiter  ==  null )
       {
            this . delimiter =",";
       }
        System . out . println (" Extractor   using   delimiter  ["
+  this . delimiter  + "].");
   }
   @ Override
    public   void   close () {
       //  no - op
   }
    private   String   recordToSt  ring ( Record   record ){
        StringBuil  der   sb  =  new   StringBuil  der ();
        for  ( int   i  =  0 ;  i  & lt ;  record . getColumnC
ount ();  i ++)
       {
            if  ( null  ==  record . get ( i )){
                sb . append (" NULL ");
           }
            else {
                sb . append ( record . get ( i ). toString ());
           }
            if  ( i  ! =  record . getColumnC  ount () -  1 ){
                sb . append ( this . delimiter );
           }
```

```
        }
         sb . append ("\ n ");
         return   sb . toString ();
    }
}
```

All output logic must call the Outputer API. There are three outputer APIs (setup, output, and close) which all correspond to the three extractor APIs (setup, extract , and close). Where setup() and close() are called only once in an outputer. The user may perform initialization preparation in setup. Furthermore, the three parameters returned by setup() must be saved as outputer class variables to be used in the output() or close() APIs. The interface, close (), is used to sweep the end of the Code.

Typically, most of the data processing occurs in the output (Record) interface. The MaxCompute system calls output (Record) Once based on each input record processed by the current outputer assignment). Assuming that when an output (Record) call returns, the Code has already consumed the Record, so after the current output (Record) returns, the system uses the memory used by the record for it, so when the information in Record is used across multiple output() function calls, the record for the current process needs to be invoked.clone() method to save the current record.

- *Define Extractor*

Exatrractor is used for Data Reading, parsing, processing, and so on, if the output tables eventually do not need to be read by MaxCompute and so on, you do not need to define them.

```
 package   com . aliyun . odps . examples . unstructur  ed . text ;
 import   com . aliyun . odps . Column ;
 import   com . aliyun . odps . data . ArrayRecor  d ;
 import   com . aliyun . odps . data . Record ;
 import   com . aliyun . odps . io . InputStrea  mSet ;
 import   com . aliyun . odps . udf . DataAttrib  utes ;
 import   com . aliyun . odps . udf . ExecutionC  ontext ;
 import   com . aliyun . odps . udf . Extractor ;
 import   java . io . BufferedRe  ader ;
 import   java . io . IOExceptio  n ;
 import   java . io . InputStrea  m ;
 import   java . io . InputStrea  mReader ;
/**
 *  Text   extractor   that   extract   schematize  d   records
 from   formatted   plain - text ( csv ,  tsv   etc .)
 **/
 public   class   TextExtrac  tor   extends   Extractor  {
     private   InputStrea  mSet   inputs ;
     private   String   columnDeli  miter ;
     private   DataAttrib  utes   attributes ;
     private   BufferedRe  ader   currentRea  der ;
```

```
    private   boolean   firstRead  =  true ;
    public   TextExtrac  tor () {
       //  default   to  ",",  this   can   be   overwritte  n
if   a   specific   delimiter   is   provided  ( via   DataAttrib
utes )
        this . columnDeli  miter  = ",";
   }
   //  no   particular   usage   for   execution   context   in
this   example
   @ Override
    public   void   setup ( ExecutionC  ontext   ctx ,  InputStrea
mSet   inputs ,  DataAttrib  utes   attributes ) {
        this . inputs  =  inputs ;
        this . attributes  =  attributes ;
       //  check   if  " delimiter "  attribute   is   supplied
via   SQL   query
        String   columnDeli  miter  =  this . attributes .
getValueBy  Key (" delimiter ");
        if  (  columnDeli  miter  ! =  null )
       {
            this . columnDeli  miter  =  columnDeli  miter ;
       }
        System . out . println (" TextExtrac  tor   using
delimiter  [" +  this . columnDeli  miter  + "].");
       //  note :  more   properties   can   be   inited   from
attributes   if   needed
   }
   @ Override
    public   Record   extract ()  throws   IOExceptio  n  {
        String   line  =  readNextLi  ne ();
        if  ( line  ==  null ) {
            return   null ;
       }
        return   textLineTo  Record ( line );
   }
   @ Override
    public   void   close (){
       //  no - op
   }
    private   Record   textLineTo  Record ( String   line )  throws
  IllegalArg  umentExcep  tion
   {
        Column []  outputColu  mns  =  this . attributes .
getRecordC  olumns ();
        ArrayRecor  d   record  =  new   ArrayRecor  d (
outputColu  mns );
        if  ( this . attributes . getRecordC  olumns (). length  !
=  0  ){
           //  string   copies   are   needed ,  not   the   most
efficient   one ,  but   suffice   as   an   example   here
            String []  parts  =  line . split ( columnDeli  miter
);
            int []  outputInde  xes  =  this . attributes .
getNeededI  ndexes ();
            if  ( outputInde  xes  ==  null ){
                throw   new   IllegalArg  umentExcep  tion (" No
outputInde  xes   supplied .");
           }
            if  ( outputInde  xes . length  ! =  outputColu  mns .
length ){
                throw   new   IllegalArg  umentExcep  tion ("
Mismatched   output   schema :  Expecting  "
                       +  outputColu  mns . length  + "  columns
but   get  " +  parts . length );
```

```
            }
             int   index  =  0 ;
             for ( int   i  =  0 ;  i  & lt ;  parts . length ;  i +
+){
                // only  parse  data  in  columns  indexed
 by  output  indexes
                 if  ( index  & lt ;  outputInde  xes . length  &&
 i  ==  outputInde  xes [ index ]){
                     switch  ( outputColu  mns [ index ]. getType
 ()) {
                         case   STRING :
                             record . setString ( index ,  parts [ i
 ]);
                             break ;
                         case   BIGINT :
                             record . setBigint ( index ,  Long .
 parseLong ( parts [ i ]));
                             break ;
                         case   BOOLEAN :
                             record . setBoolean ( index ,  Boolean
 . parseBoole  an ( parts [ i ]));
                             break ;
                         case   DOUBLE :
                             record . setDouble ( index ,  Double .
 parseDoubl  e ( parts [ i ]));
                             break ;
                         case   DATETIME :
                         case   DECIMAL :
                         case   ARRAY :
                         case   MAP :
                         Default :
                             throw   new   IllegalArg  umentExcep
 tion (" Type  " +  outputColu  mns [ index ]. getType () + "  not
 supported   for   now .");
                    }
                     index ++;
                }
            }
        }
         return   record ;
    }
    /**
     *  Read   next   line   from   underlying   input   streams .
     * @ return   The   next   line   as   String   object .  If
 all   of   the   contents   of   input
     *  streams   has   been   read ,  return   null .
     */
     private   String   readNextLi  ne ()  throws   IOExceptio  n  {
         if  ( firstRead ) {
             firstRead  =  false ;
            //  the   first   read ,  initialize   things
             currentRea  der  =  moveToNext  Stream ();
             if  ( currentRea  der  ==  null ) {
                //  empty   input   stream   set
                 return   null ;
            }
        }
         while  ( currentRea  der  ! =  null ) {
             String   line  =  currentRea  der . readLine ();
             if  ( line  ! =  null ) {
                 return   line ;
            }
             currentRea  der  =  moveToNext  Stream ();
        }
```

```
            return   null ;
        }
         private   BufferedRe  ader   moveToNext  Stream ()  throws
    IOExceptio  n  {
                InputStrea  m   stream  =  inputs . next ();
                if  ( stream  ==  null ) {
                    return   null ;
              }  else  {
                    return   new   BufferedRe  ader ( new   InputStrea
    mReader ( stream ));
              }
        }
    }
```

For more information, see Accessing the OSS unstructured data documentation.

- *Define StorageHandler*

```
    package   com . aliyun . odps . examples . unstructur  ed . text ;
    import   com . aliyun . odps . udf . Extractor ;
    import   com . aliyun . odps . udf . OdpsStorag  eHandler ;
    import   com . aliyun . odps . udf . Outputer ;
    public   class   TextStorag  eHandler   extends   OdpsStorag
    eHandler  {
       @ Override
        public   Class & lt ;?  extends   Extractor & gt ;  getExtract
    orClass () {
                return   TextExtrac  tor . class ;
        }
       @ Override
        public   Class & lt ;?  extends   Outputer >  getOutpute
    rClass () {
                return   TextOutput  er . class ;
        }
    }
```

If the table does not need to be read, you do not need to specify an Extractor interface.

- *Compile and package*

Compile your custom code into a package and upload it to MaxCompute. If the jar package is named 'odps-TextStorageHandler.jar', upload to MaxCompute

```
    add   jar   odps - TextStorag  eHandler . jar ;
```

- *Creating External tables*

Like using the built-in StorageHandler, an External table needs to be created, the difference is that this time you need to specify that the data is output to an external table, using a custom StorageHandler.

```
    CREATE   EXTERNAL   TABLE   IF   NOT   EXISTS   output_dat
    a_txt_exte  rnal
    (
    vehicleId   int ,
    recordId   int ,
```

```
 patientId   int ,
 calls   int ,
 locationLa  titute   double ,
 locationLo  ngtitue   double ,
 recordTime   string ,
 direction   string
)
 STORED   BY  ' com . aliyun . odps . examples . unstructur  ed .
 text . TextStorag  eHandler '
 WITH   SERDEPROPE  RTIES (
    ' delimiter '='|'
    [,' odps . properties . rolearn '='${ roleran }'])
 LOCATION  ' oss ://${ endpoint }/${ bucket }/${ userfilePa  th }/'
 USING  ' odps - TextStorag  eHandler . jar ';
```

Note:

If you need `odps . properties . rolearn` property, for more information, see *custom authorization* for STS mode authorization of Access the OSS unstructured data. If not, you can refer to *one-click authorization* or use clear-text AK on top of location.

- *Write unstructured files into External Table using INSERT*

After creating an external table Association on the OSS storage path by customizing the storagehandler, you can do a standard SQL insert override/insert into operation on the External table to output both data to OSS, in the same way as the built-in storagehandler:

```
 INSERT   OVERWRITE | INTO   TABLE  & lt ; external_t  ablename & gt
 ; [ PARTITION  ( partcol1 = val1 ,  partcol2 = val2  ...)]
 Select_sta  tement
 FROM  & lt ; from_table  name & gt ;
[ WHERE   where_cond  ition ];
```

When the insert operation is successful,as the built-in StorageHandler, you can see a series of files generated in the OSS corresponding LOCATION path . `odps` folder.

7.6 Access Table Store data

This document introduces how to import data from Table Store to the MaxCompute computing environment. This allows seamless connections between multiple data sources.

Table Store is a NoSQL database service that built on Alibaba Cloud’ s Apsara distributed file system, enabling you to store and access massive volumes of structured data in real time. For more information about Table Store, see What is Table Store.

MaxCompute and TableStore are two independent big data computing and storage services. Therefore, these two services must ensure that the network between them is open. When MaxCompute’s public cloud service accesses data stored in Table Store, we recommend that you use Table Store’s *private network* address, usually a host name suffixed ‘ots-internal.aliyuncs.com’, for example `tablestore :// odps - ots - dev . cn - shanghai . ots - internal . aliyuncs . com`.

The previous article showed you how to #unique_103.

Both TableStore and MaxCompute have their own type systems. Both Table Store and MaxCompute have their own data type systems. When you process Table Store data in MaxCompute, the data type associations are as follow:

MaxCompute Type	TableStore Type
STRING	STRING
BIGINT	INTEGER
DOUBLE	Double
BOOLEAN	BOOLEAN
BINARY	BINARY

Authorization with STS Mode

To access Table Store data, MaxCompute requires a secure authorization channel. On this issue, MaxCompute integrates Alibaba Cloud Resource Access Management (RAM) and Token Service (STS) to implement secure data access.

You can authorize permissions in the following two ways:

- When the MaxCompute and Table Store's owner are the same account, you can directly log on with the Alibaba Cloud account and click here to complete authorization.

- Custom authorization

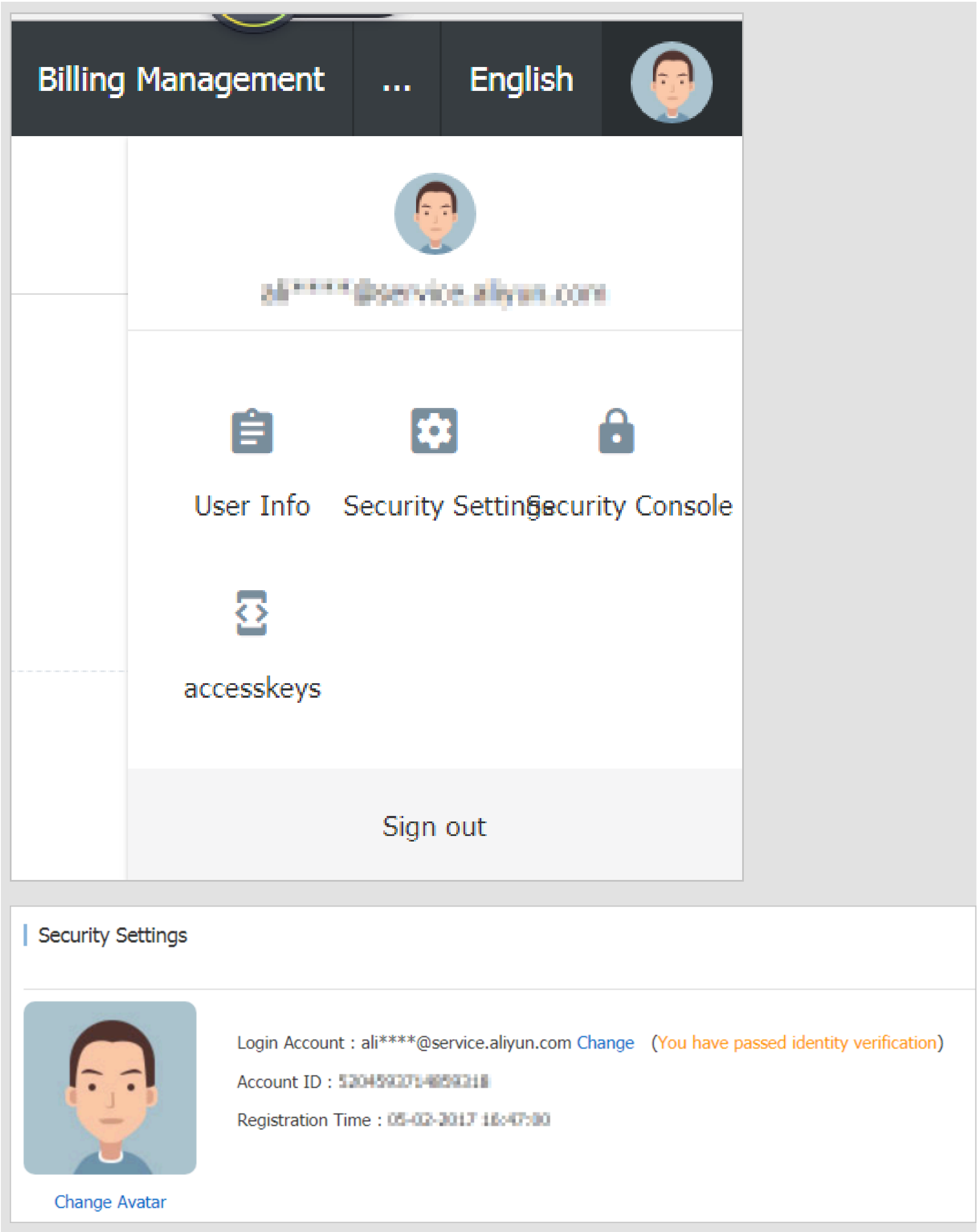
1. Firstly, you must grant Table Store access permission to MaxCompute in the RAM console.

   Log on to the RAM console (if MaxCompute and Table Store are not the same account, you must log on with the Table Store account to authorize), and create the role AliyunODPSDefaultRole.

2. Set its policy content as follows:

```
-- if   MaxCompute   and   Table   Store   are   same   account
{
" Statement ": [
{
 " Action ": " sts : AssumeRole ",
 " Effect ": " Allow ",
 " Principal ": {
   " Service ": [
     " odps . aliyuncs . com "
   ]
 }
}
],
" Version ": " 1 "
}
-- if   MaxCompute   and   Table   Store   are   not   the   same
   account
{
" Statement  ":[
{
 " Action ": " sts : AssumeRole ",
 " Effect ": " Allow ",
 " Principal ": {
   " Service ": [
     " MaxCompute ' s   Owner   cloud   account   UID @ odps .
 aliyuncs . com "
   ]
 }
}
],
" Version ": " 1 "
}
```

Note:
On the upper-right corner, click the avatar to open the Billing Management page, and then check the account UID.



3. Edit this role’ s authorization policy AliyunODPSRolePolicy:

```
{
" Version ": " 1 ",
" Statement  ":[
{
 " Action  ":[
   " ots : ListTable ",
   " ots : DescribeTa  ble ",
   " ots : GetRow ",
   " ots : PutRow ",
   " ots : UpdateRow ",
   " ots : DeleteRow ",
   " ots : GetRange ",
```

```
    " ots : BatchGetRo  w ",
    " ots : BatchWrite  Row ",
    " ots : ComputeSpl  itPointsBy  Size "
  ],
  " Resource ": "*",
  " Effect ": " Allow "
}
]
}
-- You   can   also   customize   other   permission  s
```

4. Grant the permission AliyunODPSRolePolicy to this role.

Creating an External table

In MaxCompute, after creating an external table and introducing the Table Store table data descriptions to the MaxCompute meta system, you can process Table Store data. The following example demonstrates the concept and practice that used in MaxCompute's Table Store access.

Use following statements to create an external table:

```
 DROP   TABLE   IF   EXISTS   ots_table_  external ;
 CREATE   EXTERNAL   TABLE   IF   NOT   EXISTS   ots_table_  external
(
 odps_order  key   bigint ,
 odps_order  date   string ,
 odps_custk  ey   bigint ,
 odps_order  status   string ,
 odps_total  price   double
)
 STORED   BY  ' com . aliyun . odps . TableStore  StorageHan  dler '
 -- ( 1 )
 WITH   SERDEPROPE  RTIES  ( -- ( 2 )
' tablestore . columns . mapping '=': o_orderkey ,: o_orderdat  e ,
 o_custkey ,  o_ordersta  tus , o_totalpri  ce ', -- ①
' tablestore . table . name '=' ots_tpch_o  rders ' -- ②
' odps . properties . rolearn '=' acs : ram :: xxxxx : role /
 aliyunodps  defaultrol  e ' --③
)
 LOCATION  ' tablestore :// odps - ots - dev . cn - shanghai . ots -
 internal . aliyuncs . com '; --  ( 3 )
```

The statement is described as follows:

- `com.aliyun.odps.TableStoreStorageHandler` is MaxCompute's built-in StorageHandler for processing Table Store data. It defines the interaction between MaxCompute and Table Store. The relevant logic is implemented by MaxCompute.
- `SERDEPROPERITES` is an interface that provides parameter options. When using `TableStoreStorageHandler`, two options must be specified, *tablestore*

. columns . mapping and *tablestore . table . name* and *odps . properties . rolearn* .

1. *tablestore . columns . mapping option* : required to describe the columns of the table store table that MaxCompute is going to access, including primary key and attribute columns.
   - At the beginning of the column name, `:` indicates a Table Store primary key. In this example`: o_orderkey` and `: o_orderdat e` are primary key columns and all others are attribute columns.
   - Table Store supports up to 4 primary keys. Primary keys support the STRING, INTEGER, and BINARY data types. The first primary key is the partition key.
   - When specifying a mapping relationship, you must provide all the primary keys of the specified Table Store table, but you do not have to provide all attribute columns, only the attribute columns you must access by using MaxCompute.
2. *tablestore . table . name* : the name of the table store table that needs to be accessed. If you specify an incorrect Table Store table name (such as a table that does not exist), the system reports an error. MaxCompute does not create a new Table Store table with the specified name.
3. *odps . properties . rolearn* : Arn information in RAM's AliyunODPSDefaultRole. You can get it through the details of the role in the RAM console.

- LOCATION clause: specific information for specifying Table Storeinstance names , endpoint, and so on. The secure access to Table Store data here is based on the premise of RAM/STS authorization introduced earlier.

If you want to view the created external table structure, run the following statement:

```
desc extended < table_name >;
```

In the returned information, “Extended Info” contains external tables information such as StorageHandler and Location.

Access Table Data by Using an External Table

After creating an external table, you can introduce Table Store data to the MaxCompute ecosystem.There, you can use MaxCompute SQL syntax to access Table Store data as follows:

```
SELECT   odps_order  key ,  odps_order  date ,  SUM ( odps_total
price )  AS   sum_total
FROM   ots_table_  external
WHERE  odps_order  key  >  5000   AND   odps_order  key  <  7000
AND   odps_order  date  >= ' 1996 - 05 - 03 '  AND   odps_order  date
 < ' 1997 - 05 - 01 '
GROUP   BY   odps_order  key ,  odps_order  date
HAVING   sum_total >  400000 . 0 ;
```

When using the MaxCompute SQL syntax, all of the accessed Table Store details are processed in MaxCompute. This includes column name selection. For example, the column names used in the preceding SQL statements (such as odps_orderkey and odps_totalprice) are not the original primary key names (o_orderkey) or attribute column names (o_totalprice) used in Table Store. This is because mapping was already performed in the DDL statement used to create the external table. Certainly, you can retain the original Table Store primary key/column names when creating the external table.

If you perform *multiple computations* on a single data set, instead of remotely reading data from Table Store each time, you can import all the necessary data to MaxCompute, to create a MaxCompute (internal) table. For example:

```
CREATE   TABLE   internal_o  rders   AS
SELECT   odps_order  key ,  odps_order  date ,  odps_custk  ey ,
odps_total  price
FROM   ots_table_  external
Where   fig >  5000 ;
```

Currently, internal_orders is a MaxCompute table, with all features of a MaxCompute internal table, including an efficiently compressed column storage data format and complete internal macro data, and statistics information. Furthermore, because the data is stored in MaxCompute, the access speed is faster than when accessing external Table Store data. This is especially suitable for hotspot data that is frequently computed.

Export MaxCompute Data to TableStore

Note:

MaxCompute does not directly create external Table Store tables.Therefore, before outputting data to a Table Store table, you must make sure this table has already been created (or the system reports an error).

In the preceding operations, the external table ots_table_external has been created to connect MaxCompute with the Table Store table ots_tpch_orders, and data has been stored in the internal MaxCompute table internal_orders. Now you can write the processed data from internal_orders back to Table Store, perform the `INSERT OVERWITE TABLE` operation on the external table as follows:

```
INSERT   OVERWRITE   TABLE   ots_table_  external
SELECT   odps_order  key ,  odps_order  date ,  odps_custk  ey ,
CONCAT ( odps_custk  ey , ' SHIPPED '),  CEIL ( odps_total  price )
FROM   internal_o  rders ;
```

Note:

If the data in the ODPS table itself has a certain order, such as sorting once according to Primary Key, then when writing to the OTS table, the pressure will be concentrated on an OTS partition, which can not make full use of the characteristics of distributed writing. Therefore, when this happens, we recommend that we first scatter the data through `distribute by Rand ().`

```
INSERT   OVERWRITE   TABLE   ots_table_  external
SELECT   odps_order  key ,  odps_order  date ,  odps_custk  ey ,
CONCAT ( odps_custk  ey , ' SHIPPED '),  CEIL ( odps_total  price )
FROM  ( SELECT  *  FROM   internal_o  rders   DISTRIBUTE   BY   rand
())  t ;
```

Because Table Store is a KV data NoSQL storage medium, the data output from MaxCompute only affects the rows with the corresponding primary keys. In this example, the output only affects data in rows with corresponding dps_orderkey + odps_orderdate primary key values. In addition, in the Table Store rows, only the attribute columns specified during External Table(ots_table_external) creation are updated. Data columns that do not appear in the External Table are not modified.

Note:

- The data in MaxCompute cannot be written to OTS more than 4 MB at a time, otherwise, the user is required to remove the oversized data and write it back. An error may be generated at this time:

```
ODPS - 0010000 : System   internal   error  -  Output   to
TableStore   failed   with   exception :
```

```
TableStore  BatchWrite  request  id  XXXXX  failed  with
error  code  OTSParamet erInvalid  and  message : The  total
  data  size  of  BatchWrite  Row  request  exceeds  the
limit
```

- It is a single operation to write data in bulk or by branch. Please refer to BatchWriteRow for a detailed description. Therefore, if the volume of bulk write data is too large, you can also branch write.
- When writing data in bulk, be aware that you do not have duplicate rows, otherwise it may cause errors to be reported:

```
Errorcode :  FIG ,  errormessa  ge :  the  input  parameter  is
  invalid
```

For a detailed description, please refer to using BatchWriteRow to report an OTSParameterInvalid error when submitting 100 pieces of data at a time.

8 Spark

8.1 Spark on MaxCompute overview

This topic provides an overview of Spark on MaxCompute. It is an open-source framework that functions on the service level to support data processing and analysis operations. Equipped with unified computing resources and data set permissions, Spark on MaxCompute allows you to submit and run jobs while using your preferred development methods.

Features

- Supports different versions of native Spark jobs.

  MaxCompute is compatible with the APIs of all native Spark versions that run in MaxCompute. Different versions of Spark can run in MaxCompute at the same time . Spark on MaxCompute provides you with native Spark Web UIs.
- Runs in unified computing resources.

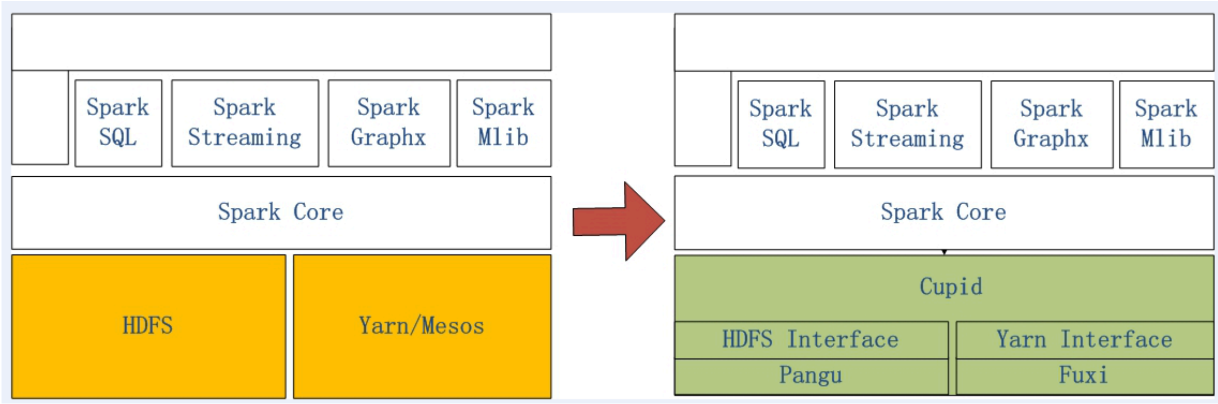
  Similar to MaxCompute SQL and MaxCompute MapReduce, Spark on MaxCompute runs in the unified computing resources activated for MaxCompute projects.
- Supports unified data and permission management.

  Spark on MaxCompute complies with the permissions you set for MaxCompute projects, allowing you to query data without any additional permission modificati ons required.
- Provides the same experience as open-source systems.

  Spark on MaxCompute provides the same user experience as open-source systems , both in terms of an open-source application UI and online interactions. Specifical ly, it supports native, open-source, and real-time UIs that are essential for debugging open-source applications, while also provides the historical log query function.

Architecture

The Spark on MaxCompute architecture solution allows native Spark engines to run in MaxCompute. The following figure shows this architecture.



The left half of the diagram shows the architecture of a native Spark engine, and the right half shows the architecture of Spark on MaxCompute. This second architecture runs on the Cupid platform developed by Alibaba Cloud. This platform also supports computing frameworks such as native Spark engines.

Supported services

MaxCompute Spark supports the following services:

- All Java and Scala offline jobs such as GraphX, MLlib, RDD, Spark SQL, and PySpark
- Read and write operations on MaxCompute tables
- Unstructured storage in OSS

MaxCompute Spark will support the following services in its later versions:

- Read and write operations on services such as RDS, Redis, and ECS in VPCs
- Streaming services
- Interactive services such as Spark shell, Spark SQL shell, and PySpark shell

8.2 Set up a Spark on MaxCompute development environment

This topic describes how to set up a Spark on MaxCompute development environment. To do so, you need to download the Spark on MaxCompute client, set environment variables, configure the `Spark - defaults . conf` file, and configure dependencies.

Download the Spark on MaxCompute client

The Spark on MaxCompute software packages are interoperable with the authentication function of MaxCompute. This allows Spark on MaxCompute to serve as a client that submits jobs with the `spark - submit` script that is encrypted.

The following two Spark on MaxCompute software packages are provided to meet different needs:

- spark-1.6.3: Develops Spark1.*x* applications.
- spark-2.3.0: Develops Spark2.*x* applications.

Set environment variables

- Set the *JAVA_HOME* environment variable as follows:

```
# We recommend that you use JDK 1 . 8 or later .
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 the *SPARK_HOME* environment variable as follows:

```
export SPARK_HOME =/ path / to / spark_extr acted_pack age
export PATH =$ SPARK_HOME / bin :$ PATH
```

- If you use PySpark, install Python 2.7 and set the *PATH* environment variable as follows:

```
export PATH =/ path / to / python / bin /:$ PATH
```

Configure the *Spark - defaults . conf* file

You can use the *spark - defaults . conf . template* file in the *$ SPARK_HOME / conf* directory as a template to prepare your own *spark - defaults . conf* file. However, before you submit Spark on MaxCompute jobs to MaxCompute, you must set the required MaxCompute account and region information in your *spark - defaults . conf* file.

In the *spark - defaults . conf* file, you can retain the default settings and enter the MaxCompute account information as follows:

```
# Set the MaxCompute project and account informatio n :
spark . hadoop . odps . project . name =
spark . hadoop . odps . access . id =
spark . hadoop . odps . access . key =

# Configure the endpoint through which the Spark on
  MaxCompute client accesses MaxCompute projects ( this
endpoint varies depending on the network conditions and
  region ):
spark . hadoop . odps . end . point = http :// service . cn .
maxcompute . aliyun . com / api
# Configure the endpoint that runs Spark on MaxCompute
( this endpoint runs in the MaxCompute VPC in your
region ):
```

```
spark . hadoop . odps . runtime . end . point  =  http :// service .
cn . maxcompute . aliyun - inc . com / api

# Retain the following default settings :
spark . sql . catalogImp lementatio n = odps
spark . hadoop . odps . task . major . version  =  cupid_v2
spark . hadoop . odps . cupid . container . image . enable  =  true
spark . hadoop . odps . cupid . container . vm . engine . type  =
hyper
```

Configure dependencies

- Configure the dependencies for Spark on MaxCompute jobs to access MaxCompute tables.

  Spark on MaxCompute jobs use the odps-spark-datasource module to access MaxCompute tables. The Maven coordinates of this module are as follows:

```
<!-- Spark - 2 . x uses the following module :-->
< dependency >
    < groupId > com . aliyun . odps </ groupId >
    < artifactId > odps - spark - datasource _2 . 11 </ artifactId
 >
    < version > 3 . 3 . 3 - public </ version >
</ dependency >

<!-- Spark - 1 . x uses the following module :-->
< dependency >
  < groupId > com . aliyun . odps </ groupId >
  < artifactId > odps - spark - datasource _2 . 10 </ artifactId >
  < version > 3 . 3 . 3 - public </ version >
</ dependency >
```

- Configure the dependencies for Spark on MaxCompute jobs to access OSS.

  If Spark on MaxCompute jobs need to access OSS, add the following dependencies:

```
< dependency >
    < groupId > com . aliyun . odps </ groupId >
    < artifactId > hadoop - fs - oss </ artifactId >
    < version > 3 . 3 . 3 - public </ version >
```

```
</ dependency >
```

8.3 Develop a Spark on MaxCompute application

8.3.1 Develop a Spark on MaxCompute application by using Java or Scala

This topic describes how to develop a Spark on MaxCompute application by using Java or Scala.

Download an example project

You can run the following commands to download an example project:

```
 git   clone   git @ github . com : aliyun / aliyun - cupid - sdk .
 git
 cd   aliyun - cupid - sdk
 git   checkout   3 . 3 . 3 - public
#  Download   an   example   project   for   Spark - 2 . x .
 cd   spark / spark - 2 . x / spark - examples
#  Download   an   example   project   for   Spark - 1 . x .
 cd   spark / spark - 1 . x / spark - examples
#  Package   data   to   create   a   shaded   JAR   package   in
 the   target   directory .
 mvn   clean   package
```

Configure dependencies for Spark-1.x

If you want to submit your Spark-1.*x* application by using the Spark on MaxCompute client, you must add the following dependencies to the `pom . xml` file:

```
< properties >
    < spark . version > 1 . 6 . 3 </ spark . version >
    < cupid . sdk . version > 3 . 3 . 3 - public </ cupid . sdk .
 version >
    < scala . version > 2 . 10 . 4 </ scala . version >
    < scala . binary . version > 2 . 10 </ scala . binary . version >
</ properties >
< dependency >
    < groupId > org . apache . spark </ groupId >
    < artifactId > spark - core_ ${ scala . binary . version }</
 artifactId >
    < version >${ spark . version }</ version >
    < scope > provided </ scope >
</ dependency >
< dependency >
    < groupId > org . apache . spark </ groupId >
    < artifactId > spark - sql_ ${ scala . binary . version }</
 artifactId >
    < version >${ spark . version }</ version >
    < scope > provided </ scope >
</ dependency >
< dependency >
    < groupId > org . apache . spark </ groupId >
    < artifactId > spark - mllib_ ${ scala . binary . version }</
 artifactId >
```

```
    < version >${ spark . version }</ version >
    < scope > provided </ scope >
</ dependency >
< dependency >
    < groupId > org . apache . spark </ groupId >
    < artifactId > spark - streaming_ ${ scala . binary . version }</
 artifactId >
    < version >${ spark . version }</ version >
    < scope > provided </ scope >
</ dependency >
< dependency >
    < groupId > com . aliyun . odps </ groupId >
    < artifactId > cupid - sdk </ artifactId >
    < version >${ cupid . sdk . version }</ version >
    < scope > provided </ scope >
</ dependency >
< dependency >
    < groupId > com . aliyun . odps </ groupId >
    < artifactId > hadoop - fs - oss </ artifactId >
    < version >${ cupid . sdk . version }</ version >
</ dependency >
< dependency >
    < groupId > com . aliyun . odps </ groupId >
    < artifactId > odps - spark - datasource  _ ${ scala . binary .
 version }</ artifactId >
    < version >${ cupid . sdk . version }</ version >
</ dependency >
< dependency >
    < groupId > org . scala - lang </ groupId >
    < artifactId > scala - library </ artifactId >
    < version >${ scala . version }</ version >
</ dependency >
< dependency >
    < groupId > org . scala - lang </ groupId >
    < artifactId > scala - actors </ artifactId >
    < version >${ scala . version }</ version >
</ dependency >
```

Note:

You need to set the `scope` parameter as follows:

- Set it to `provided` for all packages that are released in the Apache Spark community, such as spark-core and spark-sql.
- Set it to `compile` for the odps-spark-datasource module.

Develop a Spark-1.x application

- Develop the WordCount application.

  For this application, you will need to download aliyun-cupid-sdk.

  To submit the code, follow these steps:

  1. Build the aliyun-cupid-sdk module.
  2. Configure the *spark . defaults . conf* file.
  3. Run the following script:

  ```
   bin / spark - submit  -- master   yarn - cluster  -- class  \
   com . aliyun . odps . spark . examples . WordCount  \
  ${ path   to   aliyun - cupid - sdk }/ spark / spark - 1 . x /
   spark - examples / target / spark - examples_2 . 10 - version -
   shaded . jar
  ```

- Develop the Spark SQL application on MaxCompute tables.

  For this application, you will need to download aliyun-cupid-sdk.

  To submit the code, follow these steps:

  1. Build the aliyun-cupid-sdk module.
  2. Configure the *spark . defaults . conf* file.
  3. Run the following script:

  ```
   bin / spark - submit  -- master   yarn - cluster  -- class  \
   com . aliyun . odps . spark . examples . sparksql . SparkSQL  \
  ${ path   to   aliyun - cupid - sdk }/ spark / spark - 1 . x /
   spark - examples / target / spark - examples_2 . 10 - version -
   shaded . jar
  ```

  Note:

  - If the "Table Not Found" error is returned, the table you specify in the code cannot be found in the MaxCompute project.
  - You can develop a Spark SQL application for the target table with reference to various APIs in the code.

- Develop the GraphX PageRank application.

  For this application, you will need to download aliyun-cupid-sdk.

  To submit the code, follow these steps:

  1. Build the aliyun-cupid-sdk module.
  2. Configure the *spark . defaults . conf* file.
  3. Run the following script:

```
bin / spark - submit  -- master   yarn - cluster  -- class  \
com . aliyun . odps . spark . examples . graphx . PageRank  \
${ path   to   aliyun - cupid - sdk }/ spark / spark - 1 . x /
spark - examples / target / spark - examples_2 . 10 - version -
shaded . jar
```

- Develop the MLlib Kmeans-ON-OSS application.

  For this application, you will need to download aliyun-cupid-sdk.

  Note:
  Before you submit the code, make sure that you enter the following OSS account information in the code:

```
conf . set (" spark . hadoop . fs . oss . accessKeyI  d ", "***")
conf . set (" spark . hadoop . fs . oss . accessKeyS  ecret ",
"***")
conf . set (" spark . hadoop . fs . oss . endpoint ", " oss - cn -
hangzhou - zmf . aliyuncs . com ")
```

  To submit the code, follow these steps:

  1. Build the aliyun-cupid-sdk module.
  2. Configure the *spark . defaults . conf* file.
  3. Run the following script:

```
bin / spark - submit  -- master   yarn - cluster  -- class  \
com . aliyun . odps . spark . examples . mllib . KmeansMode
lSaveToOss  \
${ path   to   aliyun - cupid - sdk }/ spark / spark - 1 . x /
spark - examples / target / spark - examples_2 . 10 - version -
shaded . jar
```

- Devel the OSS UnstructuredData application.

  For this application, you will need to download aliyun-cupid-sdk.

  Note:

Before you submit the code, make sure that you enter the following OSS account information in the code:

```
conf . set (" spark . hadoop . fs . oss . accessKeyI  d ", "***")
conf . set (" spark . hadoop . fs . oss . accessKeyS  ecret ",
"***")
conf . set (" spark . hadoop . fs . oss . endpoint ", " oss - cn -
hangzhou - zmf . aliyuncs . com ")
```

To submit the code, follow these steps:

1. Build the aliyun-cupid-sdk module.
2. Configure the `spark . defaults . conf` file.
3. Run the following script:

```
 bin / spark - submit  -- master   yarn - cluster  -- class  \
 com . aliyun . odps . spark . examples . oss . SparkUnstr
 ucturedDat  aCompute  \
${ path   to   aliyun - cupid - sdk }/ spark / spark - 1 . x /
 spark - examples / target / spark - examples_2 . 10 - version -
 shaded . jar
```

Configure dependencies for Spark-2.x

If you want to submit your Spark-2.*x* application by using the Spark on MaxCompute client, you must add the following dependencies to the `pom . xml` file:

```
< properties >
    < spark . version > 2 . 3 . 0 </ spark . version >
    < cupid . sdk . version > 3 . 3 . 3 - public </ cupid . sdk .
 version >
    < scala . version > 2 . 11 . 8 </ scala . version >
    < scala . binary . version > 2 . 11 </ scala . binary . version >
</ properties >
< dependency >
    < groupId > org . apache . spark </ groupId >
    < artifactId > spark - core_ ${ scala . binary . version }</
 artifactId >
    < version >${ spark . version }</ version >
    < scope > provided </ scope >
</ dependency >
< dependency >
    < groupId > org . apache . spark </ groupId >
    < artifactId > spark - sql_ ${ scala . binary . version }</
 artifactId >
    < version >${ spark . version }</ version >
    < scope > provided </ scope >
</ dependency >
< dependency >
    < groupId > org . apache . spark </ groupId >
    < artifactId > spark - mllib_ ${ scala . binary . version }</
 artifactId >
    < version >${ spark . version }</ version >
    < scope > provided </ scope >
</ dependency >
< dependency >
```

```
    < groupId > org . apache . spark </ groupId >
    < artifactId > spark - streaming_ ${ scala . binary . version }</
 artifactId >
    < version >${ spark . version }</ version >
    < scope > provided </ scope >
</ dependency >
< dependency >
    < groupId > com . aliyun . odps </ groupId >
    < artifactId > cupid - sdk </ artifactId >
    < version >${ cupid . sdk . version }</ version >
    < scope > provided </ scope >
</ dependency >
< dependency >
    < groupId > com . aliyun . odps </ groupId >
    < artifactId > hadoop - fs - oss </ artifactId >
    < version >${ cupid . sdk . version }</ version >
</ dependency >
< dependency >
    < groupId > com . aliyun . odps </ groupId >
    < artifactId > odps - spark - datasource  _ ${ scala . binary .
 version }</ artifactId >
    < version >${ cupid . sdk . version }</ version >
</ dependency >
< dependency >
    < groupId > org . scala - lang </ groupId >
    < artifactId > scala - library </ artifactId >
    < version >${ scala . version }</ version >
</ dependency >
< dependency >
    < groupId > org . scala - lang </ groupId >
    < artifactId > scala - actors </ artifactId >
    < version >${ scala . version }</ version >
</ dependency >
```

Note:

You need to set the `scope` parameter as follows:

- Set it to `provided` for all packages that are released in the Apache Spark community, such as spark-core and spark-sql.
- Set it to `compile` for the odps-spark-datasource module.

Develop a Spark-2.x application

- Develop the WordCount application.

  For this application, you will need to download aliyun-cupid-sdk.

  To submit the code, follow these steps:

  1. Build the aliyun-cupid-sdk module.
  2. Configure the *spark . defaults . conf* file.
  3. Run the following script:

```
bin / spark - submit  -- master   yarn - cluster  -- class  \
com . aliyun . odps . spark . examples . WordCount  \
```

```
${ path   to   aliyun - cupid - sdk }/ spark / spark - 2 . x /
 spark - examples / target / spark - examples_2 . 11 - version -
 shaded . jar
```

- Develop the Spark SQL application on MaxCompute tables.

  For this application, you will need to download aliyun-cupid-sdk.

  Note:

  - If the "Table Not Found" error is returned, the table you specify in the code cannot be found in the MaxCompute project.
  - You can develop a Spark SQL application for the target table with reference to various APIs in the code.

  To submit the code, follow these steps:

  1. Build the aliyun-cupid-sdk module.
  2. Configure the *spark . defaults . conf* file.
  3. Run the following script:

  ```
   bin / spark - submit  -- master   yarn - cluster  -- class  \
   com . aliyun . odps . spark . examples . sparksql . SparkSQL  \
  ${ path   to   aliyun - cupid - sdk }/ spark / spark - 2 . x /
   spark - examples / target / spark - examples_2 . 11 - version -
   shaded . jar
  ```

- Develop the GraphX PageRank application.

  For this application, you will need to download aliyun-cupid-sdk.

  To submit the code, follow these steps:

  1. Build the aliyun-cupid-sdk module.
  2. Configure the *spark . defaults . conf* file.
  3. Run the following script:

  ```
   bin / spark - submit  -- master   yarn - cluster  -- class  \
   com . aliyun . odps . spark . examples . graphx . PageRank  \
  ${ path   to   aliyun - cupid - sdk }/ spark / spark - 2 . x /
   spark - examples / target / spark - examples_2 . 11 - version -
   shaded . jar
  ```

- Develop the MLlib Kmeans-ON-OSS application.

  For this application, you will need to download aliyun-cupid-sdk.

  Note:

Before you submit the code, make sure that you enter the following OSS account information in the code:

```
val   spark  =  SparkSessi  on
     . builder ()
     . config (" spark . hadoop . fs . oss . accessKeyI  d ",
"***")
     . config (" spark . hadoop . fs . oss . accessKeyS  ecret ",
"***")
     . config (" spark . hadoop . fs . oss . endpoint ", " oss -
cn - hangzhou - zmf . aliyuncs . com ")
     . appName (" KmeansMode  lSaveToOss ")
     . getOrCreat  e ()
```

To submit the code, follow these steps:

1. Build the aliyun-cupid-sdk module.
2. Configure the *spark . defaults . conf* file.
3. Run the following script:

```
bin / spark - submit  -- master   yarn - cluster  -- class  \
com . aliyun . odps . spark . examples . mllib . KmeansMode
lSaveToOss  \
${ path   to   aliyun - cupid - sdk }/ spark / spark - 2 . x /
spark - examples / target / spark - examples_2 . 11 - version -
shaded . jar
```

- Develop the OSS UnstructuredData application.

  For this application, you will need to download aliyun-cupid-sdk.

Note:
Before you submit the code, make sure that you enter the following OSS account information in the code:

```
val   spark  =  SparkSessi  on
     . builder ()
     . config (" spark . hadoop . fs . oss . accessKeyI  d ",
"***")
     . config (" spark . hadoop . fs . oss . accessKeyS  ecret ",
"***")
     . config (" spark . hadoop . fs . oss . endpoint ", " oss -
cn - hangzhou - zmf . aliyuncs . com ")
     . appName (" SparkUnstr  ucturedDat  aCompute ")
```

```
        . getOrCreat  e ()
```

To submit the code, follow these steps:

1. Build the aliyun-cupid-sdk module.
2. Configure the *spark . defaults . conf* file.
3. Run the following script:

```
bin / spark - submit  -- master   yarn - cluster  -- class  \
com . aliyun . odps . spark . examples . oss . SparkUnstr
ucturedDat  aCompute  \
${ path   to   aliyun - cupid - sdk }/ spark / spark - 2 . x /
spark - examples / target / spark - examples_2 . 11 - version -
shaded . jar
```

8.3.2 Develop a Spark on MaxCompute application by using PySpark

This topic describes how to develop a Spark on MaxCompute application by using PySpark.

If you want to access MaxCompute tables, you must compile a package for the odps-spark-datasource package. For more information, see #unique_233.

Develop a Spark SQL application in Spark 1.6

1. Compile the following code:

```
from   pyspark   import   SparkConte  xt ,  SparkConf
from   pyspark . sql   import   OdpsContex  t
if   __name__  == ' __main__ ':
    conf  =  SparkConf (). setAppName (" odps_pyspa  rk ")
    sc  =  SparkConte  xt ( conf = conf )
    sql_contex  t  =  OdpsContex  t ( sc )
    sql_contex  t . sql (" DROP   TABLE   IF   EXISTS   spark_sql_
test_table ")
    sql_contex  t . sql (" CREATE   TABLE   spark_sql_  test_table
( name   STRING ,  num   BIGINT )")
    sql_contex  t . sql (" INSERT   INTO   TABLE   spark_sql_
test_table   SELECT  ' abc ',  100000 ")
    sql_contex  t . sql (" SELECT  *  FROM   spark_sql_  test_table
"). show ()
    sql_contex  t . sql (" SELECT   COUNT (*)  FROM   spark_sql_
test_table "). show ()
```

2. Run the following command to submit the code:

```
./ bin / spark - submit  \
-- jars   cupid / odps - spark - datasource  _xxx . jar  \
```

```
example . py
```

Develop a Spark SQL application in Spark 2.3

1. Compile the following code:

```
from   pyspark . sql   import   SparkSessi  on
if   __name__  == ' __main__ ':
    spark  =  SparkSessi  on . builder . appName (" spark   sql ").
getOrCreat  e ()
    spark . sql (" DROP   TABLE   IF   EXISTS   spark_sql_
test_table ")
    spark . sql (" CREATE   TABLE   spark_sql_  test_table ( name
STRING ,  num   BIGINT )")
    spark . sql (" INSERT   INTO   spark_sql_  test_table   SELECT
' abc ',  100000 ")
    spark . sql (" SELECT  *  FROM   spark_sql_  test_table ").
show ()
    spark . sql (" SELECT   COUNT (*)  FROM   spark_sql_
test_table "). show ()
```

2. Run one of the following commands based on which mode you use:

   - In cluster mode, run the following command to submit the code:

```
 spark - submit  -- master   yarn - cluster  \
-- jars   cupid / odps - spark - datasource  _xxx . jar  \
 example . py
```

   - In local mode, run the following command to submit the code:

```
 cd  $ SPARK_HOME
./ bin / spark - submit  -- master   local [ 4 ] \
-- driver - class - path   cupid / odps - spark - datasource  _xxx
 . jar  \
/ path / to / odps - spark - examples / spark - examples / src /
 main / python / spark_sql . py
```

Required packages

A Python library cannot be directly installed in the MaxCompute cluster. When PySpark depends on a Python library, plugin, or project, you need to package this Python library, plugin, or project on your computer and then upload the package by running the `spark - submit` script. The Python version that you use to package the Python library, plugin, or project must be the same as the Python version in which your Spark on MaxCompute jobs run. You can choose one of the following two packaging formats: egg and Python.

- Compile egg packages on your computer.

  For example, if MLlib requires the NumPy and Setuptools plugins, you need to compile egg packages for them and then upload the packages by running the `-- py - files` script. Detailed steps are as follows:

  > **Note:**
  > Spark on MaxCompute jobs run in Python 2.7. Therefore, you must package the plugins by using Python 2.7 on your computer.

  1. To compile egg packages for the NumPy and Setuptools plugins, follow these steps:
     a. Download the NumPy and Setuptools software packages found in [Find, install and publish Python packages with the Python Package Index](https://pypi.org/).
     b. Enter the source code path of the Setuptools plugin and run the `python setup . py bdist_egg` script. An egg file is generated in the *dist* directory.
     c. Enter the source code path of the NumPy plugin and run the `python setupeggs . py bdist_egg` script. An egg file is generated in the *dist* directory.
  2. Run the following command to submit your Spark on MaxCompute jobs:

```
 cd $ SPARK_HOME
./ bin / spark - submit -- master yarn - cluster \
-- jars cupid / odps - spark - datasource _2 . 11 - 3 . 3 . 2 -
 hotfix1 . jar \
-- py - files / path / to / numpy - 1 . 7 . 1 - py2 . 7 - lunux -
 x85_64 . egg ,/ path / to / setuptools - 33 . 1 . 1 - py2 . 7 .
 egg \
 app . py
```

- Compile Python packages on your computer.

  If the Spark on MaxCompute application depends on a large number of plugins or any of these plugins contain files such as .so files that cannot be imported by the zipimport module, you need to download all the plugins, compile Python packages for the plugins, and then upload the packages. Detailed steps are as follows:

1. Add the following configuration information:

```
spark . pyspark . python =./ public . python - 2 . 7 - ucs4 . zip
/ python - 2 . 7 - ucs4 / bin / python2 . 7
```

2. Run the following command to submit your Spark on MaxCompute jobs:

```
 cd  $ SPARK_HOME
./ bin / spark - submit  -- master   yarn - cluster  \
-- jars   cupid / odps - spark - datasource  _2 . 11 - 3 . 3 . 2 -
 hotfix1 . jar  \
-- archives  ./ python - 2 . 7 - ucs4 . zip   app . py
```

If you do not want to submit your Spark on MaxCompute jobs by running the `--archives` script, you can submit them as public resources.

1. Add the following configuration information:

```
spark . hadoop . odps . cupid . resources = public . python - 2 .
7 - ucs4 . zip
spark . pyspark . python =./ public . python - 2 . 7 - ucs4 . zip
/ python - 2 . 7 - ucs4 / bin / python2 . 7
```

2. Run the following command to submit your Spark on MaxCompute jobs:

```
 cd  $ SPARK_HOME
./ bin / spark - submit  -- master   yarn - cluster  \
-- jars   cupid / odps - spark - datasource  _2 . 11 - 3 . 3 . 2 -
 hotfix1 . jar   app . py
```

If the Spark on MaxCompute application also depends on other plugins, you can package them with reference to the following script:

```
 work_root =` dirname  $ 0 `
 work_root =` cd  ${ work_root };  pwd `
#  Step   1   compile   python
#  1 . 1   python   source   code
 cd  ${ work_root }
 if  [ ! - f   Python - 2 . 7 . 13 . tgz  ];  then
     wget   https :// www . python . org / ftp / python / 2 . 7 . 13
 / Python - 2 . 7 . 13 . tgz
 fi
#  1 . 2   configure  &&  make  &&  make   install
 if  [ ! - d  ${ work_root }/ Python - 2 . 7 . 13  ];  then
     cd  ${ work_root }
     tar   xf  ${ work_root }/ Python - 2 . 7 . 13 . tgz
 fi
 if  [ - d  ${ work_root }/ python - 2 . 7 - ucs4  ];  then
     rm  - rf  ${ work_root }/ python - 2 . 7 - ucs4
 fi
 cd  ${ work_root }/ Python - 2 . 7 . 13
./ configure  -- prefix =${ work_root }/ python - 2 . 7 - ucs4  --
 enable - unicode = ucs4
```

```
 sed  - i  ' s /#.* zlib   zlibmodule . c / zlib   zlibmodule . c /
 g '  Modules / Setup
 make  - j20
 make   install
#  1 . 3   install   pip
 cd  ${ work_root }
 if  [ ! - f   get - pip . py  ];  then
     curl  - s   https :// bootstrap . pypa . io / get - pip . py  -
 o  ${ work_root }/ get - pip . py
 fi
${ work_root }/ python - 2 . 7 - ucs4 / bin / python  ${ work_root
 }/ get - pip . py
#  1 . 4   install   numpy
${ work_root }/ python - 2 . 7 - ucs4 / bin / pip   install   numpy
#  1 . 6   make   python   zip
 if  [ - f  ${ work_root }/ python - 2 . 7 - ucs4 . zip  ];  then
     rm  - rf  ${ work_root }/ python - 2 . 7 - ucs4 . zip
 fi
 cd  ${ work_root }
 zip  - r  ${ work_root }/ python - 2 . 7 - ucs4 . zip   python - 2
 . 7 - ucs4
```

8.4 Spark on MaxCompute running modes

This topic describes the running modes of Spark on MaxCompute, including the local, cluster, and DataWorks modes.

Local mode

The local mode allows you to easily debug application code, through a similar method to that of native Spark, and allows you to read and write MaxCompute tables by running the undefined `tunnel` command. You need to add the required tunnel configuration items and endpoint information in the *Spark - defaults . conf* file. The endpoint varies depending on the network conditions and the region where the MaxCompute project is located. For more information, see Configure Endpoint. You can enable the local mode in an integrated development environment (IDE) or command line interface (CLI). To do so, you need to add the `spark . master = local [ N ]` configuration item, where `N` indicates the CPU resources required for running in the local mode. The following is an example of enabling the local mode in the CLI:

```
 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 . jar
```

Cluster mode

In cluster mode, you need to specify Main, which is a custom program entry and a crucial part of this mode. In this mode, the Main must succeed or fail for the Spark job to end. This mode is suitable to offline jobs and can be used in combination with Alibaba Cloud DataWorks for job scheduling. The method of submitting the CLI is as follows:

```
 1 . bin / spark - submit  -- master   yarn - cluster  \
- class   SparkPi  \
${ ProjectRoo  t }/ spark / spark - 2 . x / spark - examples / target
 / spark - examples_2 . 11 - version - shaded . jar
```

DataWorks mode

Note:
Supported Region: China (Hong Kong), West USA 1, Central Europe 1, Asia Pacific SOU 1, Asia Pacific SE 1.

In DataWorks, you can run offline Spark on MaxCompute jobs in cluster mode. This helps to integrate Spark on MaxCompute nodes with other types of nodes and better schedule these nodes. To run an offline Spark on MaxCompute job, follow these steps:undefined

1. Log on to DataWorks, and then upload and submit resources as a file in the target workflow.
2. In the left-side navigation, click a workflow and select ODPS Spark.
3. Drag a Spark on MaxCompute node to the workflow and double-click the node to define a Spark on MaxCompute job.
4. Select a Spark version, language, and resource file (the file you have uploaded and submitted in Step 1), specify configuration items (for example, the number of executors and memory size), and set the endpoint configuration item `spark . hadoop . odps . cupid . webproxy . endpoint` for the Spark on MaxCompute service (the value of the endpoint configuration item is the connection address of the endpoint serving the region where your Spark on MaxCompute project is located).

5. Manually run the Spark on MaxCompute node. You can view the logs of this job and based on the logs you can obtain the LogView data of the job and the URL of LogView. In addition, you can compile the data to diagnose the job.

   Note:
   After the Spark on MaxCompute job is defined, you can orchestrate and centrally schedule and run different types of services in the corresponding workflow.

8.5 Diagnose a Spark on MaxCompute job

This topic describes how to diagnose a Spark on MaxCompute job based on the job log. You can use LogView or the Spark Web UI to check whether a Spark on MaxCompute job is submitted or run.

Background information

When you submit a Spark on MaxCompute job by running the `spark - submit` script, MaxCompute creates an instance and adds instance information to the LogView log.

Specifically, you can submit a Spark on MaxCompute job through running the following `spark - submit` script:

```
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 adds the instance information to the LogView log as follows:

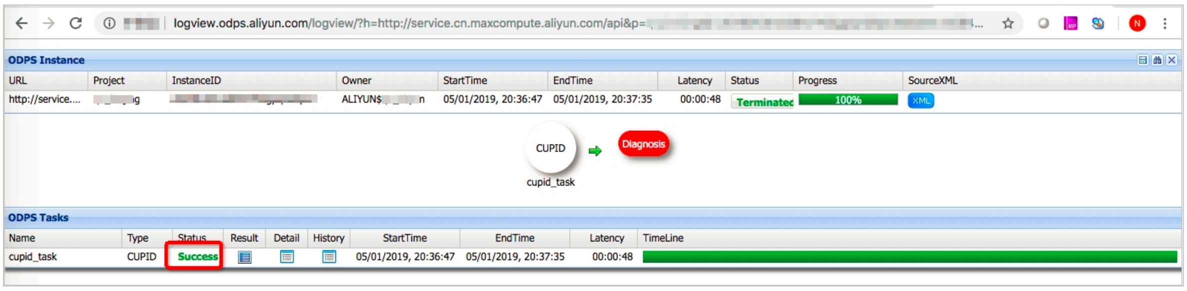
```
19 / 01 / 05   20 : 36 : 47   INFO   YarnClient  ImplUtil :  logview
  url :  http :// logview . odps . aliyun . com / logview /? h = http
:// service . cn . maxcompute . aliyun . com / api & p = qn_beijing &
i = xxx & token = xxx
If   the   job   is   submitted ,  the   logged   informatio  n
includes   but   is   not   limited   to   the   following :
19 / 01 / 05   20 : 37 : 34   INFO   Client :
   client   token :  N / A
   diagnostic  s :  N / A
   Applicatio  nMaster   host :  11 . 220 . xxx . xxx
   Applicatio  nMaster   RPC   port :  30002
   queue :  queue
   start   time :  1546691807  945
   final   status :  SUCCEEDED
   tracking   URL :  http :// jobview . odps . aliyun . com /
proxyview / jobview /? h = http :// service . cn . maxcompute .
```

```
aliyun - inc . com / api & p = project_na  me & i = xxx & t = spark &
id = applicatio  n_xxx & metaname = xxx & token = xxx
```

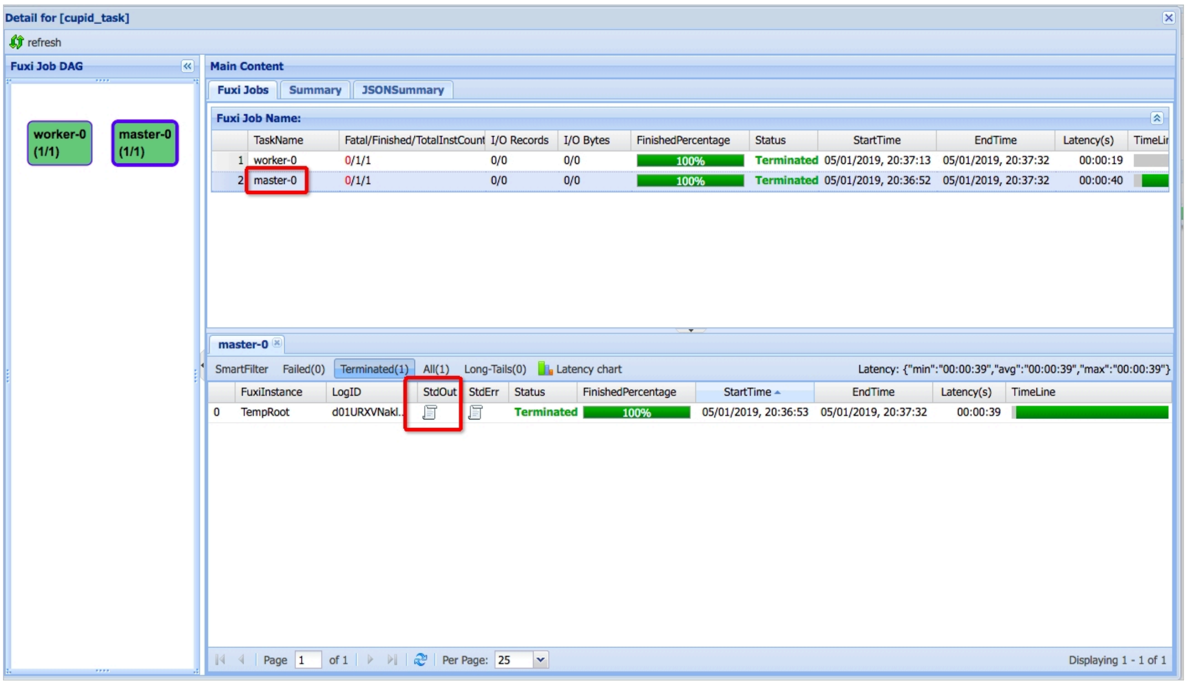
Note:
When you run a Spark on MaxCompute task in DataWorks, a similar log is created.

Diagnose a Spark on MaxCompute job by using LogView

1. Open a browser. Then use LogView to view the basic information about your Spark on MaxCompute job, a cupid-type task.



2. On theFuxi Jobstab in the upper pane, find the task namedmaster-0in theTaskNamecolumn. Then, in the lower pane, click theALLtab.

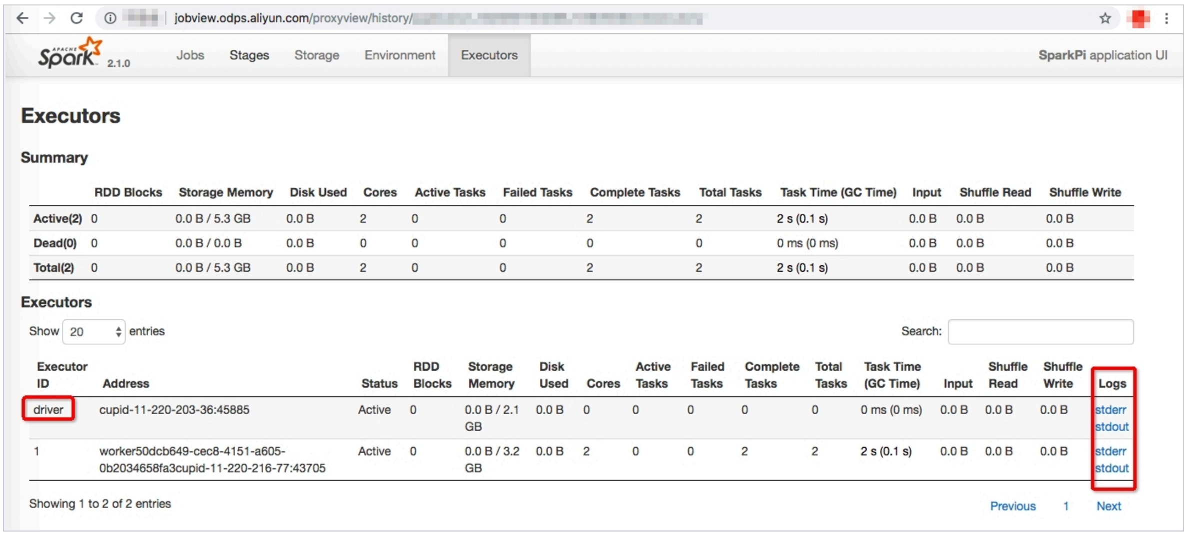


3. On the TempRoot tab, find the log you want to view, and click the icon in the StdOut column. Then you can view the log details generated by SparkPi.

Diagnose a Spark on MaxCompute job by using the Spark Web UI

If the log for a Spark on MaxCompute job contains a tracking URL, the job is submitted to the MaxCompute cluster. Both the Spark Web UI and the History Server use this tracking URL.

1. Open a browser and enter the tracking URL in the address bar to track your Spark on MaxCompute job.



2. Find the driver you want to view, and then click stdout in the Logs column.

8.6 Spark on MaxCompute FAQ

This topic describes the FAQ related to Spark on MaxCompute.

How should I migrate open-source Spark code to Spark on MaxCompute?

The method by which you migrate open-source Spark code to Spark on MaxCompute depends on the access requirements of your Spark on MaxCompute jobs. Specifically, consider the following:

- If Spark on MaxCompute jobs require access to MaxCompute tables or OSS, configure the required objects, re-package them, and then upload these packages to Spark on MaxCompute.
- If Spark on MaxCompute jobs do not require such access, migrate Spark code by running the JAR packages of the required objects on Spark on MaxCompute.

For this method, you must set the `scope` parameter to `provided` for the corresponding Spark or Hadoop module.

For more information on migrating Spark code, see Set up a Spark on MaxCompute development environment.

How do I use Spark on MaxCompute to access services in a VPC?

If you want to access services in a VPC, open a ticket.

What can I do if the ID and key in the *spark - defaults . conf* file are incorrect?

If you receive an error message similar to the following:

```
Stack :
com . aliyun . odps . OdpsExcept  ion :  ODPS - 0410042 :
Invalid   signature   value  -  User   signature   dose   not   match
```

You can log on to the Alibaba Cloud CDN console and obtain the AccessKey ID and Access Key Secret from the User Management page. Then change the ID and key in the *spark - defaults . conf* file to the obtained AccessKey ID and Access Key Secret, respectively.

What can I do if I do not have the permissions to operate a project?

If you receive an error message similar to the following:

```
Stack :
com . aliyun . odps . OdpsExcept  ion :  ODPS - 0420095 :
Access   Denied  -  Authorizat  ion   Failed  [ 4019 ],  You   have
  NO   privilege  ' odps : CreateReso  urce '  on  { acs : odps :*:
projects /*}
```

You can ask the project owner to grant you the permissions to read and create resources in the project.

What can I do if Spark on MaxCompute tasks cannot run in a project?

If you receive an error message similar to the following:

```
Exception   in   thread  " main "  org . apache . hadoop . yarn .
exceptions . YarnExcept  ion :  com . aliyun . odps . OdpsExcept  ion
:  ODPS - 0420095 :  Access   Denied  -  The   task   is   not   in
release   range :  CUPID
```

You can check whether the Spark on MaxCompute service is enabled for the region to which the project belongs. In addition, check whether the *Spark - defaults . conf* file is correctly configured according to the MaxCompute product documentation. If the Spark on MaxCompute service is enabled and the `Spark - defaults . conf` file is correctly configured, open a ticket or join our DingTalk group 21969532 for technical support.

What can I do if the system reports a `No space left on device` error?

You can increase the bucket size, which is determined by the `spark . hadoop . odps . cupid . disk . driver . device_siz e` parameter. The default bucket size is 20 GB and the maximum bucket size is 100 GB. If the error persists even after you increase the bucket size to 100 GB, check whether your data, including shuffled data and the data overflowing from BlockManager, is skewed among blocks during the shuffle or cache process. If data skew is found, set the `spark . executor . cores` parameter to a smaller value to decrease the number of cores that can run concurrently in each executor while you set the `spark . executor . instances` parameter to a greater value to increase the number of executors.

9 Interactive SQL (Lightning)

9.1 Overview

MaxCompute Lightning provides interactive query services for MaxCompute, and supports easy connection to MaxCompute projects based on the PostgreSQL protocol and syntax. This service allows you to quickly query and analyze MaxCompute project data using standard SQL and commonly used tools.

You can use major BI tools, such as Tableau and FineReport, to easily connect to MaxCompute projects, and perform BI analysis or ad hoc queries. The quick query feature in MaxCompute Lightning allows you to provide services by encapsulating project table data in APIs, supporting diverse application scenarios without data migration.

MaxCompute Lightning offers serverless computing services. No infrastructure is required and you pay only for queries.

Key features

- Compatibility with the PostgreSQL protocol

  MaxCompute Lightning provides Java Database Connectivity (JDBC) or Open Database Connectivity (ODBC) interfaces that are compatible with the PostgreSQL protocol. Tools or applications based on PostgreSQL databases can easily be connected to MaxCompute projects using default drivers. The easy connection enables diverse PostgreSQL tools to be used for analyzing MaxCompute project data.
- Improved performance

  Quick query for MaxCompute tables is optimized, especially for small datasets and high query concurrency, supporting diverse application scenarios, such as regular reports and service APIs.
- Unified permissions management

  MaxCompute Lightning is a product designed for MaxCompute products and provides access to MaxCompute projects. This service shares the same access control system with MaxCompute projects. This ensures that users can only query data that they are authorized to access.

- Out-of-the-box feature and pay by queries

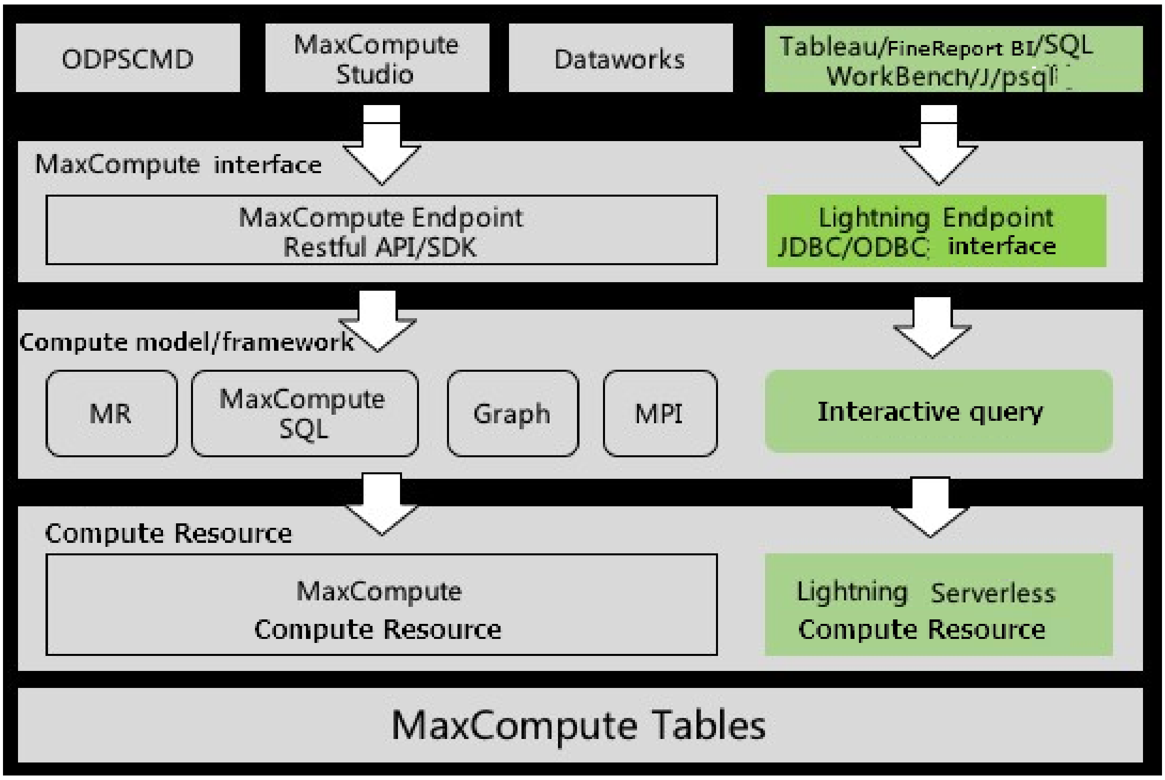
  MaxCompute Lightning provides serverless computing services based on existing MaxCompute computing resources. To perform queries, you only need to establish connections to MaxCompute projects using MaxCompute Lightning.

  You do not need to configure, manage, or maintain MaxCompute Lightning resources.When using MaxCompute Lightning, you only incur costs for the data amount processed for each query.

System architecture

MaxCompute Lightning provides a method of connecting endpoints, clients, or applications to JDBC or ODBC interfaces using PostgreSQL drivers. This enables secure data access within the unified access control system for MaxCompute projects.

Query tasks, connected and submitted by JDBC or ODBC interfaces, use serverless computing resources of MaxCompute Lightning to ensure query service quality.



Scenarios

- Ad hoc query

  The query for small datasets (less than 100 GB) is optimized to allow you to easily query MaxCompute tables with low latency. You do not need to import the

MaxCompute data into the AnalyticDB (ADS), Relational Database Service (RDS), or other systems, which reduces required resources and administration costs.

This scenario has the following characteristics: flexible data objects for queries, complicated logic, quick query, easy adjustment of query logic, and low latency query requirements within one minute. Users are often data analysts who master SQL skills and want to use familiar client tools for query analysis.

- Reporting and analysis

  Analysis reports are generated based on the MaxCompute project data consolidated in the Extract-Transform-Load (ETL) process. The reports are provided to managers and business users for regular checks.

  This scenario has the following characteristics: The queried data objects are usually the aggregated data. The queried data objects are included in small datasets. Queries are based on fixed and simple query logic. The scenario has low latency requirements. Latency for most queries is within 5 seconds. The query latency period varies greatly depending on the data volume and query complexity.
- Online application

  MaxCompute project data can be encapsulated in RESTful APIs to support online applications.

  In this scenario, MaxCompute Lightning serves as an accelerated query engine to provide MaxCompute table data as API services with the least amount of manual intervention. This is enabled by integrating data service components of Alibaba Cloud DataWorks.

9.2 Quick Start

This topic describes how to access MaxCompute Lightning services with major third-party tools, including how to view tables of a specified MaxCompute project, and how to perform BI analysis.

Prerequisites

- Activate MaxCompute and create a project.

  Using MaxCompute Lightning requires that MaxCompute has been activated and a project has been created.

  If you have not activated MaxCompute, activate the service first. For more information, see Activate MaxCompute. Then, create a MaxCompute project.
- Create a table and import data.

  Tables have been created in the project and data has been loaded. For more information, see MaxCompute Quick Start.
- Obtain account information.

  The access ID and access key for the MaxCompute project have been obtained.

  You can log on to the Alibaba Cloud website, and click Console to view the AccessKey page. Contact the owner of the primary account if your RAM user is not granted permission to view AccessKey. You also need to ensure your RAM user is granted permission to view project tables.

Prepare client tools for connection

MaxCompute Lightning is compatible with PostgreSQL interfaces and is accessible to client tools that are connected to PostgreSQL databases.

Tableau Desktop BI tools are used in this tutorial. Download related tools from the Tableau official website.

Other commonly used client tools, such as SQL Workbench/J, PSQL, FineReport BI, and MicroStrategy BI tools, can be connected to MaxCompute Lightning in the same way as to PostgreSQL databases.

Access services and perform analysis

After the connection service is successful, you can view the data table under the specified MaxCompute project for BI analysis.

1. Select PostgreSQL when establishing a connection to a server.

   Start Tableau Desktop. In the left-side navigation pane, select Select > To Servers > More > PostgreSQL.

2. Enter service connection and user authentication information.

Parameter	Description
Server	Enter the MaxCompute Lightning endpoint of a specified region in the `Server` field. For example, enter the value `lightning . cn - shanghai . maxcompute . aliyun . com` as the endpoint for the China East 2 region.
	443
Database	MaxCompute project name
ID Verification	User name and password
Username/ Password	User Access Key ID/Access Key Secret
SSL connection	Select the SSL connection check box.

3. Obtain project table information and create a data source or model.

   After you configure the contact information and log on to the Tableau Desktop, this software loads tables of the connected MaxCompute project. You can choose tables to create data models and charts as required.

   The following figure shows an example of a chart created based on required dimensions and measures.

Now you have gained access to MaxCompute Lightning using Tableau Desktop. You can perform BI analysis on the data of the connected MaxCompute projects.

Note:

For better performance, it is recommended that you customize the connection to the Lightning data source using the TDC file supported by Tableau. For more information, see #unique_241/unique_241_Connect_42_section_p1m_3yk_z2b.

9.3 Access domain name

MaxCompute Lightning provides region-specific endpoints that allow you to access MaxCompute Lightning services in the corresponding regions.

The following tables describe the MaxCompute Lightning service connection status in different regions and public cloud network environments.

Table 9-1: Service connection status in different regions with external network

Region	Service status	External network endpoint
China East 1	In service	lightning.cn-hangzhou.maxcompute.aliyun.com
China East 2	In service	lightning.cn-shanghai.maxcompute.aliyun.com
China North 2	In service	lightning.cn-beijing.maxcompute.aliyun.com
Southern China 1	In service	lightning.cn-shenzhen.maxcompute.aliyun.com
China (Hong Kong)	Beta	lightning.cn-hongkong.maxcompute.aliyun.com
Asia Pacific SE 1	Beta	lightning.ap-southeast-1.maxcompute.aliyun.com
Other regions	Not activated	-

Table 9-2: Service connection status in different regions with classic network

Region	Service status	Classic network endpoint
China East 1	In service	lightning.cn-hangzhou.maxcompute.aliyun-inc.com
China East 2	In service	lightning.cn-shanghai.maxcompute.aliyun-inc.com
China North 2	In service	lightning.cn-beijing.maxcompute.aliyun-inc.com
Southern China 1	In service	lightning.cn-shenzhen.maxcompute.aliyun-inc.com
China (Hong Kong)	Beta	lightning.cn-hongkong.maxcompute.aliyun-inc.com

Region	Service status	Classic network endpoint
Asia Pacific SE 1	Beta	lightning.ap-southeast-1.maxcompute.aliyun-inc.com
Other regions	Not activated	-

Table 9-3: Service connection status in different regions with VPC network

Region	Service status	VPC endpoint
China East 1	In service	lightning.cn-hangzhou.maxcompute.aliyun-inc.com
China East 2	In service	lightning.cn-shanghai.maxcompute.aliyun-inc.com
China East 2 Financial Cloud	In service	lightning.cn-shanghai-finance.maxcompute.aliyun-inc.com
China North 2	In service	lightning.cn-beijing.maxcompute.aliyun-inc.com
Southern China 1	In service	lightning.cn-shenzhen.maxcompute.aliyun-inc.com
China (Hong Kong)	Beta	lightning.cn-hongkong.maxcompute.aliyun-inc.com
Asia Pacific SE 1	Beta	lightning.ap-southeast-1.maxcompute.aliyun-inc.com
Other regions	Not activated	-

9.4 Access services using JDBC interfaces

The MaxCompute Lightning query engine is based on PostgreSQL 8.2 and currently only supports SELECT queries for existing MaxCompute tables. For more information about the query syntax and functions.

If no data has been added to MaxCompute projects or existing data needs to be processed, see the MaxCompute help document. You can use the MaxCompute client or DataWorks to access MaxCompute projects for creating and processing data objects.

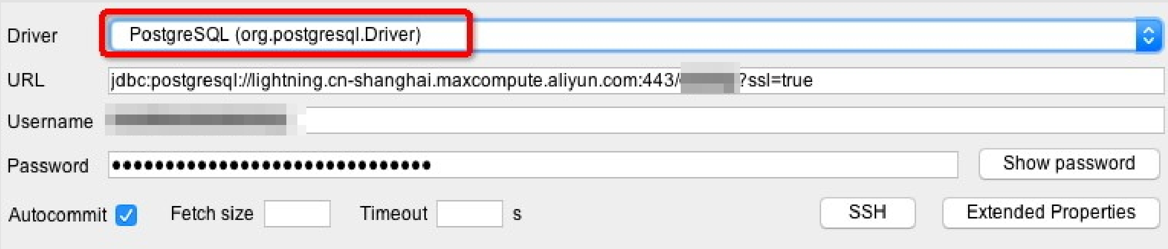
9.4.1 JDBC driver

MaxCompute provides JDBC interfaces that are fully compatible with the PostgreSQL protocol. Users can connect SQL client tools to the MaxCompute Lightning service using JDBC interfaces.

MaxCompute Lightning can be accessed using JDBC drivers from the PostgreSQL official website or other drivers optimized for MaxCompute Lightning.

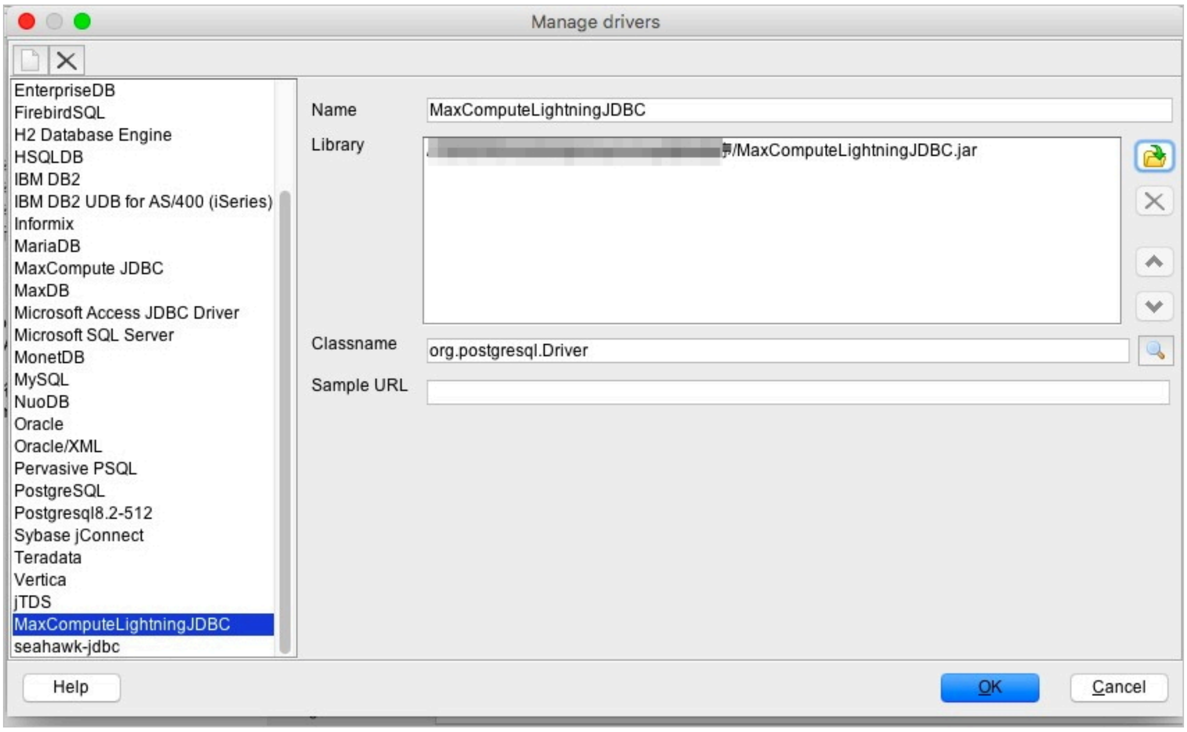
1. JDBC drivers from the PostgreSQL official website.

    Note:
    Many client tools already have PostgreSQL database drivers built in, you can use the built-in drivers. If it is not integrated, you can download required drivers from the PostgreSQL official website. Take the SQL Workbench/J client as an example. You can choose the PostgreSQL official drivers when creating a connection.

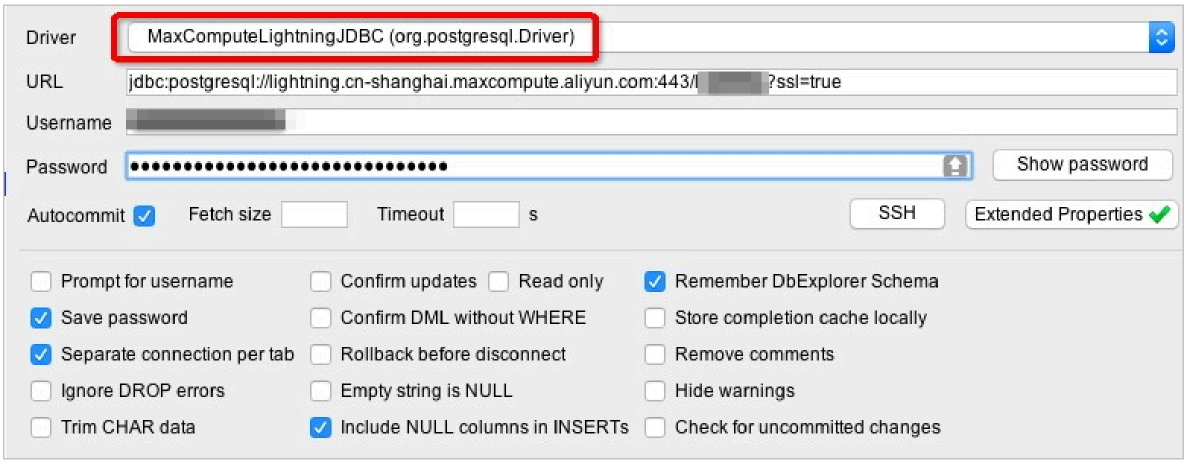
    

2. JDBC drivers optimized by Alibaba Cloud MaxCompute Lightning

    The downloaded MaxCompute Lightning JDBC driver is saved as a MaxComputeLightningJDBC.jar file. Take the SQL Workbench/J client as an example. In the Driver Management menu, add the MaxCompute Lightning JDBC driver entry.



When you create a connection, select the MaxCompute Lightning JDBC driver that you just added from the Driver list.



9.4.2 Configure JDBC connections

To connect SQL client tools to MaxCompute projects, you must have JDBC URLs for the MaxCompute projects.

The following shows the format of a JDBC URL:

```
jdbc : postgresql :// endpoint : port / database
```

The following table describes the connection parameters:

Parameter	Value	Description
endpoint	Access domain name of MaxCompute Lightning in the region	For more information, see #unique_247. For example, accessing the Shanghai Region service through the external network using `lightning . cn - shanghai . maxcompute . aliyun . com`
port	443	-
database	Name of a MaxCompute project	-
User	Access Key ID of the user	-
password	Access Key Secret of the user	-
ssl	true	MaxCompute Lightning servers are enabled with SSL protection by default , and you must use SSL connections.
prepareThreshold	0	Optional. When using the JDBC PrepareStatement function, it is recommended to set `prepareThreshold = 0`.

For example, `jdbc : postgresql :// lightning . cn - shanghai . maxcompute . aliyun . com : 443 / myproject`

You must specify the user, password, and SSL connection parameters before establishing a connection to MaxCompute projects.

You can also add parameters to the JDBC URL to connect to MaxCompute projects. For example:

```
jdbc : postgresql :// lightning . cn - shanghai . maxcompute . aliyun
. com : 443 / myproject ?  ssl = true &  prepareThr  eshold = 0 &
user = xxx & password = yyy
```

Note:

- lightning.cn-shanghai.maxcompute.aliyun.com: The endpoint of the China East 2 region.
- Myproject: The name of the MaxCompute project you want to access.
- SSL=true: The application of SSL connections.
- xxx: Access Key ID of the user.

- yyy: Access Key Secret of the user.

9.4.3 Access services using common tools

The following sections use major client tools, such as SQL Workbench/J, PSQL, and Tableau BI tools, as examples to describe how to access MaxCompute Lightning. Other commonly used tools can be connected to MaxCompute Lightning in the same way as to PostgreSQL databases.

Alibaba Cloud Quick BI

1. Log on Quick BI console, click Data source in the left-side navigation pane.
2. On the data source management page, click the Create data source in the upper-right corner.
3. Select PostgreSQL in the cloud database or external data source, and add a data source.
4. In the dialog box that appears, enter the connection information for MaxCompute Lightning. Then, test the connection.

Parameter	Description
Database address	Enter the endpoint for the region of MaxCompute Lightning . You can enter the endpoint for a public network, classic network, or VPC network.
Database	Enter the name of the to-be-accessed MaxCompute project.
Schema	MaxCompute project name
User name/ Password	User Access Key ID/Access Key Secret.

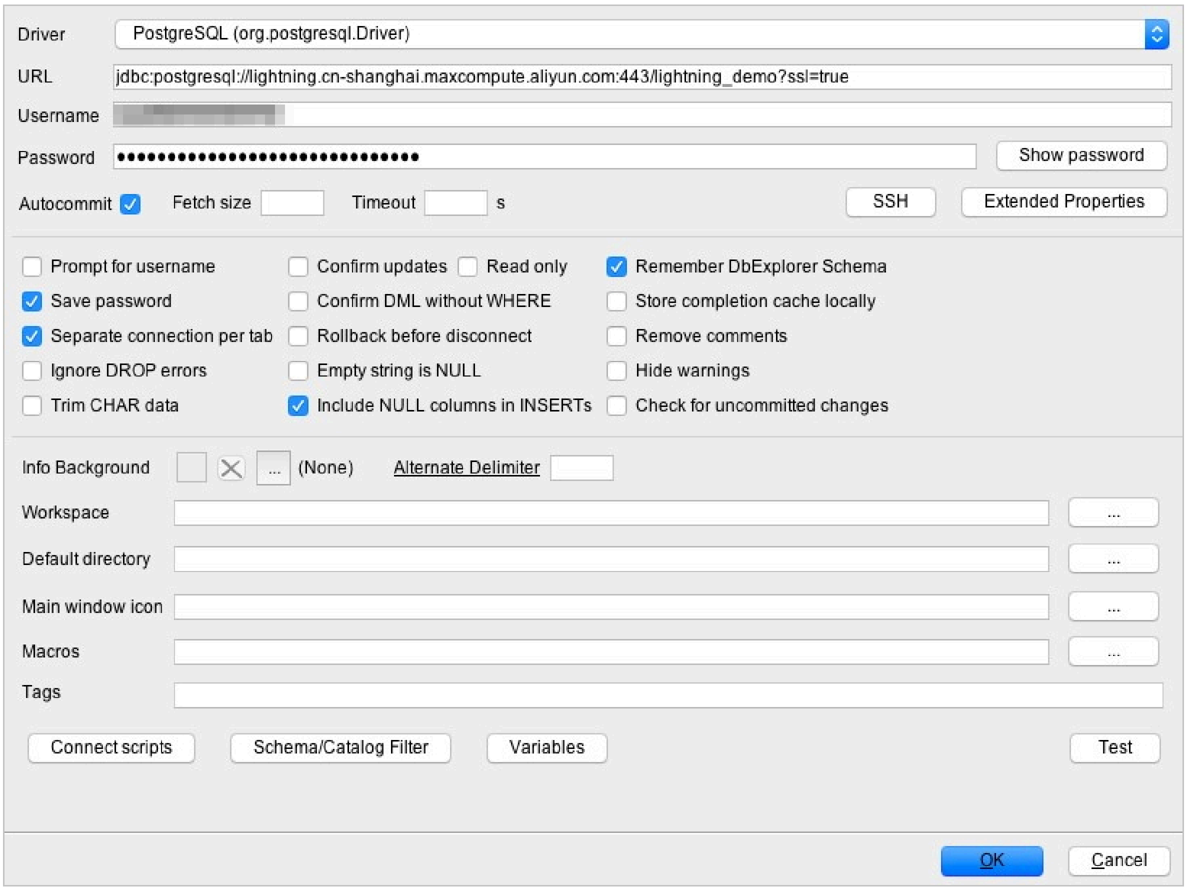
SQL Workbench/J

SQL Workbench/J is a widely used free and cross-platform SQL query tool. This tool can be connected to MaxCompute Lightning using the PostgreSQL driver.

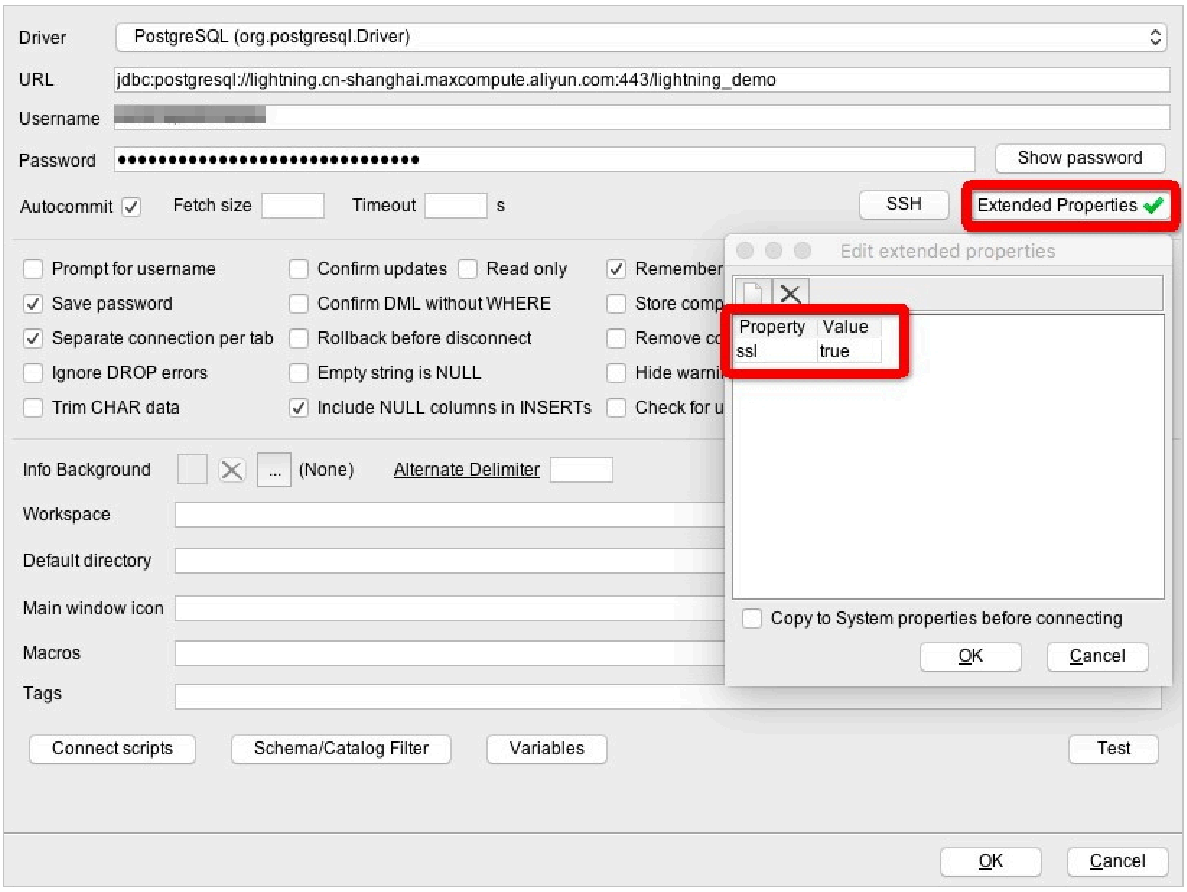
1. Download and install SQL Workbench/J.

2. Start SQL Workbench/J, establish a database connection.

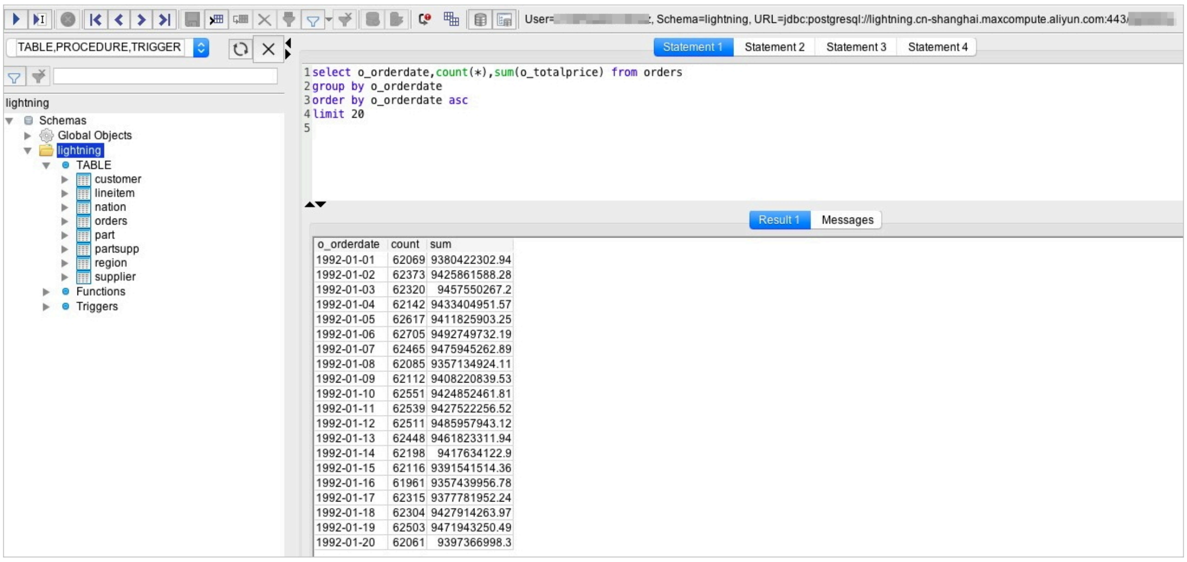
   Select the PostgreSQL driver, connect SQL Workbench/J to the MaxCompute Lightning URL of a project. You must enter the Access Key ID and Access Key Secret of the user.

   Alternatively, you can click Extended Properties and set ssl to true in the displayed dialog box.



3. After SQL Workbench/J is connected to MaxCompute Lightning, you can view, query, and analyze the table data in the SQL Workbench/J workspace.



psql

The psql is a PostgreSQL interactive terminal that enables you to perform queries using commands. The clients of psql are installed by default when PostgreSQL databases are installed in a local PC.

You can connect psql to MaxCompute Lightning using psql commands. The syntax for the connection is the same as that for the connection to the PostgreSQL database.

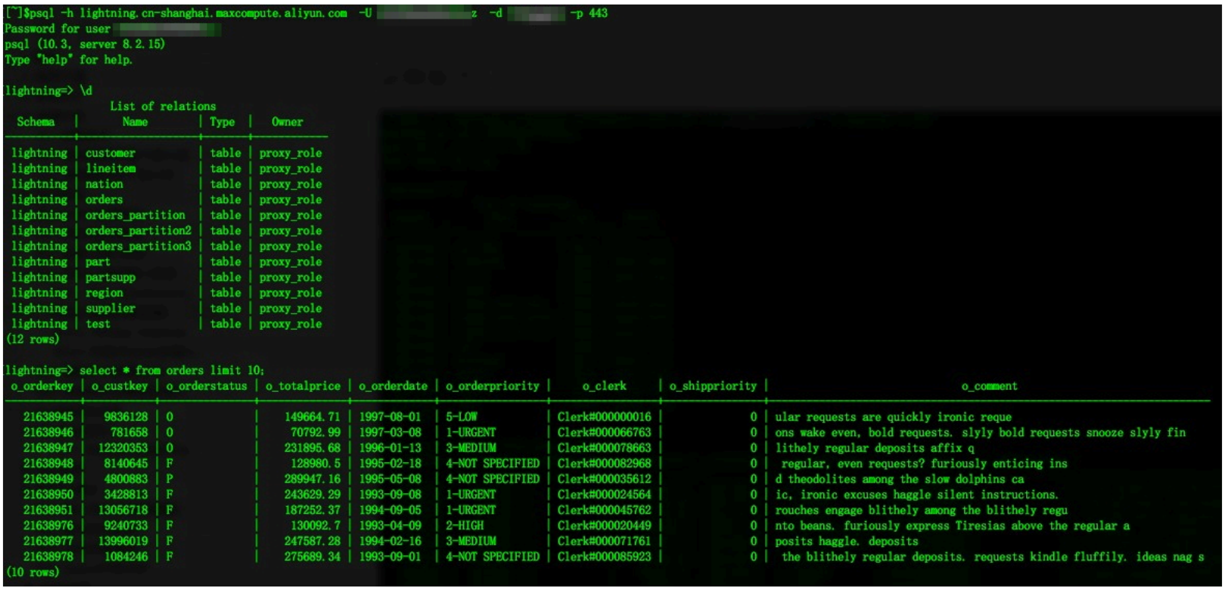
```
psql  - h  < endpoint > - U  < userid > - d  < databasena  me > - p
< port >
```

Parameter description:

- <endpoint>: The endpoint of MaxCompute Lightning. For more information, see #unique_247.
- <userid>: Access Key ID.
- <databasename>: MaxCompute project name.
- <port>: 443

After the command is executed, enter the <userid> password (Access Key Secret) in the command prompt.

Example:



> **Note:**
> SSL connections are preferred for psql by default.

Tableau Desktop

Start BI tools, select the PostgreSQL data source, and configure the connection.

When you configure the connection, select the SSL Connection check box.

After logging on to Tableau Desktop, you can create charts for visual analysis.

Note:

For better performance, it is recommended that you customize the connection to the Lightning data source using the TDC file supported by Tableau. Procedure:

1. Save the following xml content as a postgresql.tdc file.

```
<? xml   version =' 1 . 0 '  encoding =' utf - 8 ' ?>
< connection - customizat  ion   class =' postgres '  enabled ='
 true '  version =' 8 . 10 '>
< vendor   name =' postgres '/>
< driver   name =' postgres '/>
< customizat  ions >
< customizat  ion   name =' CAP_CREATE  _TEMP_TABL  ES '  value ='
 no ' />
< customizat  ion   name =' CAP_STORED  _PROCEDURE  _TEMP_TABL
 E_FROM_BUF  FER '  value =' no ' />
< customizat  ion   name =' CAP_CONNEC  T_STORED_P  ROCEDURE '
 value =' no ' />
< customizat  ion   name =' CAP_SELECT  _INTO '  value =' no ' />
< customizat  ion   name =' CAP_SELECT  _TOP_INTO '  value =' no
 ' />
< customizat  ion   name =' CAP_ISOLAT  ION_LEVEL_  SERIALIZAB  LE
 '  value =' yes ' />
< customizat  ion   name =' CAP_SUPPRE  SS_DISCOVE  RY_QUERIES '
 value =' yes ' />
< customizat  ion   name =' CAP_SKIP_C  ONNECT_VAL  IDATION '
 value =' yes ' />
< customizat  ion   name =' CAP_ODBC_T  RANSACTION  S_SUPPRESS
 _EXPLICIT_  COMMIT '  value =' yes ' />
< customizat  ion   name =' CAP_ODBC_T  RANSACTION  S_SUPPRESS
 _AUTO_COMM  IT '  value =' yes ' />
< customizat  ion   name =' CAP_ODBC_R  EBIND_SKIP  _UNBIND '
 value =' yes ' />
< customizat  ion   name =' CAP_FAST_M  ETADATA '  value =' no ' />
< customizat  ion   name =' CAP_ODBC_M  ETADATA_SU  PPRESS_SEL
 ECT_STAR '  value =' yes ' />
< customizat  ion   name =' CAP_ODBC_M  ETADATA_SU  PPRESS_EXE
 CUTED_QUER  Y '  value =' yes ' />
< customizat  ion   name =' CAP_ODBC_U  NBIND_AUTO '  value =' yes
 ' />
< customizat  ion   name =' SQL_TXN_CA  PABLE '  value =' 0 ' />
< customizat  ion   name =' CAP_ODBC_C  URSOR_FORW  ARD_ONLY '
 value =' yes ' />
< customizat  ion   name =' CAP_ODBC_T  RANSACTION  S_COMMIT_I
 NVALIDATES  _PREPARED_  QUERY '  value =' yes ' />
</ customizat  ions >
</ connection - customizat  ion >
```

2. Save the file to the `\ My  Documents \ My  Tableau  Repository \ Datasource  s` directory. If it is Tableau Server, save it in `C :\ ProgramDat a \ Tableau \ Tableau  Server \ data \ tabsvc \ vizqlserve r \ Datasource  s` under Windows, and save it in `/ var / opt / tableau / tableau_se rver / data / tabsvc / vizqlserve r / Datasource  s /` under Linux. .

3. Reopen Tableau and use the PostgreSQL data source to connect to the MaxCompute Lightning service. For more information about custom data sources for tdc files, see official Tableau documentation.

FineReport

1. Start FineReport, and select Server > Define database connection.
2. Add a JDBC connection.

   The configurations are described as follows:

Parameter	Description
Database	Postgre
Driver	org.postgresql.Driver that is integrated in FineReport
URL	`jdbc : postgresql ://< MaxCompute Lightning Endpoint >: 443 /< Project_Na me >? ssl = true & amp ; prepareThr eshold = 0` For example, `jdbc : postgresql :// lightning . cn - shanghai . maxcompute . aliyun . com : 443 / lightning_ demo ? ssl = true & amp ; prepareThr eshold = 0`
User name/ Password	User Access Key ID and Access Key Secret

9.5 SQL reference

Based on the official PostgreSQL function, MaxCompute Lightning adds the following built-in functions.

Query syntax

The MaxCompute Lightning query engine is based on PostgreSQL 8.2 and currently only supports SELECT queries for existing MaxCompute tables. For more information about the query syntax, see PostgreSQL documentation.

Function

The MaxCompute Lightning query engine is based on PostgreSQL 8.2 supports builtin funtion, for more information, see PostgreSQL documentation.

Based on the official PostgreSQL function, MaxCompute Lightning adds the following builtin functions.

- MAX_PT

  Command format

  ```
  max_pt ( table_full  _name )
  ```

  Command description

  For partitioned tables, this function returns the maximum value of the level-one partition of the partitioned table, sorted alphabetically, and there is a correspond ing data file under the partition.

  Parameter description

  table_full_name: String type, used to specify the table name (must carry the project name, such as prj.src), you must have read access to this table.

  Return value

  Returns the value of the largest level-one partition.

  Example

  Suppose tbl is a partition table, the corresponding partition is as follows, and both contain data files:

  ```
  pt  =‘ 20120901 ’
  pt  =‘ 20120902 ’
  ```

  Then the partition max_pt returns the value of '20120902' in the following statement, and the MaxCompute SQL statement reads the data under the pt= ‘ 20120902’ partition.

  ```
  select  *  from   tbl   where   pt = max_pt (' myproject . tbl ');
  ```

9.6 View tasks

MaxCompute Lightning provides a system view stv_recents. By querying the view, you can view all query tasks that the current user is running.

View running queries

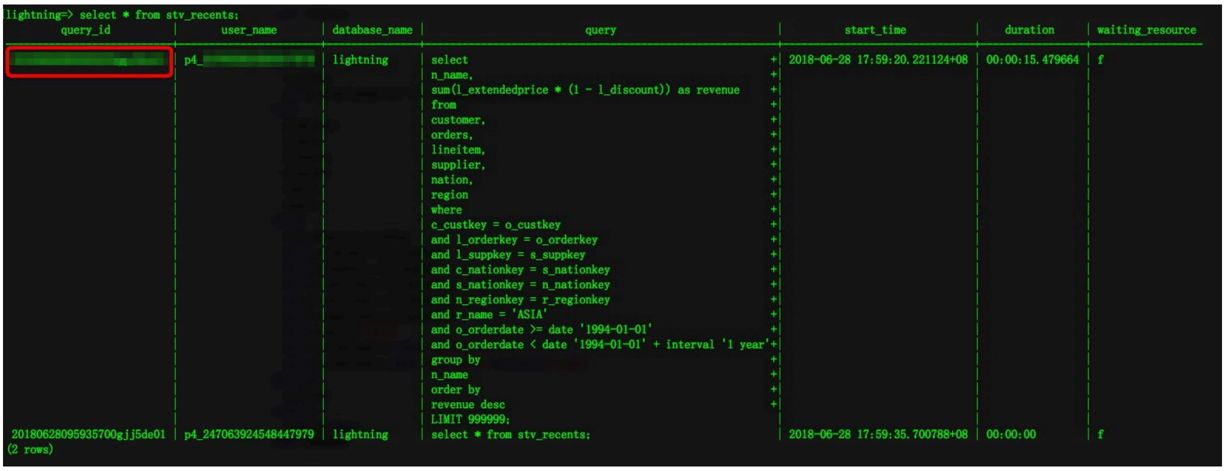
You can execute the query command to view the related information, including query ID, user name, query SQL statement, start time, duration, and waiting resources.

Note: The "t" indicates that a query task has not been executed yet and is waiting for resources. The "f" indicates that the resources are being acquired and that the query task is being executed.

Run the following query command.

```
select  *  from   stv_recent  s ;
```

The following figure shows a command output example.



Cancel running queries

You can obtain information on running queries by querying the stv_recents table. To cancel a running query, execute the following query command.

```
select   cancel (' query_id ');
```

In parentheses is the query_id of a running query.

9.7 Constraints and limitations

This article introduces you to the constraints and limitations of using the MaxCompute Lightning service.

DDL/DML constraints and limitations

MaxCompute Lightning only supports Select queries for MaxCompute tables and does not support UPDATE, CREATE, DELETE, and INSERT operations on MaxCompute tables.

Query constraints and limitations

- A maximum number of 1,024 scanned partitions can be queried when you query partitioned tables.
- Currently, views cannot be created or used.
- Currently, MAP、ARRAY、TINYINT、BINARY、TIMESTAMP and DECIMAL with accuracy data types are not supported.
- A maximum of 1 TB data can be scanned for a table in each query.
- The size of the submitted query statement cannot exceed 100 KB.
- The query timeout period is one hour.

UDF constraints and limitations

- User-defined functions (UDF) created using MaxCompute cannot be used in MaxCompute Lightning.
- PostgreSQL user-defined functions cannot be created or used in MaxCompute Lightning.
- MaxCompute built-in functions are not supported at this time.

Query concurrency constraints

A maximum of 20 concurrent queries for a MaxCompute project is supported by MaxCompute Lightning.

9.8 FAQs

This article will help you organize common problems in the application of MaxCompute Lightning.

- Q: How can I query data using MaxCompute Lightning when I have not created any tables?

  A: You need to use the DataWorks or odpscmd client tool to create tables for a MaxCompute project and then upload the data. You can access the project using MaxCompute Lightning and query the tables in the project.
- Q: What are the limits on the amount of data that I can query? What is the limit to the amount of queried data MaxCompute Lightning can process and still show excellent performance?

  A: Currently, a maximum of 1 TB data can be scanned for a table in each query. Of course, less of queried data will provide better query performance.

  > Note:
  > We recommend that the table data to be scanned does not exceed 100 GB. Query performance gradually decreases with the increase of data volume. If the queried data exceeds 100 GB, MaxCompute SQL is recommended for better performance.
- Q: What should I do if I receive the following error message when using BI tools to drag a partitioned table for analysis: `ERROR : AXF Exception : specified partitions count in odps table : <project_name.table_name> is : xxx , exceeds the limitation of xxx , please add stricter partition filter`.

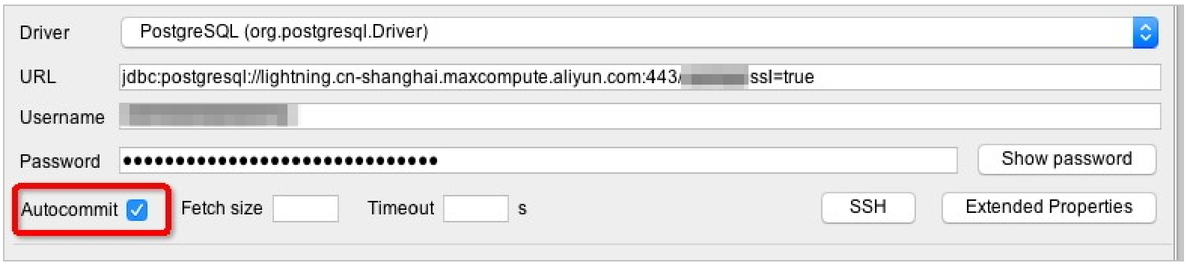
  A: MaxCompute Lightning limits the number of partitions for a partitioned table to ensure the query performs efficiently. A maximum of 1,024 partitions can be scanned for a table in each query. With some BI tools, you can select tables for analysis using the drag-and-drop method. In this way, you are not able to specify partition settings before the analysis. This may cause the number of partitions to be scanned to exceed the limit, triggering the report of an error from MaxCompute Lightning. We recommend that you process the to-be-queried tables before the analysis. You can either convert partitioned tables into non-partitioned tables or reduce the number of partitions to a value lower than 1,024.

- Q: Why is `ERROR : SSL required` displayed during the connection to MaxCompute Lightning?

  A: MaxCompute Lightning requires SSL connections and therefore users must use SSL connections. If you use a client tool, you can select the SSL connection check box. If SSL connections cannot be selected in the client tool, you can add the SSL parameter to the JDBC URL. In the JDBC URL, you must enter the endpoint of the region where your project belongs and the name of the connected project, for example, `jdbc:postgresql://lightning.cn-shanghai.maxcompute.aliyun.com:443/myproject?ssl=true`.

- Q: What should I do when I receive the following error message during a query using the SQL Workbench/J client: `Error : current transaction is aborted , commands ignored until end of transaction block`.

  A: Select the Autocommit check box in the client.



10 Graph

10.1 Summary

MaxCompute Graph is a processing framework designed for iterative graph computing. MaxCompute Graph jobs use graphs to build models. Graphs are composed of vertices and edges, which contain values.

MaxCompute Graph supports the following graph editing operations:

- Editing the value of Vertex or Edge.
- Add/delete Vertices.
- Add/delete Edges.

> Note:
> When editing a vertex and an edge, you must maintain their relationship.

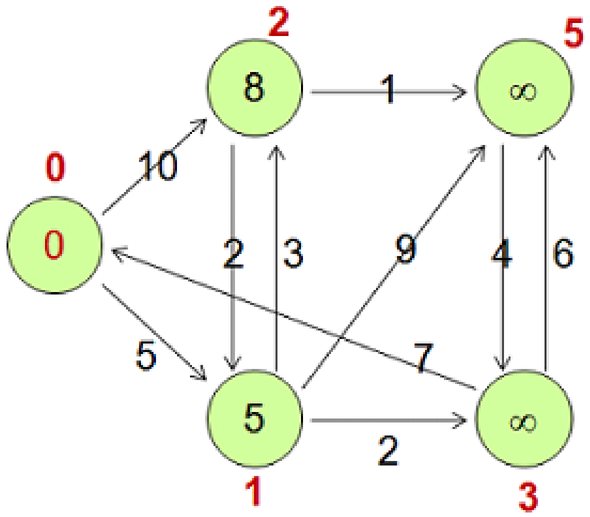
This process outputs a final solution after performing iterative graph editing and evolution. Typical applications include PageRank, SSSP algorithm, and Kmeans algorithm. Use Java SDK, an interface provided by MaxCompute Graph to compile graph computing programs.

Graph Data structure

Graphs processed by MaxCompute Graph must be directed graphs consisting of vertices and edges. As MaxCompute only provides a two-dimensional storage structure, you must resolve graph data into two-dimensional tables and store them in MaxCompute.

During graph computing analysis, use custom GraphLoader to convert two-dimensional table data to vertices and edges in the MaxCompute Graph engine. You can determine how to resolve graph data into two-dimensional tables based on your service scenarios. In the sample code, the table formats correspond to different graph data structures.

The vertex structure can be described as < ID, Value, Halted, Edges >, which respectively indicates the vertex ID (ID), value (Value), status (Halted, indicating whether an iteration needs to be stopped), and edge set (Edges, indicating lists of all edges starting from the vertex). The edge structure is described as < DestVertexID, Value >, which respectively indicates the destination vertex (DestVertexID) and value (Value).



For example, the preceding figure consists of the following vertices:

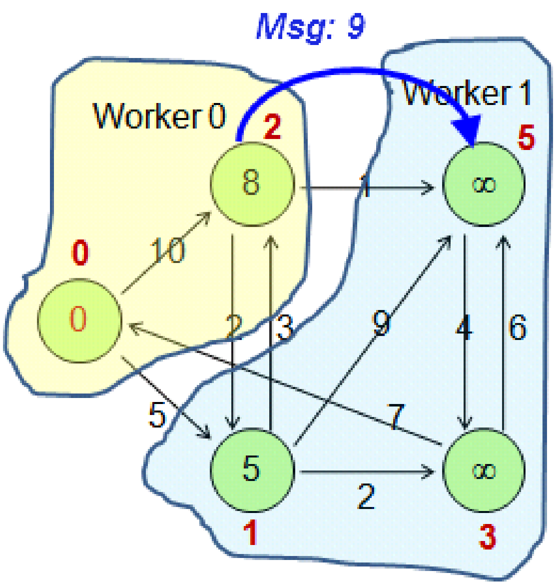
Vertex	<ID, Value, Halted, Edges>
v0	<0, 0, false, [<1, 5 >, <2, 10 >] >
v1	<1, 5, false, [<2, 3>, <3, 2>, <5, 9>]>
v2	<2, 8, false, [<1, 2>, <5, 1 >]>
v3	<3, Long.MAX_VALUE, false, [<0, 7>, <5, 6>]>
v5	<5, Long.MAX_VALUE, false, [<3, 4 >]>

Graph program logic

Graph loading

The framework calls custom GraphLoader and resolves records of an input table to vertices or edges.

Distributed architecture: The framework calls custom Partitioner to partition vertices and distributes them to corresponding Workers. (Default partitioning logic : Calculates the hash value of a vertex ID and performs the modulo operation on the number of Workers.)



For example, assume in the preceding figure that the number of Workers is 2. v0 and v2 are allocated to Worker 0 because the result of the ID mod 2 is 0. v1, v3, and v5 are allocated to Worker 1 as the result of the ID mod 2 is 1.

Iteration calculation

- An iteration is called a superstep. It traverses all vertices in a non-halted status (the value of the halted is false) or all vertices that receive messages (a vertex in halted status is automatically activated after receiving a message), and calls their compute (ComputeContext context, Iterable messages) method.
- Follow these steps on your implemented compute (ComputeContext context, Iterable messages) method:
  - Process messages sent from the previous SuperStep to the current Vertex.
  - Edit graph as needed:
    - Revise value of Vertex/Edge
    - Send messages to certain Vertices
    - Add/Delete Vertex or Edge
  - Use Aggregator to collect information to update the global information.
  - Set the current vertex to a halted or non-halted status.
  - During iteration, the framework asynchronously sends messages to the corresponding Worker and processes the messages in the next SuperStep without your intervention.

Iteration termination

If any of the following conditions are met, iteration is terminated.

- All vertices are in the halted state (the value of Halted is true) and no new message is generated.
- A maximum number of iterations is reached.
- The terminate method of an Aggregator returns true.

The pseudocode is as follows:

```
// 1 . load
 for each record in input_tabl e {
   GraphLoade r . load ();

// 2 . setup
 WorkerComp uter . setup ();
 for each aggr in aggregator s {
   aggr . createStar tupValue ();

 for each v in vertices {
   v . setup ();

// 3 . superstep
 for ( step = 0 ; step < max ; step ++) {
   for each aggr in aggregator s {
     aggr . createInit ialValue ();

   for each v in vertices {
      v . compute ();


// 4 . cleanup
 for each v in vertices {
   v . cleanup ();

 WorkerComp uter . cleanup ();
```

10.2 Aggregator

This article explains the implementation and related APIs of Aggregator and uses KmeansClustering as an example to illustrate the use of Aggregator.

In MaxCompute Graph, Aggregator helps to collect and process global information. In MaxCompute Graph, Aggregator is used to summarize and process global informatio n.

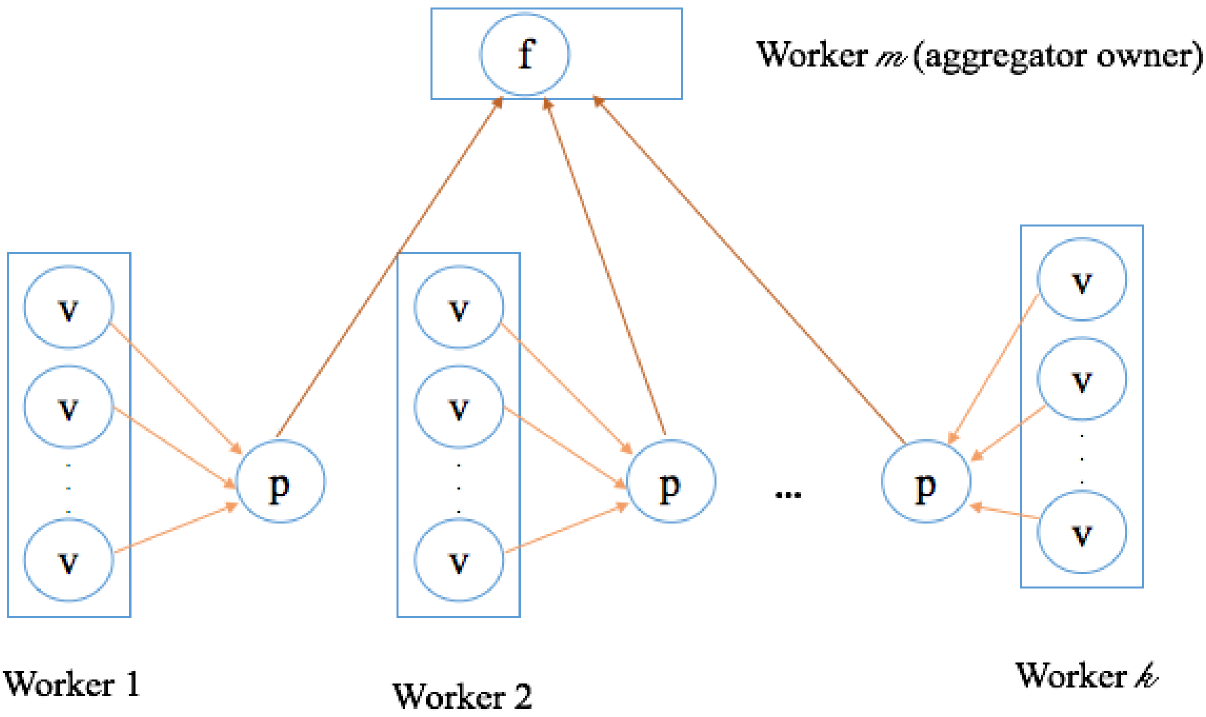
Aggregator implementation

The logic of Aggregator is divided into the following two parts:

- One part is run on all Workers in distributed mode.

- The other part is only run on the Worker where AggregatorOwner is located in a single vertex mode.

Operations run on all Workers include creating an initial value and partial aggregation. The partial aggregation result is sent to the Worker where AggregatorOwner is located. The Worker then aggregates partial aggregation objects sent by common Workers to obtain a global aggregation result, and determines whether the iteration is ended or not. The global aggregation result is sent to all Workers over the next round of supersteps for the next iteration, as shown in the following figure.



Aggregator APIs

Aggregator provides five APIs for user implementation. The following section describes the call time and application of the five APIs.

- createStartupValue(context)

  This API runs once on all Workers. It is called before all supersteps start, and is generally used to initialize AggregatorValue. In the first superstep iteration (superstep equals 0), the AggregatorValue object initialized by the API can be obtained by the call of WorkerContext.getLastAggregatedValue() or ComputeContext.getLastAggregatedValue().

- createInitialValue(context)

  This API is called once on all Workers when each superstep is initiated. It is used to initialize AggregatorValue for the current iteration. Generally, the result of the previous iteration is obtained through WorkerContext.getLastAggregatedValue(), and partial initialization is run.
- aggregate(value, item)

  This API runs on all Workers. It is triggered by an explicit call of ComputeContext #aggregate(item), while the preceding two APIs are automatically called by the framework. This API is used to run partial aggregation. The first parameter value indicates the result that the Worker has aggregated in the current superstep. (The initial value is the object returned by createInitialValue). The second parameter is transmitted when the user code calls ComputeContext#aggregate(item). In this API, item is usually used to update value for aggregation. After all the aggregate operations are executed, the obtained value is the partial aggregation result of the Worker. Then, the result is sent by the framework to the Worker where Aggregator Owner is located.
- merge(value, partial)

  This API runs by the Worker where AggregatorOwner is located. It is used to merge partial aggregation results of Workers to obtain the global aggregation object. Similar to aggregate, value indicates aggregated results, while partial indicates objects to be aggregated. Partial is used to update value.

  For example, assume that three Workers w0, w1, and w2 exist with the partial aggregation results of p0, p1, and p2. If p1, p0, and p2 in sequence are sent to the Worker where the AggregatorOwner is located, then the merge sequence will be as follows:

  1. merge(p1, p0) runs first, and p1 and p0 are aggregated as p1’.
  2. merge(p1’, p2) runs, and p1’ and p2 are aggregated as p1’’, which is the global aggregation result in this superstep.

  The preceding example shows that execution of the merge() operation is not required when only one Worker exists. That is, merge() is not called.
- terminate(context, value)

  After the Worker where AggregatorOwner is located runs merge(), the framework calls terminate(context, value) to perform the final processing. The second parameter value indicates the global aggregation result obtained by merge(). The global aggregation can be modified further in this method. After terminate() is run , the framework distributes global aggregation objects to all Workers for the next superstep. A special feature of terminate() is that if true is returned, iteration of the entire job ends. Otherwise, iteration continues. In machine learning scenarios , it is usually determined that a job ends when true is returned after convergence.

KmeansClustering example

The following section uses typical KmeansClustering as an example to describe how to use Aggregator. The following section uses KmeansClustering as an example to describe how to use the Aggregator.

Note:
The complete code is provided in the Kmeans attachment. Here, the code is resolved in the following sequence.

- GraphLoader section

GraphLoader: The GraphLoader part is used to load an input table and convert it to a vertex or edge of a graph. Each row of data in the input table is a sample, a sample constructs a vertex, and VertexValue is used to store samples.

Initially, a writable class KmeansValue is defined as the VertexValue type:

```
public   static   class   KmeansValu  e   implements   Writable  {
  DenseVecto  r   sample ;
  public   KmeansValu  e () {

  public   KmeansValu  e ( DenseVecto  r   v ) {
    this . sample  =  v ;

 @ Override
  public   void   write ( DataOutput   out )  throws   IOExceptio
n  {
    wirteForDe  nseVector ( out ,  sample );

 @ Override
  public   void   readFields ( DataInput   in )  throws
IOExceptio  n  {
    sample  =  readFields  ForDenseVe  ctor ( in );
```

KmeansValue: A DenseVector object is encapsulated in KmeansValue to store a sample. The DenseVector type is from matrix-toolkits-java. wirteForDenseVector()

and readFieldsForDenseVector() are used for serialization and deserialization. For more information, see the complete code in the Kmeans attachment.

The custom KmeansReader code is as follows:

```
public   static   class   KmeansRead  er   extends
                                GraphLoade  r < LongWritab  le ,
KmeansValu  e ,  NullWritab  le ,  NullWritab  le > {
 @ Override
  public   void   load (
      LongWritab  le   recordNum ,
      WritableRe  cord   record ,
      MutationCo  ntext < LongWritab  le ,  KmeansValu  e ,
NullWritab  le ,  NullWritab  le >  context )
      throws   IOExceptio  n  {
    KmeansVert  ex   v  =  new   KmeansVert  ex ();
    v . setId ( recordNum );
    int   n  =  record . size ();
    DenseVecto  r   dv  =  new   DenseVecto  r ( n );
    for  ( int   i  =  0 ;  i  <  n ;  i ++) {
      dv . set ( i , (( DoubleWrit  able ) record . get ( i )). get
());

    v . setValue ( new   KmeansValu  e ( dv ));
    context . addVertexR  equest ( 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 the DenseVector object and encapsulated in VertexValue.

- Vertex

Custom KmeansVertex code:Regarding its logic, partial aggregation is performed for samples maintained in each iteration. For more information about its logic, see implementation of Aggregator in the following section:

```
public   static   class   KmeansVert  ex   extends
                                Vertex < LongWritab  le ,
KmeansValu  e ,  NullWritab  le ,  NullWritab  le > {
 @ Override
  public   void   compute (
  ComputeCon  text < LongWritab  le ,  KmeansValu  e ,  NullWritab
le ,  NullWritab  le >  context ,
  Iterable < NullWritab  le >  messages )  throws   IOExceptio  n
{
    context . aggregate ( getValue ());
```

- Aggregator

The main logic of entire Kmeans is centralized in
Aggregator. Custom KmeansAggrValue is used to maintain the content to be aggregated and distributed.

```
public   static   class   KmeansAggr  Value   implements   Writable
 {
  DenseMatri  x   centroids ;
  DenseMatri  x   sums ; //  used   to   recalculat  e   new
centroids
  DenseVecto  r   counts ; //  used   to   recalculat  e   new
centroids
 @ Override
  public   void   write ( DataOutput   out )  throws   IOExceptio
n  {
    wirteForDe  nseDenseMa  trix ( out ,  centroids );
    wirteForDe  nseDenseMa  trix ( out ,  sums );
    wirteForDe  nseVector ( out ,  counts );

 @ Override
  public   void   readFields ( DataInput   in )  throws
IOExceptio  n  {
    centroids  =  readFields  ForDenseMa  trix ( in );
    sums  =  readFields  ForDenseMa  trix ( in );
    counts  =  readFields  ForDenseVe  ctor ( in );
```

Three objects are maintained in KmeansAggrValue. centroids indicates the existing K centers. If the sample is m-dimensional, centroids is a matrix of K x m. sums is a matrix of the same size as centroids, and 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, records the number of samples closest to each center. sums and counts are used together to calculate a new center, which is a main content of aggregation.

The next is KmeansAggregator used for custom Aggregator implementation. The following describes implementation in order of the preceding APIs.

1. Run createStartupValue(), see the following:

```
public   static   class   KmeansAggr  egator   extends
Aggregator < KmeansAggr  Value > {
public   KmeansAggr  Value   createStar  tupValue ( WorkerCont
ext   context )  throws   IOExceptio  n  {
KmeansAggr  Value   av  =  new   KmeansAggr  Value ();
byte []  centers  =  context . readCacheF  ile (" centers ");
String   lines [] =  new   String ( centers ). split ("\ n ");
int   rows  =  lines . length ;
```

```
  int   cols  =  lines [ 0 ]. split (","). length ; //  assumption
    rows  >=  1
  av . centroids  =  new   DenseMatri  x ( rows ,  cols );
  av . sums  =  new   DenseMatri  x ( rows ,  cols );
  av . sums . zero ();
  av . counts  =  new   DenseVecto  r ( 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 ;
```

In the preceding method, a KmeansAggrValue object is initialized, the initial center is read from the resource file centers, and a value is granted to centroids. The initial values of sums and counts are 0.

2. Run createInitialValue(), see the following:

```
@ Override
 public   void   aggregate ( KmeansAggr  Value   value ,  Object
 item )
   throws   IOExceptio  n  {
 DenseVecto  r   sample  = (( KmeansValu  e ) item ). sample ;
//  find   the   nearest   centroid
 int   min  =  findNeares  tCentroid ( 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 );
```

In the createInitialValue() method, findNearestCentroid() is called to find the index of the center that has the shortest Euclidean distance with the sample item. Then, each dimension is added to sums, and the value of counts is plus 1 . For more information about how to implement findNearestCentroid(), see the Kmeans attachment.

The preceding three functions run on all Workers to implement partial aggregation. The following describes global aggregation-related operations that run on the Worker where AggregatorOwner is located.

1. Run merge:

```
@ Override
 public   void   merge ( KmeansAggr  Value   value ,  KmeansAggr
 Value   partial )
   throws   IOExceptio  n  {
 value . sums . add ( partial . sums );
```

```
value . counts . add ( partial . counts );
```

The implementation logic of merge is to add values of sums and counts aggregated by each Worker .

2. Run terminate():

```
@ Override
 public   boolean   terminate ( WorkerCont  ext   context ,
 KmeansAggr  Value   value )
    throws   IOExceptio  n  {
 //  Calculate   the   new   means   to   be   the   centroids  (
 original   sums )
  DenseMatri  x   newCentrio  ds  =  calculateN  ewCentroid  s (
 value . sums ,  value . counts ,  value . centroids );
 //  print   old   centroids   and   new   centroids   for
 debugging
  System . out . println ("\ nsuperstep : " +  context . getSuperst
 ep () +
     "\ nold   centriod :\ n " +  value . centroids  + "  new
 centriod :\ n " +  newCentrio  ds );
  boolean   converged  =  isConverge  d ( newCentrio  ds ,  value .
 centroids ,  0 . 05d );
  System . out . println (" superstep : " +  context . getSuperst
 ep () + "/"
     + ( context . getMaxIter  ation () -  1 ) + "  converged : " +
 converged );
  if  ( converged  ||  context . getSuperst  ep () ==  context .
 getMaxIter  ation () -  1 ) {
   //  converged   or   reach   max   iteration ,  output
 centriods
    for  ( int   i  =  0 ;  i  <  newCentrio  ds . numRows ();  i +
+) {
     Writable []  centriod  =  new   Writable [ newCentrio  ds .
 numColumns ()];
     for  ( int   j  =  0 ;  j  <  newCentrio  ds . numColumns ();
 j ++) {
       centriod [ j ] =  new   DoubleWrit  able ( newCentrio  ds .
 get ( i ,  j ));

     context . write ( centriod );

   //  true   means   to   terminate   iteration
    return   true ;

 //  update   centriods
  value . centroids . set ( newCentrio  ds );
 //  false   means   to   continue   iteration
  return   false ;
```

In terminate(), calculateNewCentroids() is called based on sums and counts to calculate the average value and obtain the new center. Then, isConverged() is called based on the Euclidean distance between the new and old centers to determine whether the center has been converged. If the number of convergences or iterations reaches the upper threshold, the new center is output, and true is returned to end the iteration. Otherwise, the center is updated, and false is returned to continue iteration. For more information about how to implement calculateNewCentroids() and isConverged(), see the attachment.

- main() method

  The main() method is used to build GraphJob, perform related settings, and submit a job. The code is as follows:

```
public  static  void  main ( String []  args )  throws
IOExceptio  n  {
                              if  ( args . length  <  2 )
    printUsage ();
  GraphJob  job  =  new  GraphJob ();
  job . setGraphLo  aderClass ( KmeansRead  er . class );
  job . setRuntime  Partitioni  ng ( false );
  job . setVertexC  lass ( KmeansVert  ex . class );
  job . setAggrega  torClass ( KmeansAggr  egator . class );
  job . addInput ( TableInfo . builder (). tableName ( args [ 0 ]).
build ());
  job . addOutput ( TableInfo . builder (). tableName ( args [ 1
]). build ());
 //  default  max  iteration  is  30
  job . setMaxIter  ation ( 30 );
  if  ( args . length  >=  3 )
    job . setMaxIter  ation ( Integer . parseInt ( args [ 2 ]));
  long  start  =  System . currentTim  eMillis ();
  job . run ();
  System . out . println (" Job  Finished  in  "
     + ( System . currentTim  eMillis () -  start ) /  1000 . 0  +
"  seconds ");
```

> **Note:**
> If job.setRuntimePartitioning(false) is set to false, data loaded by each worker will not be partitioned based on Partitioner. That is, who loads the data maintains it.

Conclusion

This article introduces the aggregator features in the MaxCompute graph, the API meaning, and the kmeans Clustering example. To sum it up, Aggregator can be implemented as follows:

1. Each Worker runs createStartupValue during startup to create AggregatorValue.
2. Each Worker runs createInitialValue before each iteration initializes Aggregator Value in the current round.
3. In an iteration, each vertex uses context.aggregate() to run aggregate(), implementing 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 AggregatorOwner is located runs merge several times to implement global aggregation.
6. The Worker where AggregatorOwner is located runs terminate to process the global aggregation result and determines whether to end the iteration.

Attachment

Kmeans

10.3 Function overview

Running jobs

The MaxCompute console provides JAR commands to run MaxCompute Graph jobs. These commands are used the same way as MapReduce JAR commands run.

This article introduces you to these commands.

```
Usage :  jar  [< GENERIC_OP  TIONS >] < MAIN_CLASS > [ ARGS ]
               - conf  < configurat  ion_file >  Specify   an
applicatio  n   configurat  ion   file
               - classpath  < local_file  _list >  classpaths   used
  to   run   mainClass
               - D  < name >=< value >  Property   value   pair ,
which   is   used   to   run   mainClass
               - local   Run   job   in   local   mode
               - resources  < resource_n  ame_list >  file / table
resources   used   in   graph ,  separated   by   command
```

< GENERIC_OPTIONS> can be the following parameters (all are optional):

- -conf < configuration file >: Specifies the JobConf configuration file.
- -classpath < local_file_list >: Indicates the class path for local implementation. It is mainly used to specify the JAR package containing the main function.

  The main function and Graph job are usually written in the same package, for example, in the Single Source Shortest Path (SSSP) package. Therefore, the -resources and -classpath parameters in the sample code both contain the JAR package. The difference is that -resources refers to the value of the Graph job and runs in a distributed environment, while -classpath refers to the main function and runs locally. The specified JAR package path is also a local file path. Package names are separated using system default file delimiters. Generally, the delimiter is a semicolon (;) in a Windows system and a comma (,) in a Linux system.
- -D < prop_name > = < prop_value >: Specifies the Java attributes of < mainClass > for local implementation. Multiple attributes can be defined.

- -local: Runs the Graph job in local mode, which is mainly used for program debugging.
- -resources <resource_name_list >: Indicates the resource statement used for Graph job running. Generally, the name of the resource where the Graph job is located must be specified in resource_name_list. If you read other MaxCompute resources in the Graph job, the resource names must be added to resource_name_list. Resource names are separated by commas (,). When resources are used across projects, PROJECT_NAME/resources/ must be prefixed. For example, `- resources otherproje ct / resources / resfile ;`.

In addition, run the main function of the Graph job to directly submit a job to MaxCompute, rather than submitting a job through the MaxCompute console. The following section uses the PageRank algorithm as an example:

```
public   static   void   main ( String [] args ) throws   Exception
 {
                    if  ( args . length  <  2 )
    printUsage ();
  Account   account  =  new   AliyunAcco  unt ( accessId ,  accessKey
);
  Odps   odps  =  new   Odps ( account );
  odps . setEndpoin  t ( endPoint );
  odps . setDefault  Project ( project );
  SessionSta  te   ss  =  SessionSta  te . get ();
  ss . setOdps ( odps );
  ss . setLocalRu  n ( false );
  String   resource  = " mapreduce - examples . jar ";
  GraphJob   job  =  new   GraphJob ();
 //  Add   the   JAR   file   in   use   and   other   files   to
  class   cache   resource ,  correspond  ing   to   resources
specified   by  - libjars   in   the   JAR   command
  job . addCacheRe  sourcesToC  lassPath ( resource );
  job . setGraphLo  aderClass ( PageRankVe  rtexReader . class );
  job . setVertexC  lass ( PageRankVe  rtex . class );
  job . addInput ( TableInfo . builder (). tableName ( args [ 0 ]).
build ());
  job . addOutput ( TableInfo . builder (). tableName ( args [ 1 ]).
build ());
 //  default   max   iteration   is   30
  job . setMaxIter  ation ( 30 );
  if  ( args . length  >=  3 )
    job . setMaxIter  ation ( Integer . parseInt ( args [ 2 ]));
  long   startTime  =  System . currentTim  eMillis ();
  job . run ();
  System . out . println (" Job   Finished   in  "
     + ( System . currentTim  eMillis () -  startTime ) /  1000 . 0
     + "  seconds ");
```

Input and output

You cannot customize input and output formats.

The following example shows how to define a job input. Multiple inputs are supported:

```
GraphJob  job  =  new  GraphJob ();
job . addInput ( TableInfo . builder (). tableName (“ tblname ”).
build ()); // Table  as  input
job . addInput ( TableInfo . builder (). tableName (“ tblname ”).
partSpec (" pt1 = a / pt2 = b "). build ()); // Shard  as  input
// Read - only  columns  col2  and  col0  of  the  input
table .  In  the  load ()  method  of  GraphLoade  r ,  column
col2  is  obtained  by  record . get ( 0 ),  and  the  sequence
  is  the  same
job . addInput ( TableInfo . builder (). tableName (“ tblname ”).
partSpec (" pt1 = a / pt2 = b "). build (),  new  String []{" col2
", " col0 "});
```

Note:

- For more information about the job input definition, see the description of the addInput() method in a GraphJob. The framework reads records in the input table and transmits them to custom GraphLoader to load data.
- Limits: Currently, shard filtering conditions are not supported. For more information , see Application restrictions.

The following example shows how to define a job output. Multiple job outputs are supported. Each output is marked by a label:

```
GraphJob  job  =  new  GraphJob ();
// If  the  output  table  is  a  shard  table ,  the  last
level  of  shards  must  be  provided
job . addOutput ( TableInfo . builder (). tableName (" table_name ").
partSpec (" pt1 = a / pt2 = b "). build ());
//  Parameter  true  indicates  overwritin  g  shards  specified
  by  tableinfo ,  that  is ,  the  meaning  of  INSERT
OVERWRITE .  Parameter  false  indicates  the  meaning  of
INSERT  INTO
job . addOutput ( TableInfo . builder (). tableName (" table_name ").
partSpec (" pt1 = a / pt2 = b "). lable (" output1 "). build (),
true );
```

Note:

- For more information about the job output definition, see the description of the addOutput() method in GraphJob.
- When a Graph job runs, records can be written to an output table using the write () method of WorkerContext. Labels must be specified for multiple outputs, such as “output1” in the preceding section.
- For more information, see Application limits.

Read resources

- Add resources to the graph program

  In addition to JAR commands, you can use the following two methods of GraphJob to specify resources read by Graph:

```
void   addCacheRe  sources ( String   resourceNa  mes )
void   addCacheRe  sourcesToC  lassPath ( String   resourceNa  mes
)
```

- Use resources in the graph program

  To read resources in the Graph program, follow these steps:

```
public   byte []  readCacheF  ile ( String   resourceNa  me )
throws   IOExceptio  n ;
                                    public   Iterable < byte
[]>  readCacheA  rchive ( String   resourceNa  me )  throws
IOExceptio  n ;
                                    public   Iterable < byte
[]>  readCacheA  rchive ( String   resourceNa  me ,  String
relativePa  th ) throws   IOExceptio  n ;
                                    public   Iterable < WritableRe
cord >  readResour  ceTable ( String   resourceNa  me );
public   BufferedIn  putStream   readCacheF  ileAsStrea  m ( String
  resourceNa  me )  throws   IOExceptio  n ;
public   Iterable < BufferedIn  putStream >  readCacheA
rchiveAsSt  ream ( String   resourceNa  me )  throws   IOExceptio
n ;
public   Iterable < BufferedIn  putStream >  readCacheA
rchiveAsSt  ream ( String   resourceNa  me ,  String   relativePa
th )  throws   IOExceptio  n ;
```

Note:

- Resources are generally read using the setup() method of WorkerComputer, stored in Worker Value, and obtained using the getWorkerValue() method.
- To reduce overall memory consumption, use the preceding stream APIs so that resources can be read and processed simultaneously.
- For more information , see Application limits.

10.4 SDK summary

Maven users can search for odps-sdk-graph in the Maven database to get the required SDK (available in different versions). The configuration information is as follows:

```
< dependency >
    < groupId > com . aliyun . odps </ groupId >
    < artifactId > odps - sdk - graph </ artifactId >
    < version > 0 . 20 . 7 </ version >
```

```
</ dependency >
```

Main interface	Description
GraphJob	GraphJob is inherited from JobConf and is used to define, submit, and manage a MaxCompute Graph job.
Vertex	A vertex is a node that is defined by the attributes including ID, value, halted, and edges. A vertex is implemented by the setVertexClass interface of GraphJob.
Edge	Edge is the abstract of edges in a graph, including the attributes destVertexId and value. Adjacent tables are used as the graph data structure, and outbound edges of a vertex are stored in edges of the vertex.
GraphLoader	GraphLoader is used to load graphs. GraphLoader is implemented by using the setGraphLoaderClass interface of GraphJob.
VertexResolver	VertexResolver is used to customize the conflict processing logic to modify graph topology. The setLoadingVertexReso lverClass and setComputingVertexResolverClass interfaces of GraphJob provide the conflict processing logic for graph topology modification during graph loading and iteration calculation.
Partitioner	Partitioner is used to partition a graph so that the calculatio ns can be fragmented. Partitioner is implemented by using the setPartitionerClass interface of GraphJob. HashPartitioner is used by default, that is, the hash value of a vertex ID is calculated and then a modulo operation is performed for the number of Workers.
WorkerComputer	WorkerComputer allows a Worker to run a custom logic during startup and exit. WorkerComputer is implemented by using the setWorkerComputerClass interface of a GraphJob.
Aggregator	setAggregatorClass(Class …) defines one or multiple Aggregators.
Combiner	setCombinerClass sets a Combiner.
Counters	Indicates a counter. In job running logic, the WorkerContext interface can be used to obtain counters and perform counting . The framework automatically sums up the result.
WorkerContext	Indicates the context object. It encapsulates functions provided by the framework, such as modifying a graph topology, sending a message, writing a result, and reading a resource.

10.5 Development and debugging

MaxCompute does not provide Graph development plugins for users. However, you can develop the MaxCompute Graph program based on Eclipse. The development process is as follows:

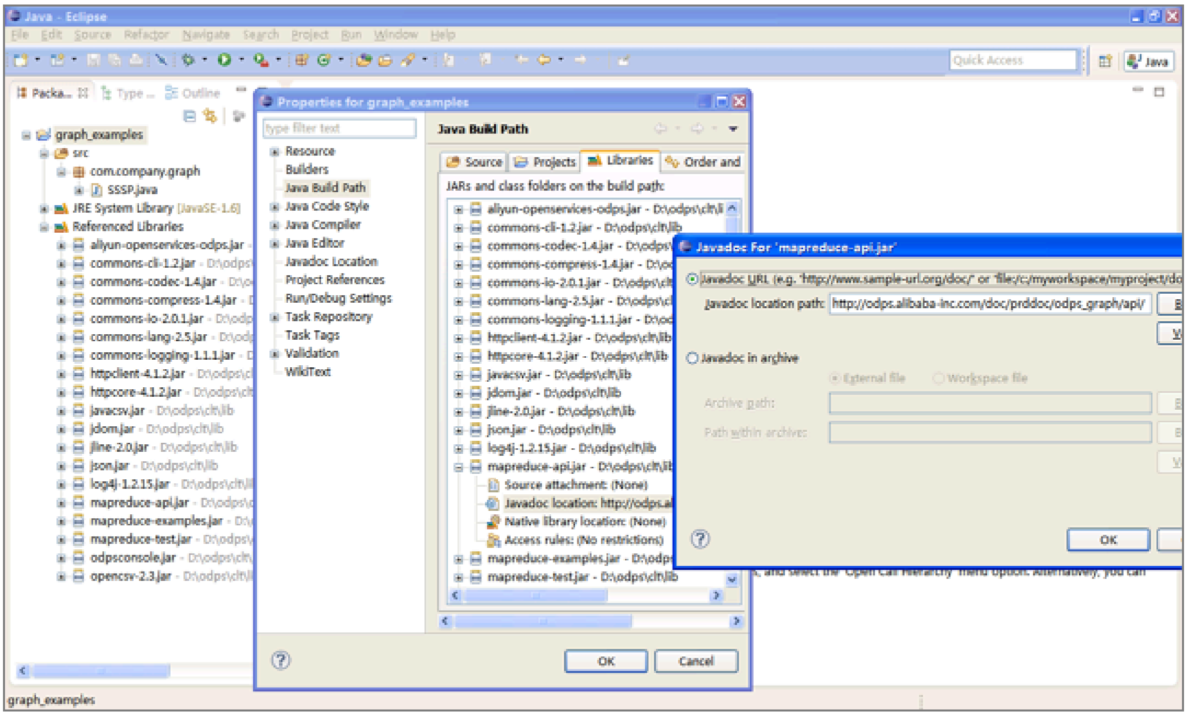
1. Compile Graph codes and perform basic tests using local debugging.
2. Perform cluster debugging and verify the result.

Example

This section uses the SSSP algorithm as an example to describe how to use Eclipse to develop and debug a Graph program.

Procedure

1. Create a Java project, for example, graph_examples.
2. 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:



3. Develop a MaxCompute Graph program.

   In the actual development process, an example (such as SSSP) is often copied and then modified. In this example, only the package path is changed to package com.aliyun.odps.graph.example.

4. Compile and build the package.

   In an Eclipse environment, right-click the source code directory (the src directory in the figure) and select Export > Java > JAR file to generate a JAR package. Select the path for storing the target JAR package, for example, `D :\\ odps \\ clt \\ odps - graph - example - sssp . jar`.

5. Use the MaxCompute console to run SSSP. For more information about the related operations, see Run Graph in "Quick start".

> **Note:**
> For more information about the related development procedure, see Introduction on the Graph development plug-in.

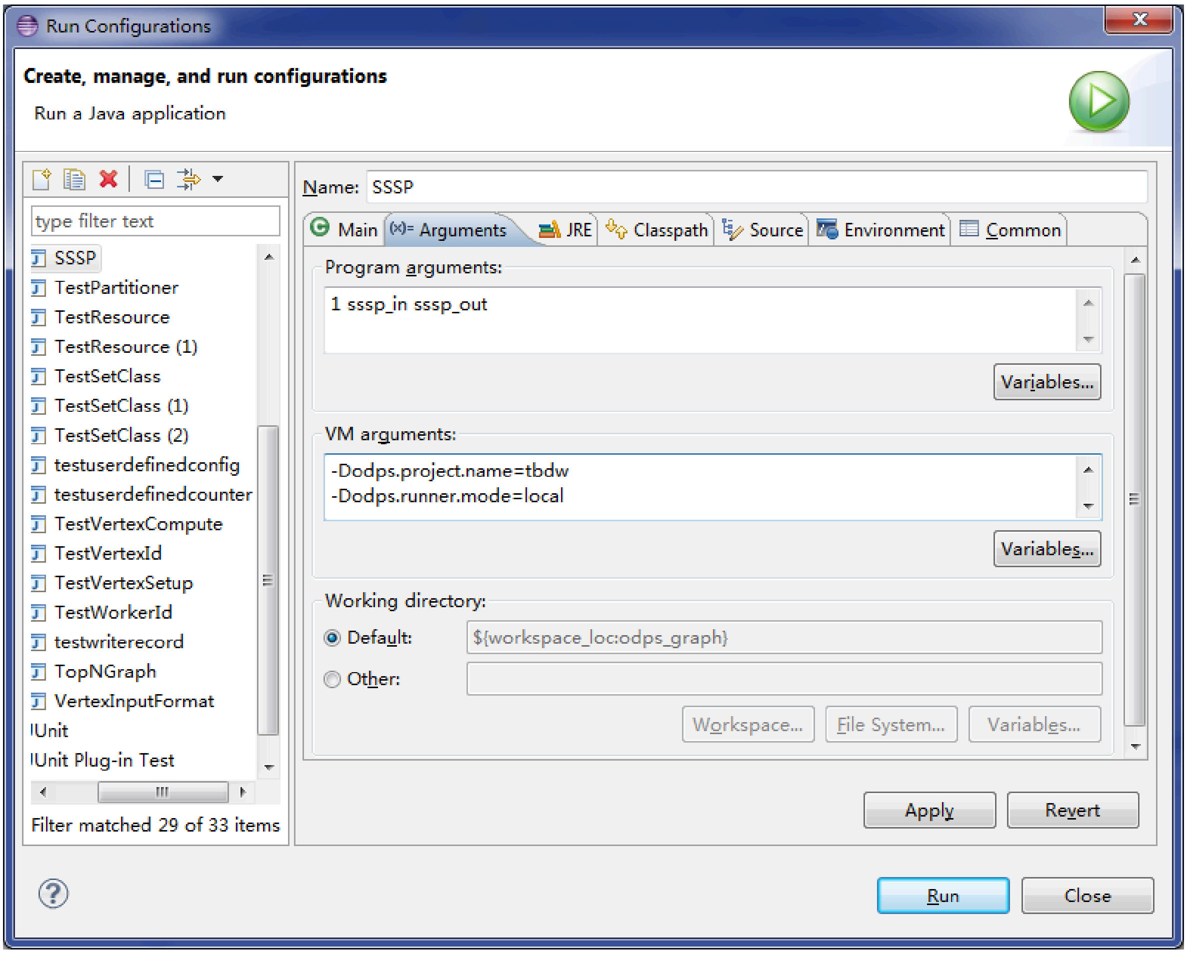
Local debugging

MaxCompute Graph supports the local debugging mode. Use Eclipse to perform breakpoint debugging.

Procedure

1. Download an odps-graph-local maven package.
2. Select the Eclipse project, right-click the main program file (including the main function) of the Graph job, and configure its running parameters (by selecting Run As > Run Configurations).
3. On the Arguments tab page, set Program arguments to `1 sssp_in sssp_out` as the input parameter of the main program.
4. On the Arguments tab page, set VM arguments to the following:

```
- Dodps . runner . mode = local
- Dodps . project . name =< project . name >
- Dodps . end . point =< end . point >
- Dodps . access . id =< access . id >
- Dodps . access . key =< access . key >
```



5. If MapReduce is in local mode (the value of odps.end.point is not specified), you must create the sssp_in and sssp_out tables in the warehouse and add data for sssp_in. Input data is listed as follows:

```
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 "
```

For more information about the warehouse, see MapReduce local running.

6. Click Run.

Note:

Check the settings of conf/odps_config.ini in the MaxCompute client to set parameters. The preceding parameters are commonly used. Other parameters are described as follows:

- odps.runner.mode: The parameter value is local. This parameter is required for the local debugging function.
- odps.project.name: (Required). Specifies the current project.
- odps.end.point: (Optional). Specifies the address of the current MaxCompute service. If this parameter is not specified, metadata of tables or resources is only read from the warehouse, and an exception is thrown when the address does not exist. If this parameter is specified, data is read from the warehouse first, and then from remote MaxCompute if the address does not exist.
- odps.access.id: Indicates the ID to connect to the MaxCompute service. This parameter is valid only when odps.end.point is specified.
- odps.access.key: Indicates the key to connect to the MaxCompute service. This parameter is valid only when odps.end.point is specified.
- odps.cache.resources: Specifies the resource list in use. This parameter has the same effect as -resources of the JAR command.
- odps.local.warehouse: Specifies the local warehouse path. This parameter is set to ./warehouse by default ,if not specified.

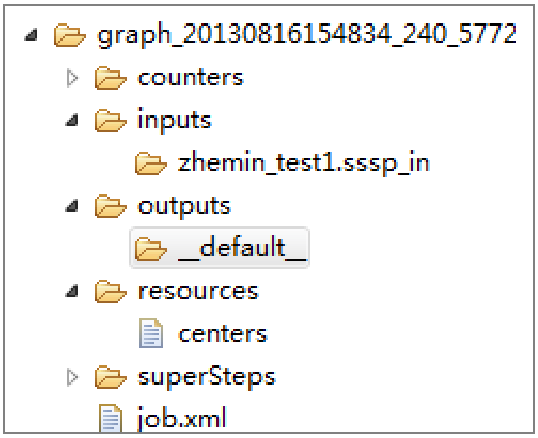
After SSSP debugging is implemented locally in Eclipse, the following information is output:

```
Counters :  3
         com . aliyun . odps . graph . local . COUNTER
                 TASK_INPUT  _BYTE = 211
                 TASK_INPUT  _RECORD = 5
                 TASK_OUTPU  T_BYTE = 161
                 TASK_OUTPU  T_RECORD = 5
 graph   task   finish
```

Note:
In the preceding example, the sssp_in and sssp_out tables must exist in the local warehouse. For more information about the sssp_in and sssp_out tables, see Run Graph in “Quick start” .

Temporary directory of local job

A temporary directory is created in the Eclipse project directory when local debugging runs each time, as shown in the following figure.



The temporary directory of a locally running Graph job contains the following directories and files:

- counters: Stores counting information about job running.
- inputs: Stores input data of the job. Data is preferentially obtained from the local warehouse. If such data does not exist locally, the MaxCompute SDK reads data from the server (if odps.end.point is set). An input reads only 10 data records by default. This threshold can be modified in the `- Dodps . mapred . local . record . limit` parameter, of which the maximum value is 10,000.
- outputs: Stores output data of the job. If the local warehouse has an output table , the result data in the outputoverwrites the corresponding table in the local warehouse after job running is complete.
- resources: Stores resources used by the job. Similar to inputs, data is preferentially obtained from the local warehouse. If such data does not exist locally, the data is read from the server using MaxCompute SDK (when odps.end.point is set).
- job.xml: Indicates job configuration.
- superstep: Stores information about message persistence in each iteration.

Note:
If a detailed log must be output during local debugging, the following log4j configuration file must be placed in the src directory: `log4j . properties _odps_grap h_cluster_ debug`.

Cluster debugging

After local debugging, submit the job to a cluster for testing.

Procedure

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 run the job, and view the running log and result data.

> **Note:**
> For more information about how to run Graph in a cluster, see Run Graph in "Quick start".

Performance Tuning

The following section describes common performance tuning methods on the MaxCompute Graph framework.

Job Parameter configuration

GraphJob configurations that have an impact on performance include:

- setSplitSize(long): Indicates the split size of an input table. The unit is in MB. Its value must be greater than 0, and the default value is 64.
- setNumWorkers(int): Specifies the number of Workers for a job. The value range is [1, 1000], and the default value is -1. The number of Workers varies depending on the number of input bytes of the job and split size.
- setWorkerCPU(int): Indicates CPU resources of the Map. A one-core CPU contains 100 resources. The value range is [50, 800], and the default value is 200.
- setWorkerMemory(int): Indicates memory resources of the Map. The unit is MB. The value range is [256 MB, 12 GB], and the default value is 4,096 MB.
- setMaxIteration(int): Specifies the maximum number of iterations. The default value is -1. If the value is smaller than or equal to 0, the maximum number of iterations is not a condition for job termination.
- setJobPriority(int): Specifies the job priority. The value range is [0, 9], and the default value is 9. A larger value indicates a smaller priority.

Additional actions that increase overall processing capabilities are as follows:

- You can use the setNumWorkers() method to increase the number of Workers.
- You can use the setSplitSize() method to reduce the split size and increase the speed for a job to load data.
- Increase the CPU or memory of Workers.

- Set the maximum number of iterations. If applications do not have high requirements on result precision, you can reduce the number of iterations to speed up the process.

The interfaces setNumWorkers and setSplitSize can be used together to speed up data loading. Assume that setNumWorkers is workerNum and setSplitSize is splitSize, and the total number of input bytes is inputSize. The number of splits is calculated using the formula: splitNum = inputSize /splitSize. The relationship between workerNum and splitNum is as follows:

- If splitNum == workerNum, each Worker is responsible for loading one split.
- If splitNum > workerNum, each Worker is responsible for loading one or multiple splits.
- If splitNum < workerNum, each Worker is responsible for loading zero or one split.

Therefore, if the first two conditions are met, you can adjust workerNum and splitSize to enable fast data loading. In the iteration phase, you only need to adjust workerNum.

If you set runtime partitioning to false, we recommend that you use setSplitSize to control the number of Workers. Regarding the third condition, the number of vertices on some Worker may be 0. You can use set odps.graph.split.size=<m>; set odps.graph.worker.num=<n>; before the JAR command, which has the same effect as setNumWorkers and setSplitSize.

Another common performance problem is data skew. For example, on Counters, the number of vertices or edges processed by some Workers is much greater than that processed by other Workers.

Data skew occurs usually when the number of vertices, edges, or messages corresponding to some keys is much greater than that corresponding to other keys. Such keys with the large data volume are processed by a small number of Workers, resulting in a long run time of these Workers.

To resolve this problem, we recommend the following steps:

- Use a combiner to locally aggregate messages of vertices corresponding to such keys to reduce the number of sent messages.
- Improve the service logic.

Use a Combiner

Define a Combiner to reduce memory that stores messages and network data traffic volume and shortens the job execution time. For more information, see introduction to Combiner in MaxCompute SDK.

Reduce the Data Input Volume

When the data volume is large, reading data in a disk may extend the processing time. Therefore, reducing the number of data bytes to be read can increase the overall throughput, thereby improving job performance. You can use either of the following methods:

- Reduce the input data volume: For decision-making applications, results obtained from processing subsets after data sampling only affect the result precision, instead of the overall accuracy. Therefore, you can perform special data sampling and import the data to the input table for processing.
- Avoid reading fields that are not used: The TableInfo class of the MaxCompute Graph framework supports reading specific columns (transmitted using column name arrays), rather than reading the entire table or table partition. This reduces the input data volume and improves job performance.

Built-in JAR Packages

The following JAR packages are loaded to JVMs running the Graph program by default. You do not have to upload these resources or carry these JAR packages when running -libjars on the command line.

- 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

Note:

In a classpath that runs a JVM, the preceding built-in JAR packages are placed before users' JAR packages, which may result in a version conflict. For example, if your program uses a function of a class in commons-codec-1.5.jar but this function is not in commons-codec-1.3.jar. Check whether an implementation method exists in commons-codec-1.3.jar or wait for MaxCompute to upgrade to a supported version.

10.6 Limits

The limits of MaxCompute Graph are as follows:

- Each job can reference up to 256 resources. A table or an archive is considered as one unit (that is, one resource).
- The total number of bytes of resources referenced by one job cannot exceed 512 MB. Each job can reference up to 512 MB of bytes of resources.
- The number of inputs of one job cannot exceed 1,024. and the number of input tables cannot exceed 64. The number of outputs of one job cannot exceed 256.
- A label can be up to 256 characters in length and can contain letters, numbers, and special characters including underscores (_), pound signs (#), periods (.), and hyphens (-). Labels specified for multiple outputs cannot be null or empty strings.
- Each job can have up to 64 custom counters. The group name and counter name can be up to 100 characters in length. The names cannot contain pound signs (#).
- The number of Workers of one job is calculated by the framework. The maximum number is 1,000. If this threshold value is exceeded, an exception is thrown.
- One Worker occupies 200 resources of the CPU by default. The range is [50, 800].
- One Worker occupies 4096 MB of the memory by default. The range is [256 MB, 12 GB].
- A threshold for a Worker to read a resource repeatedly is 64.
- The split size can be set, however,as64 MB is the by default size.. The range is 0 < split_size <= (9223372036854775807 >> 20).
- In the MaxCompute Graph program, GraphLoader/Vertex/Aggregator running in a cluster is restricted by the Java sandbox. (The main program of Graph jobs is not restricted.) For more information about the restrictions, see Java sandbox.

10.7 Examples

10.7.1 SSSP

Dijkstra is a typical algorithm that calculates the Single Source Shortest Path (SSSP) in a directed graph.

For weighted directed graph G=(V,E), many paths are routed from source vertex s to sink vertex v. In these paths, the one that has the smallest edge weight sum is called the shortest distance from s to v.

The basic concept of the algorithm is as follows:

- Initialization: The distance from source vertex s to s itself is zero (d[s] = 0), and the distance from another vertex u to s is infinite (d[u]=∞).
- Iteration: If an edge exists from u to v, the shortest distance from s to v is updated as: d[v] = min(d[v], d[u] + weight(u, v)). The iteration ends until the distance from all vertices to s does not change.

The basic concept shows that the algorithm is applicable to solutions using 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 vertex. In the next iteration, the adjacent vertex updates the current shortest distance based on the received message. The iteration ends when the current shortest distance of all vertices does not change.

Sample Code

Code of SSSP is as follows:

```
import   java . io . IOExceptio  n ;

import   com . aliyun . odps . io . WritableRe  cord ;
import   com . aliyun . odps . graph . Combiner ;
import   com . aliyun . odps . graph . ComputeCon  text ;
import   com . aliyun . odps . graph . Edge ;
import   com . aliyun . odps . graph . GraphJob ;
import   com . aliyun . odps . graph . GraphLoade  r ;
import   com . aliyun . odps . graph . MutationCo  ntext ;
import   com . aliyun . odps . graph . Vertex ;
import   com . aliyun . odps . graph . WorkerCont  ext ;
import   com . aliyun . odps . io . LongWritab  le ;
import   com . aliyun . odps . data . TableInfo ;

public   class   SSSP  {

  public   static   final   String   START_VERT  EX  = " sssp . start
. vertex . id ";

  public   static   class   SSSPVertex   extends
      Vertex < LongWritab  le ,  LongWritab  le ,  LongWritab  le ,
LongWritab  le > {
```

```
    private   static   long   startVerte  xId  = - 1 ;

    public   SSSPVertex () {
      this . setValue ( new   LongWritab  le ( Long . MAX_VALUE ));


    public   boolean   isStartVer  tex (
        ComputeCon  text < LongWritab  le ,  LongWritab  le ,
LongWritab  le ,  LongWritab  le >  context ) {
      if  ( startVerte  xId  == - 1 ) {
        String   s  =  context . getConfigu  ration (). get (
START_VERT  EX );
        startVerte  xId  =  Long . parseLong ( s );

      return   getId (). get () ==  startVerte  xId ;


   @ Override
    public   void   compute (
        ComputeCon  text < LongWritab  le ,  LongWritab  le ,
LongWritab  le ,  LongWritab  le >  context ,
        Iterable < LongWritab  le >  messages )  throws   IOExceptio
n  {
      long   minDist  =  isStartVer  tex ( context ) ?  0  :  Integer
. MAX_VALUE ;
      for  ( LongWritab  le   msg  :  messages ) {
        if  ( msg . get () <  minDist ) {
          minDist  =  msg . get ();



      if  ( minDist  <  this . getValue (). get ()) {
        this . setValue ( new   LongWritab  le ( minDist ));
        if  ( hasEdges ()) {
          for  ( Edge < LongWritab  le ,  LongWritab  le >  e  :
this . getEdges ()) {
            context . sendMessag  e ( e . getDestVer  texId (),  new
  LongWritab  le ( minDist
               +  e . getValue (). get ()));


     }  else  {
        voteToHalt ();



   @ Override
    public   void   cleanup (
        WorkerCont  ext < LongWritab  le ,  LongWritab  le ,
LongWritab  le ,  LongWritab  le >  context )
        throws   IOExceptio  n  {
      context . write ( getId (),  getValue ());



  public   static   class   MinLongCom  biner   extends
      Combiner < LongWritab  le ,  LongWritab  le > {

   @ Override
    public   void   combine ( LongWritab  le   vertexId ,
LongWritab  le   combinedMe  ssage ,
        LongWritab  le   messageToC  ombine )  throws   IOExceptio  n
 {
```

```
      if  ( combinedMe  ssage . get () >  messageToC  ombine . get
()) {
        combinedMe  ssage . set ( messageToC  ombine . get ());




  public   static   class   SSSPVertex  Reader   extends
      GraphLoade  r < LongWritab  le ,  LongWritab  le ,  LongWritab
le ,  LongWritab  le > {

   @ Override
    public   void   load (
        LongWritab  le   recordNum ,
        WritableRe  cord   record ,
        MutationCo  ntext < LongWritab  le ,  LongWritab  le ,
LongWritab  le ,  LongWritab  le >  context )
        throws   IOExceptio  n  {
      SSSPVertex   vertex  =  new   SSSPVertex ();
      vertex . setId (( LongWritab  le )  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   LongWritab  le ( Long . parseLong (
ss [ 0 ])),
            new   LongWritab  le ( Long . parseLong ( ss [ 1 ])));


      context . addVertexR  equest ( vertex );




  public   static   void   main ( String []  args )  throws
IOExceptio  n  {
    if  ( args . length  <  2 ) {
      System . out . println (" Usage : < startnode > < input > <
output >");
      System . exit (- 1 );


    GraphJob   job  =  new   GraphJob ();
    job . setGraphLo  aderClass ( SSSPVertex  Reader . class );
    job . setVertexC  lass ( SSSPVertex . class );
    job . setCombine  rClass ( MinLongCom  biner . class );

    job . set ( START_VERT  EX ,  args [ 0 ]);
    job . addInput ( TableInfo . builder (). tableName ( args [ 1 ]).
build ());
    job . addOutput ( TableInfo . builder (). tableName ( args [ 2
]). build ());

    long   startTime  =  System . currentTim  eMillis ();
    job . run ();
    System . out . println (" Job   Finished   in  "
       + ( System . currentTim  eMillis () -  startTime ) /  1000 . 0
 + "  seconds ");
```

The source code of SSSP is described as follows:

- Row 19: Defines 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.
- Row 58: If the vertex value does not change, voteToHalt() is called to notify the framework that this vertex enters the halt status. The calculation ends when all vertices enter the halt state.
- Row 70: Defines MinLongCombiner and combines messages sent to the same vertex to optimize performance and reduce memory usage.
- Row 83: Defines the SSSPVertexReader class, loads a graph, and resolves each record in the table into a vertex. The first column of the record is the vertex ID, and the second column stores all edge sets starting from the vertex, such as 2:2, 3:1, 4:4 .
- Row 106: Runs the main program (main function), defines GraphJob, and specifies the implementation of Vertex/GraphLoader/Combiner, and the input and output tables.

10.7.2 PageRank

PageRank is a typical algorithm used to calculate the web page ranking. In the input directed graph G, vertices indicate web pages. If a link exists between web pages A and B, an edge connecting A and B exists.

The basic concept of the algorithm is as follows:

- Initialization: The vertex value indicates the rank value (of the double type) of PageRank. In the initial phase, the value of all vertices is 1/TotalNumVertices.
- Iteration formula: PageRank(i) = 0.15/TotalNumVertices + 0.85 x sum. Sum indicates the sum of PageRank(j)/out_degree(j). (j indicates all vertices pointing to vertex i.)

The basic concept shows that the algorithm is applicable to solutions using the MaxCompute Graph program. Each vertex j maintains the value of PageRank. PageRank(j)/out_degree(j) is sent to the adjacent vertex (for voting) in each iteration.

In the next iteration, each vertex recalculates the PageRank value using the iteration formula.

Sample Code

```
import   java . io . IOExceptio  n ;

import   org . apache . log4j . Logger ;

import   com . aliyun . odps . io . WritableRe  cord ;
import   com . aliyun . odps . graph . ComputeCon  text ;
import   com . aliyun . odps . graph . GraphJob ;
import   com . aliyun . odps . graph . GraphLoade  r ;
import   com . aliyun . odps . graph . MutationCo  ntext ;
import   com . aliyun . odps . graph . Vertex ;
import   com . aliyun . odps . graph . WorkerCont  ext ;
import   com . aliyun . odps . io . DoubleWrit  able ;
import   com . aliyun . odps . io . LongWritab  le ;
import   com . aliyun . odps . io . NullWritab  le ;
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 );

  public   static   class   PageRankVe  rtex   extends
      Vertex < Text ,  DoubleWrit  able ,  NullWritab  le ,
DoubleWrit  able > {

   @ Override
    public   void   compute (
        ComputeCon  text < Text ,  DoubleWrit  able ,  NullWritab  le
,  DoubleWrit  able >  context ,
        Iterable < DoubleWrit  able >  messages )  throws
IOExceptio  n  {
      if  ( context . getSuperst  ep () ==  0 ) {
        setValue ( new   DoubleWrit  able ( 1 . 0  /  context .
getTotalNu  mVertices ()));
     }  else   if  ( context . getSuperst  ep () >=  1 ) {
        double   sum  =  0 ;
        for  ( DoubleWrit  able   msg  :  messages ) {
          sum  +=  msg . get ();

        DoubleWrit  able   vertexValu  e  =  new   DoubleWrit  able (
           ( 0 . 15f  /  context . getTotalNu  mVertices ()) +  0 .
85f  *  sum );
        setValue ( vertexValu  e );

      if  ( hasEdges ()) {
        context . sendMessag  eToNeighbo  rs ( this ,  new
DoubleWrit  able ( getValue ()
           . get () /  getEdges (). size ()));



   @ Override
    public   void   cleanup (
        WorkerCont  ext < Text ,  DoubleWrit  able ,  NullWritab  le
,  DoubleWrit  able >  context )
```

```
        throws   IOExceptio  n  {
      context . write ( getId (),  getValue ());



  public   static   class   PageRankVe  rtexReader   extends
      GraphLoade  r < Text ,  DoubleWrit  able ,  NullWritab  le ,
DoubleWrit  able > {

   @ Override
    public   void   load (
        LongWritab  le   recordNum ,
        WritableRe  cord   record ,
        MutationCo  ntext < Text ,  DoubleWrit  able ,  NullWritab
le ,  DoubleWrit  able >  context )
        throws   IOExceptio  n  {
      PageRankVe  rtex   vertex  =  new   PageRankVe  rtex ();
      vertex . setValue ( new   DoubleWrit  able ( 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 ( NullWritab  le . get ()))) {
          vertex . addEdge ( new   Text ( edge . toString ()),
NullWritab  le . get ());


      LOG . info (" vertex   edgs   size : "
         + ( vertex . hasEdges () ?  vertex . getEdges (). size () :
0 ));
      context . addVertexR  equest ( 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
IOExceptio  n  {
    if  ( args . length  <  2 )
      printUsage ();

    GraphJob   job  =  new   GraphJob ();

    job . setGraphLo  aderClass ( PageRankVe  rtexReader . class );
    job . setVertexC  lass ( PageRankVe  rtex . class );
    job . addInput ( TableInfo . builder (). tableName ( args [ 0 ]).
build ());
    job . addOutput ( TableInfo . builder (). tableName ( args [ 1
]). build ());

   //  default   max   iteration   is   30
    job . setMaxIter  ation ( 30 );
    if  ( args . length  >=  3 )
      job . setMaxIter  ation ( Integer . parseInt ( args [ 2 ]));

    long   startTime  =  System . currentTim  eMillis ();
    job . run ();
```

```
    System . out . println (" Job   Finished   in  "
        + ( System . currentTim  eMillis () -  startTime ) /  1000 . 0
 + "  seconds ");
```

The source code of PageRank is described as follows:

- Row 23: 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 / TotalNumVe  rtices  +  0 . 85   x   sum` to update the vertex value.
  - The cleanup() method writes the vertex and its PageRank value to the result table.
- Row 55: Defines the PageRankVertexReader class, loads a graph, and resolves each record in the table into a vertex. The first column of the record is the start vertex and other columns are the destination vertices.
- Row 88: Runs the main program (main function), defines GraphJob, and specifies the implementation of Vertex/GraphLoader, the maximum number of iterations (30 by default), and input and output tables.

10.7.3 Kmeans

The Kmeans algorithm is a typical clustering algorithm.

It performs clustering by using k number of vertices in the space as the centers and grouping the vertices closest to them. The values of the clustering centers are successively updated through iterations until the optimal clustering result is obtained .

To divide a sample set into k classes, the algorithm operates as follows:

1. Selects the initial centers of k classes.
2. Calculates the distance from any sample to the k centers in iteration i, and groups the sample to the class of the nearest center.
3. Updates the center value of the class using the mean and other methods.
4. For all k clustering centers, if the value updated after iterations remains unchanged or is smaller than a threshold, the iteration ends. Otherwise, the iteration continues.

Sample Code

Code for the K-means clustering algorithm is as follows:

```
import   java . io . DataInput ;
import   java . io . DataOutput ;
import   java . io . IOExceptio  n ;

import   org . apache . log4j . Logger ;

import   com . aliyun . odps . io . WritableRe  cord ;
import   com . aliyun . odps . graph . Aggregator ;
Import   com .  aliyun .  ODPS .  graph .  computerco  ntext ;
import   com . aliyun . odps . graph . GraphJob ;
import   com . aliyun . odps . graph . GraphLoade  r ;
import   com . aliyun . odps . graph . MutationCo  ntext ;
import   com . aliyun . odps . graph . Vertex ;
import   com . aliyun . odps . graph . WorkerCont  ext ;
import   com . aliyun . odps . io . DoubleWrit  able ;
import   com . aliyun . odps . io . LongWritab  le ;
import   com . aliyun . odps . io . NullWritab  le ;
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 );

  public   static   class   KmeansVert  ex   extends
  Vertex < Text ,  Tuple ,  NullWritab  le ,  NullWritab  le > {

   @  Override
    public   void   compute (
    ComputeCon  text < Text ,  Tuple ,  NullWritab  le ,  NullWritab
le >  context ,
    Iterable < NullWritab  le >  messages )  throws   IOExceptio  n
{
      context . aggregate ( getValue ());
   }



  public   static   class   KmeansVert  exReader   extends
  GraphLoade  r < Text ,  Tuple ,  NullWritab  le ,  NullWritab  le >
{
   @ Override
    public   void   load ( LongWritab  le   recordNum ,  WritableRe
cord   record ,
    MutationCo  ntext < Text ,  Tuple ,  NullWritab  le ,
NullWritab  le >  context )
        throws   IOExceptio  n  {
      KmeansVert  ex   vertex  =  new   KmeansVert  ex ();
      vertex . setId ( new   Text ( String . valueOf ( recordNum .
get ())));
      vertex . setValue ( new   Tuple ( record . getAll ()));
      context . addVertexR  equest ( vertex );
```

```
  public   static   class   KmeansAggr  Value   implements   Writable
 {

    Tuple   centers  =  new   Tuple ();
    Tuple   sums  =  new   Tuple ();
    Tuple   counts  =  new   Tuple ();

   @  Override
    public   void   write ( DataOutput   out )  throws   IOExceptio
n  {
      centers . write ( out );
      sums . write ( out );
      counts . write ( out );


   @ Override
    public   void   readFields ( DataInput   in )  throws
IOExceptio  n  {
      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 ();




public   static   class   KmeansAggr  egator   extends   Aggregator <
KmeansAggr  Value > {

   @ SuppressWa  rnings (" rawtypes ")
   @ Override
    public   KmeansAggr  Value   createInit  ialValue ( WorkerCont
ext   context )
        throws   IOExceptio  n  {
      KmeansAggr  Value   aggrVal  =  null ;
      if  ( context . getSuperst  ep () ==  0 ) {
        aggrVal  =  new   KmeansAggr  Value ();
        aggrVal . centers  =  new   Tuple ();
        aggrVal . sums  =  new   Tuple ();
        aggrVal . counts  =  new   Tuple ();

        byte []  centers  =  context . readCacheF  ile (" 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   DoubleWrit  able ( Double .
valueOf ( ss [ j ]. trim ())));
            sum . append ( new   DoubleWrit  able ( 0 . 0 ));

          LongWritab  le   count  =  new   LongWritab  le ( 0 );
```

```
          aggrVal . sums . append ( sum );
          aggrVal . counts . append ( count );
          aggrVal . centers . append ( center );

     }  else  {
        aggrVal  = ( KmeansAggr  Value )  context . getLastAgg
regatedVal  ue ( 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  = (( DoubleWrit  able )  point . get ( j )).
get ()
             - (( DoubleWrit  able )  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 ++) {
        DoubleWrit  able   s  = ( DoubleWrit  able )  sum . get ( i
);
        s . set ( s . get () + (( DoubleWrit  able )  point . get ( i
)). get ());

      LongWritab  le   count  = ( LongWritab  le )  value . counts .
get ( min );
      count . set ( count . get () +  1 );


   @ Override
    public   void   merge ( KmeansAggr  Value   value ,  KmeansAggr
Value   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 ++) {
          DoubleWrit  able   s  = ( DoubleWrit  able )  sum . get ( j
);
          s . set ( s . get () + (( DoubleWrit  able )  that . get (
j )). get ());



for  ( int   i  =  0 ;  i  <  value . counts . size ();  i ++) {
```

```
        LongWritab  le   count  = ( LongWritab  le )  value . counts
. get ( i );
        count . set ( count . get () + (( LongWritab  le )  partial .
counts . get ( i )). get ());



   @ SuppressWa  rnings (" rawtypes ")
   @ Override
    public   boolean   terminate ( WorkerCont  ext   context ,
KmeansAggr  Value   value )
        throws   IOExceptio  n  {

     //  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 ());
        LongWritab  le   c  = ( LongWritab  le )  value . counts .
get ( i );
        for  ( int   j  =  0 ;  j  <  sum . size ();  j ++) {

          DoubleWrit  able   s  = ( DoubleWrit  able )  sum . get ( j
);
          double   val  =  s . get () /  c . get ();
          newCenter . set ( j ,  new   DoubleWrit  able ( 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  = (( DoubleWrit  able )  newCenter . get ( j
)). get ()
             - (( DoubleWrit  able )  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 . getSuperst  ep () ==  context .
 getMaxIter  ation () -  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 );


   public   static   void   main ( String []  args )  throws
 IOExceptio  n  {
   if  ( args . length  <  2 )
       printUsage ();

     GraphJob   job  =  new   GraphJob ();

     job . setGraphLo  aderClass ( KmeansVert  exReader . class );
     job . setRuntime  Partitioni  ng ( false );
     job . setVertexC  lass ( KmeansVert  ex . class );
     job . setAggrega  torClass ( KmeansAggr  egator . class );
     job . addInput ( TableInfo . builder (). tableName ( args [ 0 ]).
 build ());
     job . addOutput ( TableInfo . builder (). tableName ( args [ 1
 ]). build ());

    //  default   max   iteration   is   30
     job . setMaxIter  ation ( 30 );
     if  ( args . length  >=  3 )
       job . setMaxIter  ation ( Integer . parseInt ( args [ 2 ]));

     long   start  =  System . currentTim  eMillis ();
     job . run ();
     System . out . println (" Job   Finished   in  "
        + ( System . currentTim  eMillis () -  start ) /  1000 . 0  +
 "  seconds ");
```

The source code of Kmeans is described as follows:

- Row 26: Defines KmeansVertex. The compute() method is simple. It calls the aggregate() method of the context object and transmits the value of the current vertex (in Tuple type and expressed by vector).

- Row 38: Defines the KmeansVertexReader class, loads a graph, and resolves each record in the table as a vertex. The vertex ID does not matter, and transmitted recordNum is used as the ID. The vertex value is the Tuple consisting of all columns of the record.
- Row 83: 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 (superstep 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 the 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 center point based on sum and count of each class. If the distance between the new and old center points is smaller than a threshold value or the number of iterations reaches the upper limit, the iteration ends (false is returned). The final center point is written to the result table.
- Row 236: Runs the main program (main function), defines GraphJob, and specifies the implementation of Vertex/GraphLoader/Aggregator, the maximum number of iterations (30 by default), and the input and output tables.
- Row 243: Specifies job.setRuntimePartitioning(false). For the Kmeans algorithm, vertices do not have to be distributed during graph loading. If RuntimePartitioning is set to false, the performance for graph loading is improved.

10.7.4 BiPartiteMatchiing

A Bipartite graph means all the graph vertices can be separated into 2 sets, and 2 vertices corresponding to each Edge belong to the 2 sets respectively. For bipartite graph G, M is one of its sub-graphs. If any two edges in the edge set of M are not attached to the same vertex, M is called a matching. The bipartite graph matching is usually used for information matching in scenarios with clear supply and demand relationships.

The basic concept of the algorithm is as follows:

- From the first vertex on the left, unmatched vertices are selected to search for the augmenting path.
- If an unmatched vertex is found, the search is successful.
- The path information is updated. If the number of matching edges is increased by 1 , the search is stopped.
- If the augmenting path is not found, the search is no longer started from this vertex.

Sample Code

BiPartiteMatchiing The code of the algorithm is as follows:

```
import   java . io . DataInput ;
import   java . io . DataOutput ;
import   java . io . IOExceptio  n ;
import   java . util . Random ;
import   com . aliyun . odps . data . TableInfo ;
import   com . aliyun . odps . graph . ComputeCon  text ;
import   com . aliyun . odps . graph . GraphJob ;
import   com . aliyun . odps . graph . MutationCo  ntext ;
import   com . aliyun . odps . graph . WorkerCont  ext ;
import   com . aliyun . odps . graph . Vertex ;
import   com . aliyun . odps . graph . GraphLoade  r ;
import   com . aliyun . odps . io . LongWritab  le ;
import   com . aliyun . odps . io . NullWritab  le ;
import   com . aliyun . odps . io . Text ;
import   com . aliyun . odps . io . Writable ;
import   com . aliyun . odps . io . WritableRe  cord ;
public   class   BipartiteM  atching  {
  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   IOExceptio
n  {
      first . write ( out );
      second . write ( out );

   @  Override
    public   void   readFields ( DataInput   in )  throws
IOExceptio  n  {
      first  =  new   Text ();
      first . readFields ( in );
      second  =  new   Text ();
      second . readFields ( in );

   @  Override
```

```
    public   String   toString () {
      return   first  + ": " +  second ;


  public   static   class   BipartiteM  atchingVer  texReader
extends
      GraphLoade  r < Text ,  TextPair ,  NullWritab  le ,  Text > {
   @  Override
    public   void   load ( LongWritab  le   recordNum ,  WritableRe
cord   record ,
        MutationCo  ntext < Text ,  TextPair ,  NullWritab  le ,
Text >  context )
        throws   IOExceptio  n  {
      BipartiteM  atchingVer  tex   vertex  =  new   BipartiteM
atchingVer  tex ();
      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 . addVertexR  equest ( vertex );


  public   static   class   BipartiteM  atchingVer  tex   extends
  Vertex  < Text ,  TextPair ,  NullWritab  le ,  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  (
    ComputeCon  text < Text ,  TextPair ,  NullWritab  le ,  Text >
context ,
        Iterable   messages )  throws   ioexceptio  n  {
      if  ( isMatched ()) {
        voteToHalt ();
        return ;

      switch  (( int )  context . getSuperst  ep () %  4 ) {
      case   0 :
        if  ( isLeft ()) {
          context . sendMessag  eToNeighbo  rs ( 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 . sendMessag  e ( 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 ) {
            setMatchVe  rtex ( luckyRight );
            context . sendMessag  e ( luckyRight ,  getId ());


        break ;
      case   3 :
        if  ( isRight ()) {
          for  ( Text   msg  :  messages ) {
            setMatchVe  rtex ( msg );


        break ;


   @  Override
    public   void   cleanup (
    WorkerCont  ext < Text ,  TextPair ,  NullWritab  le ,  Text >
context )
        throws   IOExceptio  n  {
      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   setMatchVe  rtex ( Text   matchVerte  x ) {
      getValue (). first . set ( matchVerte  x );


  private   static   void   printUsage () {
    System . err . println (" BipartiteM  atching  < input > < output
> [ maxIterati  on ]");

  public   static   void   main ( String []  args )  throws
IOExceptio  n  {
    if  ( args . length  <  2 ) {
      printUsage ();

    GraphJob   job  =  new   GraphJob ();
    job . setGraphLo  aderClass ( BipartiteM  atchingVer  texReader .
class );
    job . setVertexC  lass ( BipartiteM  atchingVer  tex . class );
    job . addInput ( TableInfo . builder (). tableName ( args [ 0 ]).
build ());
    job . addOutput ( TableInfo . builder (). tableName ( args [ 1
]). build ());
```

```
    int   maxIterati  on  =  30 ;
    if  ( args . length  >  2 ) {
      maxIterati  on  =  Integer . parseInt ( args [ 2 ]);

    job . setMaxIter  ation ( maxIterati  on );
    job . run ();
```

10.7.5 Strongly-connected component

In a digraph, if by starting from any vertex it reaches every vertex in the graph through Edges, it is called a strongly-connected graph. A strongly-connected subgraph with an extremely large vertex number is called a strongly-connected component. The algorithm is based on Parallel coloring algorithm.

Each vertex contains the following components:

- colorID: Stores the color of vertex v during forward traversal. After a calculation ends, vertices with the same colorID belong to one strongly connected component.
- transposeNeighbors: Stores the neighbor ID of vertex v in the transpose graph of the input graph.

The algorithm contains the following four steps:

- Transpose graph generation: Contains two supersteps. Each vertex sends its ID to its neighbor with the corresponding outbound edge. In the next superstep, these IDs are stored as transposeNeighbors values.
- Trim: Contains one superstep. Each vertex that has only one inbound or outbound edge sets the colorID as its own ID and the status to inactive. Subsequent signals sent to the vertex are ignored.
- Forward traversal: A vertex contains two sub-processes (supersteps): startup and sleep. In the startup phase, each vertex sets the colorID as its own ID and sends the ID to the neighbor with the corresponding outbound edge. In the sleep phase , the vertex uses the maximum colorID it received to update its own colorID, and transmits the colorID until the colorID converges. When the colorID converges, the master process sets the global object to backward traversal.
- Backward traversal: Contains two sub-processes: startup and sleep. In the startup phase, a vertex whose ID is the same as the colorID transmits its ID to the neighbor vertex in the transpose graph, and sets its status to inactive. Subsequent signals sent to the vertex can be ignored. In each sleep step, each vertex receives signals matching its colorID, transmits the colorID in the transpose graph, and then sets

its status to inactive. If active vertices exist after this step ends, the process reverts to the trim step.

Sample Code

The code for strongly connected components is as follows:

```
import   java . io . DataInput ;
import   java . io . DataOutput ;
import   java . io . IOExceptio  n ;
import   com . aliyun . odps . data . TableInfo ;
import   com . aliyun . odps . graph . Aggregator ;
import   com . aliyun . odps . graph . ComputeCon  text ;
import   com . aliyun . odps . graph . GraphJob ;
import   com . aliyun . odps . graph . GraphLoade  r ;
import   com . aliyun . odps . graph . MutationCo  ntext ;
import   com . aliyun . odps . graph . Vertex ;
import   com . aliyun . odps . graph . WorkerCont  ext ;
import   com . aliyun . odps . io . BooleanWri  table ;
import   com . aliyun . odps . io . IntWritabl  e ;
import   com . aliyun . odps . io . LongWritab  le ;
import   com . aliyun . odps . io . NullWritab  le ;
import   com . aliyun . odps . io . Tuple ;
import   com . aliyun . odps . io . Writable ;
import   com . aliyun . odps . io . WritableRe  cord ;

*  Definition   from   Wikipedia :
*  In   the   mathematic  al   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
*  Strictly   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   transposeN  eighbors .

*  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   subsequent  ly   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 transposeN eighbors and sets itself
inactive . Messages
* subsequent ly 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
* subsequent ly 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 StronglyCo nnectedCom ponents {
  public final static int STAGE_TRAN SPOSE_1 = 0 ;
  public final static int STAGE_TRAN SPOSE_2 = 1 ;
  public final static int STAGE_TRIM MING = 2 ;
  public final static int STAGE_FW_S TART = 3 ;
  public final static int STAGE_FW_R EST = 4 ;
  public final static int STAGE_BW_S TART = 5 ;
  public final static int STAGE_BW_R EST = 6 ;

  * The value is composed of component id , incoming
neighbors ,
  * active status and updated status .

  public static class MyValue implements Writable {
    LongWritab le sccID ;// strongly connected component
id
    Tuple inNeighbor s ; // transpose neighbors
    BooleanWri table active ; // vertex is active or not
    BooleanWri table updated ; // sccID is updated or
not
    public MyValue () {
      this . sccID = new LongWritab le ( Long . MAX_VALUE );
      this . inNeighbor s = new Tuple ();
      this . active = new BooleanWri table ( true );
      this . updated = new BooleanWri table ( false );

    public void setSccID ( LongWritab le sccID ) {
      this . sccID = sccID ;

    public LongWritab le getSccID () {
      return this . sccID ;

    public void setInNeigh bors ( Tuple inNeighbor s ) {
      this . inNeighbor s = inNeighbor s ;

    public Tuple getInNeigh bors () {
      return this . inNeighbor s ;

    public void addInNeigh bor ( LongWritab le neighbor ) {
```

```
      this . inNeighbor  s . append ( new   LongWritab  le ( 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   IOExceptio
n  {
      this . sccID . write ( out );
      this . inNeighbor  s . write ( out );
      this . active . write ( out );
      this . updated . write ( out );

   @ Override
    public   void   readFields ( DataInput   in )  throws
IOExceptio  n  {
      this . sccID . readFields ( in );
      this . inNeighbor  s . readFields ( in );
      this . active . readFields ( in );
      this . updated . readFields ( in );

   @ Override
    public   String   toString () {
      StringBuil  der   sb  =  new   StringBuil  der ();
      sb . append (" sccID : " +  sccID . get ());
      sb . append ("  inNeighbor  es : " +  inNeighbor  s .
toDelimite  dString (','));
      sb . append ("  active : " +  active . get ());
      sb . append ("  updated : " +  updated . get ());
      return   sb . toString ();


  public   static   class   SCCVertex   extends
  Vertex  < LongWritab  le ,  MyValue ,  NullWritab  le ,
LongWritab  le > {
    public   SCCVertex () {
      this . setValue ( new   MyValue ());

   @ Override
    public   void   compute (
    ComputeCon  text  <  LongWritab  le ,  MyValue ,  NullWritab  le
,  LongWritab  le >  context ,
    Iterable  < LongWritab  le >  msgs )  throws   IOExceptio  n  {
     //  Messages   sent   to   inactive   vertex   are   ignored .
      if  (!  this . getValue (). isActive ()) {
        this . voteToHalt ();
        return ;

      int   stage  = (( SCCAggrVal  ue ) context . getLastAgg
regatedVal  ue ( 0 )). getStage ();
      switch  ( stage ) {
      case   STAGE_TRAN  SPOSE_1 :
        context . sendMessag  eToNeighbo  rs ( this ,  this . getId
());
```

```
        break ;
      case   STAGE_TRAN  SPOSE_2 :
        for  ( LongWritab  le   msg :  msgs ) {
          this . getValue (). addInNeigh  bor ( msg );

      case   STAGE_TRIM  MING :
        this . getValue (). setSccID ( getId ());
        if  ( this . getValue (). getInNeigh  bors (). size () ==  0
||
            this . getNumEdge  s () ==  0 ) {
          this . getValue (). setActive ( false );

        break ;
      case   STAGE_FW_S  TART :
        this . getValue (). setSccID ( getId ());
        context . sendMessag  eToNeighbo  rs ( this ,  this .
getValue (). getSccID ());
        break ;
      case   STAGE_FW_R  EST :
        long   minSccID  =  Long . MAX_VALUE ;
        for  ( LongWritab  le   msg  :  msgs ) {
          if  ( msg . get () <  minSccID ) {
            minSccID  =  msg . get ();


        if  ( minSccID  <  this . getValue (). getSccID (). get ()) {
          this . getValue (). setSccID ( new   LongWritab  le (
minSccID ));
          context . sendMessag  eToNeighbo  rs ( this ,  this .
getValue (). getSccID ());
          this . getValue (). setUpdated ( true );
        }  else  {
          this . getValue (). setUpdated ( false );

        break ;
      case   STAGE_BW_S  TART :
        if  ( this . getId (). equals ( this . getValue (). getSccID
())) {
          for  ( Writable   neighbor  :  this . getValue ().
getInNeigh  bors (). getAll ()) {
            context . sendMessag  e (( LongWritab  le ) neighbor ,
this . getValue (). getSccID ());

          this . getValue (). setActive ( false );

        break ;
      case   STAGE_BW_R  EST :
        this . getValue (). setUpdated ( false );
        for  ( LongWritab  le   msg  :  msgs ) {
          if  ( msg . equals ( this . getValue (). getSccID ())) {
            for  ( Writable   neighbor  :  this . getValue ().
getInNeigh  bors (). getAll ()) {
              context . sendMessag  e (( LongWritab  le ) neighbor ,
this . getValue (). getSccID ());

            this . getValue (). setActive ( false );
            this . getValue (). setUpdated ( true );
            break ;


        break ;

      context . aggregate ( 0 ,  getValue ());
```

```
    @ Override
     public   void   cleanup (
         WorkerCont  ext < LongWritab  le ,  MyValue ,  NullWritab  le
 ,  LongWritab  le >  context )
         throws   IOExceptio  n  {
       context . write ( getId (),  getValue (). getSccID ());



   *  The   SCCAggrVal  ue   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   SCCAggrVal  ue   implements   Writable  {
     IntWritabl  e   stage   =  new   IntWritabl  e ( STAGE_TRAN
 SPOSE_1 );
     BooleanWri  table   updated   =  new   BooleanWri  table ( false
 );
     BooleanWri  table   active   =  new   BooleanWri  table ( 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   IOExceptio
 n  {
       this . stage . write ( out );
       this . updated . write ( out );
       this . active . write ( out );

    @  Override
     public   void   readFields ( DataInput   in )  throws
 IOExceptio  n  {
       this . stage . readFields ( in );
       this . updated . readFields ( in );
       this . active . readFields ( in );



   *  The   job   of   SCCAggrega  tor   is   to   schedule   global
 stage   in   every   superstep .

   public   static   class   SCCAggrega  tor   extends   Aggregator <
 SCCAggrVal  ue > {
    @ SuppressWa  rnings (" rawtypes ")
    @  Override
     public   SCCAggrVal  ue   createStar  tupValue ( WorkerCont  ext
   context )  throws   IOExceptio  n  {
       return   new   SCCAggrVal  ue ();
```

```
    @ SuppressWa  rnings (" rawtypes ")
    @  Override
     public   SCCAggrVal  ue   createInit  ialValue ( WorkerCont  ext
   context )
         throws   IOExceptio  n  {
       return  ( SCCAggrVal  ue )  context . getLastAgg  regatedVal
 ue ( 0 );

    @  Override
     public   void   aggregate ( SCCAggrVal  ue   value ,  Object
 item )  throws   IOExceptio  n  {
       MyValue   v  = ( MyValue ) item ;
       if  (( value . getStage () ==  STAGE_FW_R  EST  ||  value .
 getStage () ==  STAGE_BW_R  EST )
          &&  v . isUpdated ()) {
         value . setUpdated ( true );

      //  only   active   vertex   invoke   aggregate ()
       value . setActive ( true );

    @  Override
     public   void   merge ( SCCAggrVal  ue   value ,  SCCAggrVal  ue
   partial )
         throws   IOExceptio  n  {
       boolean   updated  =  value . getUpdated () ||  partial .
 getUpdated ();
       value . setUpdated ( updated );
       boolean   active  =  value . getActive () ||  partial .
 getActive ();
       value . setActive ( active );

    @ SuppressWa  rnings (" rawtypes ")
    @  Override
     public   boolean   terminate ( WorkerCont  ext   context ,
 SCCAggrVal  ue   value )
         throws   IOExceptio  n  {
      //  If   all   vertices   is   inactive ,  job   is   over .
       if  (!  value . getActive ()) {
         return   true ;

      //  state   machine
       switch  ( value . getStage ()) {
       case   STAGE_TRAN  SPOSE_1 :
         value . setStage ( STAGE_TRAN  SPOSE_2 );
         break ;
       case   STAGE_TRAN  SPOSE_2 :
         value . setStage ( STAGE_TRIM  MING );
         break ;
       case   STAGE_TRIM  MING :
         value . setStage ( STAGE_FW_S  TART );
         break ;
       case   STAGE_FW_S  TART :
         value . setStage ( STAGE_FW_R  EST );
         break ;
       case   STAGE_FW_R  EST :
         if  ( value . getUpdated ()) {
           value . setStage ( STAGE_FW_R  EST );
          }  else  {
           value . setStage ( STAGE_BW_S  TART );

         break ;
       case   STAGE_BW_S  TART :
         value . setStage ( STAGE_BW_R  EST );
```

```
        break ;
      case   STAGE_BW_R  EST :
        if  ( value . getUpdated ()) {
          value . setStage ( STAGE_BW_R  EST );
       }  else  {
          value . setStage ( STAGE_TRIM  MING );

        break ;

      value . setActive ( false );
      value . setUpdated ( false );
      return   false ;


  public   static   class   SCCVertexR  eader   extends
  GraphLoade  r < LongWritab  le ,  MyValue ,  NullWritab  le ,
LongWritab  le > {
   @  Override
    public   void   load (
        LongWritab  le   recordNum ,
        WritableRe  cord   record ,
        MutationCo  ntext < LongWritab  le ,  MyValue ,  NullWritab
le ,  LongWritab  le >  context )
    throws   IOExceptio  n  {
      SCCVertex   vertex  =  new   SCCVertex ();
      vertex . setId (( LongWritab  le )  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   LongWritab  le ( destID ),
NullWritab  le . get ());
       }  catch ( NumberForm  atExceptio  n   nfe ) {
          System . err . println (" Ignore  " +  nfe );


      context . addVertexR  equest ( vertex );


  public   static   void   main ( String []  args )  throws
IOExceptio  n  {
    if  ( args . length  <  2 ) {
      System . out . println (" Usage : < input > < output >");
      System . exit (- 1 );

    GraphJob   job  =  new   GraphJob ();
    job . setGraphLo  aderClass ( SCCVertexR  eader . class );
    job . setVertexC  lass ( SCCVertex . class );
    job . setAggrega  torClass ( SCCAggrega  tor . class );
    job . addInput ( TableInfo . builder (). tableName ( args [ 0 ]).
build ());
    job . addOutput ( TableInfo . builder (). tableName ( args [ 1
]). build ());
    long   startTime  =  System . currentTim  eMillis ();
    job . run ();
    System . out . println (" Job   Finished   in  "
       + ( System . currentTim  eMillis () -  startTime ) /  1000 . 0
 + "  seconds ");
```

10.7.6 Connected component

If there is path between 2 vertices, it means the 2 vertices are connected. If any two vertices in undirected graph G are connected, G is called a connected graph. 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 transmitted along edges to all vertices of the connected component.

Sample Code

Code for connecting components is as follows:

```
import   java . io . IOExceptio  n ;
import   com . aliyun . odps . data . TableInfo ;
import   com . aliyun . odps . graph . ComputeCon  text ;
import   com . aliyun . odps . graph . GraphJob ;
import   com . aliyun . odps . graph . GraphLoade  r ;
import   com . aliyun . odps . graph . MutationCo  ntext ;
import   com . aliyun . odps . graph . Vertex ;
import   com . aliyun . odps . graph . WorkerCont  ext ;
import   com . aliyun . odps . graph . examples . SSSP . MinLongCom
biner ;
import   com . aliyun . odps . io . LongWritab  le ;
import   com . aliyun . odps . io . NullWritab  le ;
import   com . aliyun . odps . io . WritableRe  cord ;

*  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   ConnectedC  omponents  {
  public   static   class   CCVertex   extends
  Vertex < LongWritab  le ,  LongWritab  le ,  NullWritab  le ,
LongWritab  le > {
   @ Override
    public   void   compute (
    ComputeCon  text < LongWritab  le ,  LongWritab  le ,
NullWritab  le ,  LongWritab  le >  context ,
    Iterable < LongWritab  le >  msgs )  throws   IOExceptio  n  {
      if  ( context . getSuperst  ep () ==  0L ) {
        this . setValue ( getId ());
        context . sendMessag  eToNeighbo  rs ( this ,  getValue ());
        return ;
```

```
        long   minID  =  Long . MAX_VALUE ;
        for  ( LongWritab  le   id  :  msgs ) {
        if  ( id . get () <  minID ) {
            minID  =  id . get ();


        if  ( minID  <  this . getValue (). get ()) {
          this . setValue ( new   LongWritab  le ( minID ));
          context . sendMessag  eToNeighbo  rs ( this ,  getValue ());
       }  else  {
          this . voteToHalt ();



      *  Output   Table   Descriptio  n :

      * |  Field  |  Type  |  Comment  |

      * |  v  |  bigint  |  vertex   id  |
      * |  minID  |  bigint  |  smallest   id   in   the   connected
component  |


     @ Override
      public   void   cleanup (
      WorkerCont  ext < LongWritab  le ,  LongWritab  le ,  NullWritab
le ,  LongWritab  le >  context )
          throws   IOExceptio  n  {
        context . write ( getId (),  getValue ());



    *  Input   Table   Descriptio  n :

    * |  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   CCVertexRe  ader   extends
    GraphLoade  r < LongWritab  le ,  LongWritab  le ,  NullWritab  le
,  LongWritab  le > {
     @ Override
      public   void   load (
          LongWritab  le   recordNum ,
          WritableRe  cord   record ,
```

```
        MutationCo  ntext < LongWritab  le ,  LongWritab  le ,
NullWritab  le ,  LongWritab  le >  context )
    throws   IOExceptio  n  {
      CCVertex   vertex  =  new   CCVertex ();
      vertex . setId (( LongWritab  le )  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   LongWritab  le ( destID ),
NullWritab  le . get ());

      context . addVertexR  equest ( vertex );


  public   static   void   main ( String []  args )  throws
IOExceptio  n  {
  if  ( args . length  <  2 ) {
  System . out . println (" Usage : < input > < output >");
      System . exit (- 1 );

    GraphJob   job  =  new   GraphJob ();
    job . setGraphLo  aderClass ( CCVertexRe  ader . class );
    job . setVertexC  lass ( CCVertex . class );
    job . setCombine  rClass ( MinLongCom  biner . class );
    job . addInput ( TableInfo . builder (). tableName ( args [ 0 ]).
build ());
    job . addOutput ( TableInfo . builder (). tableName ( args [ 1
]). build ());
    long   startTime  =  System . currentTim  eMillis ();
    job . run ();
    System . out . println (" Job   Finished   in  "
       + ( System . currentTim  eMillis () -  startTime ) /  1000 . 0
 + "  seconds ");
```

10.7.7 Topology Sorting

In directed edge (u,v), all vertex sequences satisfying u < v are called topological sequences. Topological sorting is an algorithm used to calculate the topological sequence of a directed graph.

Specifically, the algorithm:

1. Find a vertex that does not have any inbound edge from the graph and outputs the vertex.
2. Delete the vertex and all outbound edges from the graph.
3. Repeat the preceding steps until all vertices are output.

Sample Code

The code for the topology ordering algorithm is as follows:

```
import   java . io . IOExceptio  n ;
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 . ComputeCon  text ;
Import   com .  aliyun .  ODPS .  graph .  graphjob ;
import   com . aliyun . odps . graph . GraphLoade  r ;
import   com . aliyun . odps . graph . MutationCo  ntext ;
import   com . aliyun . odps . graph . Vertex ;
import   com . aliyun . odps . graph . WorkerCont  ext ;
import   com . aliyun . odps . io . LongWritab  le ;
import   com . aliyun . odps . io . NullWritab  le ;
import   com . aliyun . odps . io . BooleanWri  table ;
import   com . aliyun . odps . io . WritableRe  cord ;
public   class   TopologySo  rt  {
  private   final   static   Log   LOG  =  LogFactory . getLog (
TopologySo  rt . class );
  public   static   class   TopologySo  rtVertex   extends
  Vertex < LongWritab  le ,  LongWritab  le ,  NullWritab  le ,
LongWritab  le > {
   @ Override
    public   void   compute (
    ComputeCon  text < LongWritab  le ,  LongWritab  le ,
NullWritab  le ,  LongWritab  le >  context ,
    Iterable < LongWritab  le >  messages )  throws   IOExceptio  n
{
     //  in   superstep   0 ,  each   vertex   sends   message
whose   value   is   1   to   its
     //  neighbors
      if  ( context . getSuperst  ep () ==  0 ) {
        if  ( hasEdges ()) {
          context . sendMessag  eToNeighbo  rs ( this ,  new
LongWritab  le ( 1L ));

     }  else   if  ( context . getSuperst  ep () >=  1 ) {
       //  compute   each   vertex ' s   indegree
        long   indegree  =  getValue (). get ();
        for  ( LongWritab  le   msg  :  messages ) {
          indegree  +=  msg . get ();

        setValue ( new   LongWritab  le ( indegree ));
        if  ( indegree  ==  0 ) {
          voteToHalt ();
          if  ( hasEdges ()) {
            context . sendMessag  eToNeighbo  rs ( this ,  new
LongWritab  le (- 1L ));

          context . write ( new   LongWritab  le ( context .
getSuperst  ep ()),  getId ());
          LOG . info (" vertex : " +  getId ());

        context . aggregate ( new   LongWritab  le ( indegree ));



  public   static   class   TopologySo  rtVertexRe  ader   extends
  GraphLoade  r < LongWritab  le ,  LongWritab  le ,  NullWritab  le
,  LongWritab  le > {
   @ Override
    public   void   load (
        LongWritab  le   recordNum ,
        WritableRe  cord   record ,
        MutationCo  ntext < LongWritab  le ,  LongWritab  le ,
NullWritab  le ,  LongWritab  le >  context )
        throws   IOExceptio  n  {
```

```
      TopologySo  rtVertex   vertex  =  new   TopologySo  rtVertex
();
      vertex . setId (( LongWritab  le )  record . get ( 0 ));
      vertex . setValue ( new   LongWritab  le ( 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   LongWritab  le ( Long . parseLong
( edges [ i ])),
              NullWritab  le . get ());


      LOG . info ( record . toString ());
      context . addVertexR  equest ( vertex );


  public   static   class   LongSumCom  biner   extends
  Combiner < LongWritab  le ,  LongWritab  le > {
   @ Override
    public   void   combine ( LongWritab  le   vertexId ,
LongWritab  le   combinedMe  ssage ,
        LongWritab  le   messageToC  ombine )  throws   IOExceptio  n
 {
      combinedMe  ssage . set ( combinedMe  ssage . get () +
messageToC  ombine . get ());


  public   static   class   TopologySo  rtAggregat  or   extends
  Aggregator < BooleanWri  table > {
   @ SuppressWa  rnings (" rawtypes ")
   @ Override
    public   BooleanWri  table   createInit  ialValue ( WorkerCont
ext   context )
        throws   IOExceptio  n  {
      return   new   BooleanWri  table ( true );

   @ Override
    public   void   aggregate ( BooleanWri  table   value ,  Object
item )
        throws   IOExceptio  n  {
      boolean   hasCycle  =  value . get ();
      boolean   inDegreeNo  tZero  = (( LongWritab  le )  item ). get
() ==  0  ?  false  :  true ;
      value . set ( hasCycle  &&  inDegreeNo  tZero );

   @ Override
    public   void   merge ( BooleanWri  table   value ,  BooleanWri
table   partial )
        throws   IOExceptio  n  {
      value . set ( value . get () &&  partial . get ());

   @ SuppressWa  rnings (" rawtypes ")
   @ Override
    public   boolean   terminate ( WorkerCont  ext   context ,
BooleanWri  table   value )
        throws   IOExceptio  n  {
      if  ( context . getSuperst  ep () ==  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
IOExceptio  n  {
    if  ( args . length  ! =  2 ) {
    System . out . println (" Usage  : < inputTable > < outputTabl  e
>");
      System . exit (- 1 );

   //  The   input   table   is   in   the   format   of
   //  0   1 ,  2
   //  1   3
   //  2   3
   //  3  - 1
   //  The   first   column   is   vertexid ,  and   the   second
  column   is   the   destinatio  n   vertexid   of   the   vertex
  edge .  If   the   value   is  - 1 ,  the   vertex   does   not
have   any   outbound   edge
   //  The   output   table   is   in   the   format   of
   //  0   0
   //  1   1
   //  1   2
   //  2   3
   //  The   first   column   is   the   supstep   value ,  in
which   the   topologica  l   sequence   is   hidden .  The   second
  column   is   vertexid
   //  TopologySo  rtAggregat  or   is   used   to   determine   if
the   graph   has   loops
   //  If   the   input   graph   has   a   loop ,  the   iteration
  ends   when   the   indegree   of   vertices   in   the   active
state   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 . setGraphLo  aderClass ( TopologySo  rtVertexRe  ader .
class );
    job . setVertexC  lass ( TopologySo  rtVertex . class );
    job . addInput ( TableInfo . builder (). tableName ( args [ 0 ]).
build ());
    job . addOutput ( TableInfo . builder (). tableName ( args [ 1
]). build ());
    job . setCombine  rClass ( LongSumCom  biner . class );
    job . setAggrega  torClass ( TopologySo  rtAggregat  or . class
);
    long   startTime  =  System . currentTim  eMillis ();
    job . run ();
    System . out . println (" Job   Finished   in  "
       + ( System . currentTim  eMillis () -  startTime ) /  1000 . 0
 + "  seconds ");
```

```
```

10.7.8 Linear Regression

In statistics, linear regression is a statistical analysis method used to determine the dependency between two or more variables. Different from the classification algorithm that processes discrete prediction,

the regression algorithm can predict the continuous value type. The linear regression algorithm defines the loss function as the sum of the least square errors of the sample set. It minimizes the loss function to calculate the weight vector.

A common solution is gradient descent that:

1. Initialize the weight vector to give descent speed rate and iterations (or iteration convergence condition).
2. Calculate the least square error for each sample.
3. Get the sum of the least square error, update the weight based on the descent speed rate.
4. Repeat iterations until convergence.

Sample Code

```
import   java . io . DataInput ;
import   java . io . DataOutput ;
import   java . io . IOExceptio  n ;
import   com . aliyun . odps . data . TableInfo ;
import   com . aliyun . odps . graph . Aggregator ;
import   com . aliyun . odps . graph . ComputeCon  text ;
import   com . aliyun . odps . graph . GraphJob ;
import   com . aliyun . odps . graph . MutationCo  ntext ;
import   com . aliyun . odps . graph . WorkerCont  ext ;
import   com . aliyun . odps . graph . Vertex ;
import   com . aliyun . odps . graph . GraphLoade  r ;
import   com . aliyun . odps . io . DoubleWrit  able ;
import   com . aliyun . odps . io . LongWritab  le ;
import   com . aliyun . odps . io . NullWritab  le ;
import   com . aliyun . odps . io . Tuple ;
import   com . aliyun . odps . io . Writable ;
import   com . aliyun . odps . io . WritableRe  cord ;

*  LineRegres  sion   input :  y , x1 , x2 , x3 ,......

public   class   LinearRegr  ession  {
  public   static   class   GradientWr  itable   implements
Writable  {
    Tuple   lastTheta ;
    Tuple   currentThe  ta ;
    Tuple   tmpGradien  t ;
    LongWritab  le   count ;
    DoubleWrit  able   lost ;
   @ Override
```

```
    public   void   readFields ( DataInput   in )  throws
IOExceptio  n  {
      lastTheta  =  new   Tuple ();
      lastTheta . readFields ( in );
      currentThe  ta  =  new   Tuple ();
      currentThe  ta . readFields ( in );
      tmpGradien  t  =  new   Tuple ();
      tmpGradien  t . readFields ( in );
      count  =  new   LongWritab  le ();
      count . readFields ( in );
     /*  update   1 :  add   a   variable   to   store   lost   at
every   iteration  */
      lost  =  new   DoubleWrit  able ();
      lost . readFields ( in );

   @ Override
    public   void   write ( DataOutput   out )  throws   IOExceptio
n  {
      lastTheta . write ( out );
      currentThe  ta . write ( out );
      tmpGradien  t . write ( out );
      count . write ( out );
      lost . write ( out );


  public   static   class   LinearRegr  essionVert  ex   extends
  Vertex < LongWritab  le ,  Tuple ,  NullWritab  le ,  NullWritab
le > {
   @ Override
    public   void   compute (
    ComputeCon  text < LongWritab  le ,  Tuple ,  NullWritab  le ,
NullWritab  le >  context ,
    Iterable < NullWritab  le >  messages )  throws   IOExceptio  n
{
      context . aggregate ( getValue ());


  public   static   class   LinearRegr  essionVert  exReader
extends
  GraphLoade  r < LongWritab  le ,  Tuple ,  NullWritab  le ,
NullWritab  le > {
   @ Override
    public   void   load ( LongWritab  le   recordNum ,  WritableRe
cord   record ,
    MutationCo  ntext < LongWritab  le ,  Tuple ,  NullWritab  le ,
NullWritab  le >  context )
        throws   IOExceptio  n  {
      LinearRegr  essionVert  ex   vertex  =  new   LinearRegr
essionVert  ex ();
      vertex . setId ( recordNum );
      vertex . setValue ( new   Tuple ( record . getAll ()));
      context . addVertexR  equest ( vertex );


  public   static   class   LinearRegr  essionAggr  egator   extends
  Aggregator < GradientWr  itable > {
   @ SuppressWa  rnings (" rawtypes ")
   @ Override
    public   GradientWr  itable   createInit  ialValue ( WorkerCont
ext   context )
        throws   IOExceptio  n  {
      if  ( context . getSuperst  ep () ==  0 ) {
       /*  set   initial   value ,  all   0  */
        GradientWr  itable   grad  =  new   GradientWr  itable ();
```

```
        grad . lastTheta  =  new   Tuple ();
        grad . currentThe  ta  =  new   Tuple ();
        grad . tmpGradien  t  =  new   Tuple ();
        grad . count  =  new   LongWritab  le ( 1 );
        grad . lost  =  new   DoubleWrit  able ( 0 . 0 );
        int   n  = ( int )  Long . parseLong ( context . getConfigu
ration ()
           . get (" Dimension "));
            for  ( int   i  =  0 ;  i  <  n ;  i ++) {
          grad . lastTheta . append ( new   DoubleWrit  able ( 0 ));
          grad . currentThe  ta . append ( new   DoubleWrit  able ( 0
));
          grad . tmpGradien  t . append ( new   DoubleWrit  able ( 0
));

        return   grad ;
     }  else
        return  ( GradientWr  itable )  context . getLastAgg
regatedVal  ue ( 0 );

    public   static   double   vecMul ( Tuple   value ,  Tuple
theta ) {
     /*  perform   this   partial   computing :  y ( i )- h θ( 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 . parseDoubl  e ( value . get ( j ). toString
())
           *  Double . parseDoubl  e ( theta . get ( j ). toString
());
      Double   tmp  =  Double . parseDoubl  e ( theta . get ( 0 ).
toString ()) +  sum
         -  Double . parseDoubl  e ( value . get ( 0 ). toString ());
      return   tmp ;

   @ Override
    public   void   aggregate ( GradientWr  itable   gradient ,
Object   value )
        throws   IOExceptio  n  {

      *  perform   on   each   vertex -- each   sample   i :  set
theta ( j )  for   each   sample   i
      *  for   each   dimension

      double   tmpVar  =  vecMul (( Tuple )  value ,  gradient .
currentThe  ta );

      *  update   2 : local   worker   aggregate (),  perform   like
  merge ()  below .  This
      *  means   the   variable   gradient   denotes   the   previous
  aggregated   value

      gradient . tmpGradien  t . set ( 0 ,  new   DoubleWrit  able (
         (( DoubleWrit  able )  gradient . tmpGradien  t . get ( 0
)). get () +  tmpVar ));
      gradient . lost . set ( Math . pow ( tmpVar ,  2 ));

      *  calculate  ( y ( i )- h θ( x ( i )))  x ( i )( j )  for
each   sample   i   for   each
      *  dimension   j
```

```
        for  ( int   j  =  1 ;  j  <  gradient . tmpGradien  t . size
();  j ++)
         gradient . tmpGradien  t . set ( j ,  new   DoubleWrit  able
(
            (( DoubleWrit  able )  gradient . tmpGradien  t . get ( j
)). get () +  tmpVar
               *  Double . parseDoubl  e ((( Tuple )  value ). get (
j ). toString ())));

   @ Override
    public   void   merge ( GradientWr  itable   gradient ,
GradientWr  itable   partial )
         throws   IOExceptio  n  {
     /*  perform   SumAll   on   each   dimension   for   all
samples .
      Tuple   master  = ( Tuple )  gradient . tmpGradien  t ;
      Tuple   part  = ( Tuple )  partial . tmpGradien  t ;
      for  ( int   j  =  0 ;  j  <  gradient . tmpGradien  t . size
();  j ++) {
         DoubleWrit  able   s  = ( DoubleWrit  able )  master . get (
j );
         s . set ( s . get () + (( DoubleWrit  able )  part . get ( j
)). get ());

      gradient . lost . set ( gradient . lost . get () +  partial .
lost . get ());

   @ SuppressWa  rnings (" rawtypes ")
   @ Override
    public   boolean   terminate ( WorkerCont  ext   context ,
GradientWr  itable   gradient )
         throws   IOExceptio  n  {

      *  1 .  calculate   new   theta   2 .  judge   the   diff
between   last   step   and   this
      *  step ,  if   smaller   than   the   threshold ,  stop
iteration

      gradient . lost  =  new   DoubleWrit  able ( gradient . lost .
get ()
          / ( 2  *  context . getTotalNu  mVertices ()));

      *  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   tmpGradien  t  =  gradient . tmpGradien  t ;
      System . out . println (" tmpGra " +  tmpGradien  t );
      Tuple   lastTheta  =  gradient . lastTheta ;
      Tuple   tmpCurrent  Theta  =  new   Tuple ( gradient .
currentThe  ta . size ());
      System . out . println ( gradient . count  + "  terminate_
start_last :" +  lastTheta );
      double   alpha  =  0 . 07 ; //  learning   rate
     //  alpha  =
     //  Double . parseDoubl  e ( context . getConfigu  ration ().
get (" Alpha "));
     /*  perform   theta ( j ) =  theta ( j )- alpha * tmpGradien  t
*/
      long   M  =  context . getTotalNu  mVertices ();
```

```
      * update  3 : add  (/ M ) on  the  code . The  original
  code  forget  this  step

       for  ( int  j  =  0 ;  j  <  lastTheta . size ();  j ++) {
        tmpCurrent  Theta
           . set (
                J ,
                new  DoubleWrit  able ( Double . parseDoubl  e (
lastTheta . get ( j )
                   . toString ())
                   -  alpha
                   /  M
                   *  Double . parseDoubl  e ( tmpGradien  t . get (
j ). toString ())));

      System . out . println ( gradient . count  + "  terminate_
start_curr  ent :"
         +  tmpCurrent  Theta );
     //  judge  if  convergenc  e  is  happening .
      double  diff  =  0 . 00d ;
      for  ( int  j  =  0 ;  j  <  gradient . currentThe  ta . size
();  j ++)
        diff  +=  Math . pow ((( DoubleWrit  able )  tmpCurrent
Theta . get ( j )). get ()
           - (( DoubleWrit  able )  lastTheta . get ( j )). get (),
2 );
      if  (/*
     *  Math . sqrt ( diff ) <  0 . 0000000000  5d  ||
          */ Long . parseLong ( context . getConfigu  ration (). get
(" Max_Iter_N  um ")) ==  gradient . count
         . get ()) {
        context . write ( gradient . currentThe  ta . toArray ());
        return  true ;

      gradient . lastTheta  =  tmpCurrent  Theta ;
      gradient . currentThe  ta  =  tmpCurrent  Theta ;
      gradient . count . set ( gradient . count . get () +  1 );
      int  n  = ( int )  Long . parseLong ( context . getConfigu
ration (). 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 . tmpGradien  t . set ( i ,  new  DoubleWrit  able
( 0 ));

      return  false ;


  public  static  void  main ( String []  args )  throws
IOExceptio  n  {
    GraphJob  job  =  new  GraphJob ();
    job . setGraphLo  aderClass ( LinearRegr  essionVert  exReader .
class );
    job . setRuntime  Partitioni  ng ( false );
    job . setNumWork  ers ( 3 );
    job . setVertexC  lass ( LinearRegr  essionVert  ex . class );
    job . setAggrega  torClass ( LinearRegr  essionAggr  egator .
class );
    job . addInput ( TableInfo . builder (). tableName ( args [ 0 ]).
build ());
```

```
    job . addOutput ( TableInfo . builder (). tableName ( args [ 1
]). build ());
    job . setMaxIter  ation ( Integer . parseInt ( args [ 2 ])); //
Numbers   of   Iteration
    job . setInt (" Max_Iter_N  um ",  Integer . parseInt ( args [ 2
]));
    job . setInt (" Dimension ",  Integer . parseInt ( args [ 3
])); //  Dimension
    job . setFloat (" Alpha ",  Float . parseFloat ( args [ 4
])); //  Learning   rate
    long   start  =  System . currentTim  eMillis ();
    job . run ();
    System . out . println (" Job   Finished   in  "
       + ( System . currentTim  eMillis () -  start ) /  1000 . 0  +
"  seconds ");
```

10.7.9 Triangle Count

This algorithm is used to calculate the number of triangles passing through each vertex.

The algorithm is implemented using the following steps:

1. Each vertex sends its ID to all outbound neighbors.
2. Store inbound and outbound neighbors and sends them to the outbound neighbors .
3. Calculate the number of endpoint intersections for each Edge, get the sum, and output the result to the table.
4. Get the sum of the output result in the table, divide it by 3, and get the number of triangles.

Sample code

Code for the triangle count algorithm are as follows:

```
import   java . io . IOExceptio  n ;
import   com . aliyun . odps . data . TableInfo ;
import   com . aliyun . odps . graph . ComputeCon  text ;
import   com . aliyun . odps . graph . Edge ;
import   com . aliyun . odps . graph . GraphJob ;
import   com . aliyun . odps . graph . GraphLoade  r ;
import   com . aliyun . odps . graph . MutationCo  ntext ;
import   com . aliyun . odps . graph . Vertex ;
import   com . aliyun . odps . graph . WorkerCont  ext ;
import   com . aliyun . odps . io . LongWritab  le ;
import   com . aliyun . odps . io . NullWritab  le ;
import   com . aliyun . odps . io . Tuple ;
import   com . aliyun . odps . io . Writable ;
import   com . aliyun . odps . io . WritableRe  cord ;

*  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 intersecti on of
the sets at destinatio n
* 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 TriangleCo unt {
  public static class TCVertex extends
    Vertex < LongWritab le , Tuple , NullWritab le , Tuple > {
   @ Override
    public void setup (
        WorkerCont ext < LongWritab le , Tuple , NullWritab le
, Tuple > context )
      throws IOExceptio n {
     // collect the outgoing neighbors
      Tuple t = new Tuple ();
      if ( this . hasEdges ()) {
        for ( Edge < LongWritab le , NullWritab le > edge :
this . getEdges ()) {
          t . append ( edge . getDestVer texId ());
       }

      this . setValue ( t );

   @ Override
    public void compute (
        ComputeCon text < LongWritab le , Tuple , NullWritab le
, Tuple > context ,
        Iterable < Tuple > msgs ) throws IOExceptio n {
      if ( context . getSuperst ep () == 0L ) {
       // sends a message with its ID to all its
outgoing neighbors
        Tuple t = new Tuple ();
        t . append ( getId ());
        context . sendMessag eToNeighbo rs ( this , t );
     } else if ( context . getSuperst ep () == 1L ) {
       // store the incoming neighbors
        for ( Tuple msg : msgs ) {
          for ( Writable item : msg . getAll ()) {
            if (! this . getValue (). getAll (). contains ((
LongWritab le ) item )) {
              this . getValue (). append (( LongWritab le ) item );



       // send both incoming and outgoing neighbors to
all outgoing neighbors
        context . sendMessag eToNeighbo rs ( this , getValue ());
     } else if ( context . getSuperst ep () == 2L ) {
       // count the sum of intersecti on 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   LongWritab  le ( count ));
         this . voteToHalt ();



   public   static   class   TCVertexRe  ader   extends
   GraphLoade  r < LongWritab  le ,  Tuple ,  NullWritab  le ,  Tuple
 > {
    @ Override
     public   void   load (
         LongWritab  le   recordNum ,
         WritableRe  cord   record ,
         MutationCo  ntext < LongWritab  le ,  Tuple ,  NullWritab  le
 ,  Tuple >  context )
     throws   IOExceptio  n  {
       TCVertex   vertex  =  new   TCVertex ();
       vertex . setId (( LongWritab  le )  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   LongWritab  le ( destID ),
 NullWritab  le . get ());
        }  catch ( NumberForm  atExceptio  n   nfe ) {
           System . err . println (" Ignore  " +  nfe );


       context . addVertexR  equest ( vertex );


   public   static   void   main ( String []  args )  throws
 IOExceptio  n  {
   if  ( args . length  <  2 ) {
   System . out . println (" Usage : < input > < output >");
       System . exit (- 1 );

     GraphJob   job  =  new   GraphJob ();
     job . setGraphLo  aderClass ( TCVertexRe  ader . class );
     job . setVertexC  lass ( TCVertex . class );
     job . addInput ( TableInfo . builder (). tableName ( args [ 0 ]).
 build ());
     job . addOutput ( TableInfo . builder (). tableName ( args [ 1
 ]). build ());
     long   startTime  =  System . currentTim  eMillis ();
     job . run ();
     System . out . println (" Job   Finished   in  "
        + ( System . currentTim  eMillis () -  startTime ) /  1000 . 0
  + "  seconds ");
```

10.7.10 Vertex Input

Sample code

```
import   java . io . IOExceptio  n ;
import   com . aliyun . odps . conf . Configurat  ion ;
import   com . aliyun . odps . data . TableInfo ;
import   com . aliyun . odps . graph . ComputeCon  text ;
import   com . aliyun . odps . graph . GraphJob ;
import   com . aliyun . odps . graph . GraphLoade  r ;
import   com . aliyun . odps . graph . Vertex ;
import   com . aliyun . odps . graph . VertexReso  lver ;
import   com . aliyun . odps . graph . MutationCo  ntext ;
import   com . aliyun . odps . graph . VertexChan  ges ;
import   com . aliyun . odps . graph . Edge ;
import   com . aliyun . odps . io . LongWritab  le ;
import   com . aliyun . odps . io . WritableCo  mparable ;
import   com . aliyun . odps . io . WritableRe  cord ;

*  The   following   example   describes   how   to   compile   a
graph   job   program   to   load   data   of   different   types .
It   mainly   describes   how   GraphLoade  r
*  and   VertexReso  lver   are   cooperated   to   build   the
graph .

*  A   MaxCompute   Graph   job   uses   MaxCompute   tables   as
the   input .  Assume   that   a   job   has   two   tables   as
the   input ,  one   storing   vertices   and   the   other   storing
  edges .
*  The   format   of   the   table   storing   vertex   informatio  n
  is   as   follows :

* |  VertexID  |  VertexValu  e  |

* |  id0 |  9 |

* |  id1 |  7 |

* |  id2 |  8 |


*  The   format   of   the   table   storing   edge   informatio  n
is   as   follows :

* |  VertexID  |  DestVertex  ID |  EdgeValue |

* |  id0 |  id1 |  1 |

* |  id0 |  id2 |  2 |

* |  id2 |  id1 |  3 |


*  The   preceding   two   tables   show   that   id0   has   two
outbound   edges   pointing   to   id1   and   id2   respective  ly
.  id2   has   an   outbound   edge   pointing   to   id1 ,  and
id1   has   no   outbound   edges .

*  For   data   of   this   type ,  in   GraphLoade  r :: load (
LongWritab  le ,  Record ,  MutationCo  ntext ),
```

```
* MutationCo ntext # addVertexR equest ( Vertex ) can be used
  to add vertices to the graph , while
* link MutationCo ntext # addEdgeReq uest ( WritableCo mparable
, Edge ) can be used to add edges to the graph .
In
* link VertexReso lver # resolve ( WritableCo mparable , Vertex
, VertexChan ges , boolean )
* vertices and edges added in the load () method are
  combined to a vertex object , which is used as the
  return value and added to the graph for calculatio
n .


public class VertexInpu tFormat {
  private final static String EDGE_TABLE = " edge . table ";

  * Resolve a record to vertices and edges . Each
record indicates a vertex or an edge according to
its source .

  * Similar to com . aliyun . odps . mapreduce . Mapper # map ,
  * enter a record to generate key - value pairs . The
  keys are vertex IDs ,
  * and the values are vertices or edges written
  based on the context . These key - value pairs are
  summarized based on vertex IDs using LoadingVer
texResolve r .

  * Note : Vertices or edges added here are requests
sent based on the record content , and are not used
  in calculatio n . Only
  * vertices or edges added using VertexReso lver
participat e in calculatio n .

  public static class VertexInpu tLoader extends
  GraphLoade r < LongWritab le , LongWritab le , LongWritab le
, LongWritab le > {
    private boolean isEdgeData ;

    * Configure VertexInpu tLoader .

    * @ param conf
    * Indicates the configurat ion parameters of a job
, which are configured in the main GraphJob or set
on the console .
    * @ param workerId
    * Indicates the serial number of the operating
Worker , which starts from 0 and can be used to
build a unique vertex ID .
    * @ param inputTable Info
    * Indicates informatio n about the input table
load to the current Worker , which can be used to
determine the type of currently input data , that is
, the record format .

   @ Override
    public void setup ( Configurat ion conf , int workerId
, TableInfo inputTable Info ) {
      isEdgeData = conf . get ( EDGE_TABLE ). equals ( inputTable
Info . getTableNa me ());
```

```
    * Based   on   the   record   content , resolve   correspond
ing   edges   and   send   a   request   to   add   them   to   the
graph .

    * @ param   recordNum
    * Indicates   the   record   serial   number , which   starts
from   1   and   is   separately   counted   in   each   Worker .
    * @ param   record
    * Indicates   the   record   in   the   input   table . It
contains   three   columns , indicating   the   first   vertex ,
last   vertex , and   edge   weight .
    * @ param   context
    * Indicates   the   context , requesting   to   add   resolved
  edges   to   the   graph .

   @ Override
    public   void   load (
        LongWritab  le   recordNum ,
        WritableRe  cord   record ,
        MutationCo  ntext < LongWritab  le ,  LongWritab  le ,
LongWritab  le ,  LongWritab  le >  context )
        throws   IOExceptio  n  {
      if  ( isEdgeData ) {

        * Data   is   from   the   table   that   stores   edge
informatio  n .

        * 1 .  The   first   column   indicates   the   first
vertex   ID .

        LongWritab  le   sourceVert  exID  = ( LongWritab  le )
record . get ( 0 );

        * 2 .  The   second   column   indicates   the   last
vertex   ID .

        LongWritab  le   destinatio  nVertexID  = ( LongWritab  le )
record . get ( 1 );

        * 3 .  The   third   column   indicates   the   edge
weight .

        LongWritab  le   edgeValue  = ( LongWritab  le )  record .
get ( 2 );

        * 4 .  Create   an   edge   that   consists   of   the
last   vertex   ID   and   edge   weight .

         Edge < LongWritab  le ,  LongWritab  le >  edge  =  new
Edge < LongWritab  le ,  LongWritab  le >(
            destinatio  nVertexID ,  edgeValue );

        * 5 .  Send   a   request   to   add   an   edge   to   the
  first   vertex .

        context . addEdgeReq  uest ( sourceVert  exID ,  edge );

       * 6 .  If   each   record   indicates   a   bidirectio  nal
  edge ,  repeat   steps   4   and   5 .  Edge < LongWritab  le ,
LongWritab  le >  edge2  =  new
       * Edge < LongWritab  le ,  LongWritab  le >(  sourceVert
exID ,  edgeValue );
        * context . addEdgeReq  uest ( destinatio  nVertexID ,
edge2 );
```

```
     } else {

         * Data   comes   from   the   table   that   stores   vertex
   informatio  n .

         * 1 . The   first   column   indicates   the   vertex   ID
 .

         LongWritab  le   vertexID  = ( LongWritab  le )  record . get
 ( 0 );

         * 2 . The   second   column   indicates   the   vertex
 value .

         LongWritab  le   vertexValu  e  = ( LongWritab  le )  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 ( vertexValu  e );

         * 5 . Send   a   request   to   add   a   vertex .

         context . addVertexR  equest ( vertex );



   * Summarize   key - value   pairs   generated   using
 GraphLoade  r :: load ( LongWritab  le ,  Record ,  MutationCo  ntext
 ), which   is   similar   to
   * reduce   in   com . aliyun . odps . mapreduce . Reducer .   For
   the   unique   vertex   ID ,  all   actions   such   as
   * adding / deleting   vertices   or   edges   on   the   ID   is
 stored   in   VertexChan  ges .

   * Note : Not   only   conflictin  g   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   LoadingRes  olver   extends
   VertexReso  lver < LongWritab  le ,  LongWritab  le ,  LongWritab
 le ,  LongWritab  le > {

     * Process   a   request   about   adding / deleting   vertices
 or   edges   for   an   ID .

     * VertexChan  ges   has   four   APIs ,  which   correspond   to
   the   four   APIs   of   MutationCo  ntext :
     * VertexChan  ges :: getAddedVe  rtexList ()  correspond  s   to

     * MutationCo  ntext :: addVertexR  equest ( Vertex ).
```

```
    * In the load () method , if vertex objects with
the same ID are requested to be added , such vertex
  objects are collected to the return list .
    * VertexChan ges :: getAddedEd geList () correspond s to
    * MutationCo ntext :: addEdgeReq uest ( WritableCo mparable
, Edge )
    * If edge objects with the same first vertex ID
  are requested to be added , such edge objects are
collected to the return list .
    * VertexChan ges :: getRemoved VertexCoun t () correspond s
  to
    * MutationCo ntext :: removeVert exRequest ( WritableCo
mparable )
    * If vertices with the same ID are requested to
  be deleted , the number of total deletion requests
is returned .
    * VertexChan ges # getRemoved EdgeList () correspond s to

    * MutationCo ntext # removeEdge Request ( WritableCo mparable
, WritableCo mparable )
    * If edge objects with the same first vertex ID
  are requested to be deleted , such edge objects are
  collected to the return list .

    * By processing ID changes , you can state whether
  the ID participat es in calculatio n using the
return value . If the returned vertex is not null ,
    * the ID participat es in subsequent calculatio n .
If the returned vertex is null , the ID does not
participat e in subsequent calculatio n .

    * @ param vertexId
    * Indicates the ID of the vertex requested to be
  added or first vertex ID of the edge requested to
  be added .
    * @ param vertex
    * Indicates an existing vertex object . Its value
is always null in the data loading phase .
    * @ param vertexChan ges
    * Indicates the set of vertices or edges requested
  to be added / deleted on the ID .
    * @ param hasMessage s
    * Indicates whether the ID has any input message
. Its value is always false in the data loading
phase .

   @ Override
    public Vertex < LongWritab le , LongWritab le , LongWritab
le , LongWritab le > resolve (
        LongWritab le vertexId ,
        Vertex < LongWritab le , LongWritab le , LongWritab le
, LongWritab le > vertex ,
        VertexChan ges < LongWritab le , LongWritab le ,
LongWritab le , LongWritab le > vertexChan ges ,
        boolean hasMessage s ) throws IOExceptio n {

      * 1 . Obtain the vertex object for calculatio n .

      MyVertex computeVer tex = null ;
      if ( vertexChan ges . getAddedVe rtexList () == null
         || vertexChan ges . getAddedVe rtexList (). isEmpty ()) {
        computeVer tex = new MyVertex ();
        computeVer tex . setId ( vertexId );
     } else {
```

```
        * Assume that each record indicates a unique
vertex in the table storing vertex informatio n .

        computeVer tex = ( MyVertex ) vertexChan ges .
getAddedVe rtexList (). get ( 0 );


      * 2 . Add the edge requested to be added
to the vertex to the vertex object . If data is
  duplicated , perform deduplicat ion based on the
algorithm needs .

      if ( vertexChan ges . getAddedEd geList () ! = null ) {
      for ( Edge < LongWritab le , LongWritab le > edge :
vertexChan ges
           . getAddedEd geList ()) {
          computeVer tex . addEdge ( edge . getDestVer texId (),
edge . getValue ());



      * 3 . Return the vertex object and add it to
the final graph for calculatio n .

      return computeVer tex ;



  * Determine actions of the vertex that participat es
  in calculatio n .


  public static class MyVertex extends
  Vertex < LongWritab le , LongWritab le , LongWritab le ,
LongWritab le > {

    * Write the vertex edge to the result table
according to the format of the input table . Ensure
that the format and data of the input and output
tables are the same .

    * @ param context
    * Indicates the context during running .
    * @ param messages
    * Indicates the input message .

   @ Override
    public void compute (
    ComputeCon text < LongWritab le , LongWritab le ,
LongWritab le , LongWritab le > context ,
    Iterable < LongWritab le > messages ) throws IOExceptio n
{

      * Write the vertex ID and value to the result
  table storing vertices .

      context . write (" vertex ", getId (), getValue ());

      * Write the vertex edge to the result table
storing edges .

      if ( hasEdges ()) {
```

```
      for  ( Edge < LongWritab  le ,  LongWritab  le >  edge  :
getEdges ()) {
          context . write (" edge ",  getId (),  edge . getDestVer
texId (),
              edge . getValue ());



      *  Perform   one   round   of   iteration .

      voteToHalt ();



  * @ param   args
  * @ throws   IOExceptio  n

  public   static   void   main ( String []  args )  throws
IOExceptio  n  {
  if  ( args . length  <  4 ) {
      throw   new   IOExceptio  n (
     " Usage :  VertexInpu  tFormat  < 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
storing   edge   data .

    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 ,  resolve   the
record   as   edges .  Similar   to   the   map ,  the   generated
key   is   the   vertex   ID ,  and   the   value   is   the   edge .

    job . setGraphLo  aderClass ( VertexInpu  tLoader . class );

    *  3 .  Specify   the   data   loading   phase ,  and   generate
  the   vertex   for   calculatio  n .   Similar   to   reduce ,
edges   generated   by   map   are   combined   to   a   vertex .

    job . setLoading  VertexReso  lverClass ( LoadingRes  olver .
class );

    *  4 .  Specify   actions   of   the   vertex   that
participat  es   in   calculatio  n .   The   vertex . compute ()
method   is   used   for   each   round   of   iteration .

    job . setVertexC  lass ( MyVertex . class );

    *  5 .  Specify   the   output   table   of   the   Graph   job
,  and   write   the   calculatio  n   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 ();
```

10.7.11 Edge Input

Sample Code

```
import java . io . IOExceptio n ;
import com . aliyun . odps . conf . Configurat ion ;
import com . aliyun . odps . data . TableInfo ;
import com . aliyun . odps . graph . ComputeCon text ;
import com . aliyun . odps . graph . GraphJob ;
import com . aliyun . odps . graph . GraphLoade r ;
import com . aliyun . odps . graph . Vertex ;
import com . aliyun . odps . graph . VertexReso lver ;
import com . aliyun . odps . graph . MutationCo ntext ;
import com . aliyun . odps . graph . VertexChan ges ;
import com . aliyun . odps . graph . Edge ;
import com . aliyun . odps . io . LongWritab le ;
import com . aliyun . odps . io . WritableCo mparable ;
import com . aliyun . odps . io . WritableRe cord ;

* The following example describes how to compile a
graph job program to load data of different types .
It mainly describes how GraphLoade r
* and VertexReso lver are cooperated to build the
graph .

* A MaxCompute Graph job uses MaxCompute tables as
the input . Assume that a job has two tables as
the input , one storing vertices and the other storing
  edges .
* The format of the table storing vertex informatio n
  is as follows :

 * | VertexID | VertexValu e |

* | id0 | 9 |

* | id1 | 7 |

* | id2 | 8 |


 * The format of the table storing edge informatio n
  is as follows :

* | VertexID | DestVertex ID | EdgeValue |

* | id0 | id1 | 1 |

* | id0 | id2 | 2 |

* | id2 | id1 | 3 |
```

```
* The preceding two tables show that id0 has two
outbound edges pointing to id1 and id2 respective ly
. id2 has an outbound edge pointing to id1 , and
id1 has no outbound edges .

* For data of this type , in GraphLoade r :: load (
LongWritab le , Record , MutationCo ntext ),
* MutationCo ntext # addVertexR equest ( Vertex ) can be used
  to add vertices to the graph , while
* link MutationCo ntext # addEdgeReq uest ( WritableCo mparable
, Edge ) can be used to add edges to the graph .
In
* link VertexReso lver # resolve ( WritableCo mparable , Vertex
, VertexChan ges , boolean )
* vertices and edges added in the load () method are
  combined to a vertex object , which is used as the
  return value and added to the graph for calculatio
n .


public class VertexInpu tFormat {
  private final static String EDGE_TABLE = " edge . table ";

  * Resolve a record to vertices and edges . Each
record indicates a vertex or an edge according to
its source .
  * Similar to com . aliyun . odps . mapreduce . Mapper # map ,
  * enter a record to generate key - value pairs . The
  keys are vertex IDs ,
  * and the values are vertices or edges written
  based on the context . These key - value pairs are
  summarized based on vertex IDs using LoadingVer
texResolve r .

  * Note : Vertices or edges added here are requests
sent based on the record content , and are not used
  for calculatio n . Only
  * vertices or edges added using VertexReso lver
participat e in calculatio n .

  public static class VertexInpu tLoader extends
  GraphLoade r < LongWritab le , LongWritab le , LongWritab le
, LongWritab le > {
    private boolean isEdgeData ;

    * Configure VertexInpu tLoader .

    * @ param conf
    * Indicates the configurat ion parameters of a job
, which are configured in the main GraphJob or set
on the console .
    * @ param workerId
    * Indicates the serial number of the operating
Worker , which starts from 0 and can be used to
build a unique vertex ID .
    * @ param inputTable Info
    * Indicates informatio n about the input table
loaded to the current Worker , which can be used to
  determine the type of currently input data , that is
, the record format .

   @ Override
    public void setup ( Configurat ion conf , int workerId
, TableInfo inputTable Info ) {
```

```
      isEdgeData  =  conf . get ( EDGE_TABLE ). equals ( inputTable
Info . getTableNa  me ());


    *  Based   on   the   record   content ,  resolve   correspond
ing   edges   and   send   a   request   to   add   them   to   the
graph .

    * @ param   recordNum
    *  Indicates   the   record   serial   number ,  which   starts
from   1   and   is   separately   counted   in   each   Worker .
    * @ param   record
    *  Indicates   the   record   in   the   input   table .  It
contains   three   columns ,  indicating   the   first   vertex ,
last   vertex ,  and   edge   weight .
    * @ param   context
    *  Indicates   the   context ,  requesting   to   add   resolved
  edges   to   the   graph .

   @ Override
    public   void   load (
        LongWritab  le   recordNum ,
        WritableRe  cord   record ,
        MutationCo  ntext < LongWritab  le ,  LongWritab  le ,
LongWritab  le ,  LongWritab  le >  context )
        throws   IOExceptio  n  {
      if  ( isEdgeData ) {

        *  Data   comes   from   the   table   that   stores   edge
informatio  n .

        *  1 .  The   first   column   indicates   the   first
vertex   ID .

        LongWritab  le   sourceVert  exID  = ( LongWritab  le )
record . get ( 0 );

        *  2 .  The   second   column   indicates   the   last
vertex   ID .

        LongWritab  le   destinatio  nVertexID  = ( LongWritab  le )
record . get ( 1 );

        *  3 .  The   third   column   indicates   the   edge
weight .

        LongWritab  le   edgeValue  = ( LongWritab  le )  record .
get ( 2 );

        *  4 .  Create   an   edge   that   consists   of   the
last   vertex   ID   and   edge   weight .

         Edge < LongWritab  le ,  LongWritab  le >  edge  =  new
Edge < LongWritab  le ,  LongWritab  le >(
            destinatio  nVertexID ,  edgeValue );

        *  5 .  Send   a   request   to   add   an   edge   to   the
  first   vertex .

        context . addEdgeReq  uest ( sourceVert  exID ,  edge );

       *  6 .  If   each   record   indicates   a   bidirectio  nal
  edge ,  repeat   steps   4   and   5 .  Edge < LongWritab  le ,
LongWritab  le >  edge2  =  new
```

```
        *  Edge < LongWritab  le ,  LongWritab  le >(  sourceVert
exID ,  edgeValue );
         *  context . addEdgeReq  uest ( destinatio  nVertexID ,
edge2 );

     }  else  {

         *  Data   comes   from   the   table   that   stores   vertex
  informatio  n .

         *  1 .  The   first   column   indicates   the   vertex   ID
.

         LongWritab  le   vertexID  = ( LongWritab  le )  record . get
( 0 );

         *  2 .  The   second   column   indicates   the   vertex
value .

         LongWritab  le   vertexValu  e  = ( LongWritab  le )  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 ( vertexValu  e );

         *  5 .  Send   a   request   to   add   a   vertex .

         context . addVertexR  equest ( vertex );



  *  Summarize   key - value   pairs   generated   using
GraphLoade  r :: load ( LongWritab  le ,  Record ,  MutationCo  ntext
),  which   is   similar   to
  *  reduce   in   com . aliyun . odps . mapreduce . Reducer .   For
  the   unique   vertex   ID ,  all   actions   such   as
  *  adding / deleting   vertices   or   edges   on   the   ID   is
stored   in   VertexChan  ges .

  *  Note :  Not   only   conflictin  g   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   LoadingRes  olver   extends
  VertexReso  lver < LongWritab  le ,  LongWritab  le ,  LongWritab
le ,  LongWritab  le > {

    *  Process   a   request   about   adding / deleting   vertices
or   edges   for   an   ID .

    *  VertexChan  ges   has   four   APIs ,  which   correspond   to
  the   four   APIs   of   MutationCo  ntext :
```

```
    *  VertexChan  ges :: getAddedVe  rtexList ()  correspond  s   to

    *  MutationCo  ntext :: addVertexR  equest ( Vertex ).
    *  In   the   load ()  method ,  if   vertex   objects   with
the   same   ID   are   requested   to   be   added ,  such   vertex
  objects   are   collected   to   the   return   list .
    *  VertexChan  ges :: getAddedEd  geList ()  correspond  s   to
    *  MutationCo  ntext :: addEdgeReq  uest ( WritableCo  mparable
,  Edge )
    *  If   edge   objects   with   the   same   first   vertex   ID
  are   requested   to   be   added ,  such   edge   objects   are
collected   to   the   return   list .
    *  VertexChan  ges :: getRemoved  VertexCoun  t ()  correspond  s
  to
    *  MutationCo  ntext :: removeVert  exRequest ( WritableCo
mparable )
    *  If   vertices   with   the   same   ID   are   requested   to
  be   deleted ,  the   number   of   total   deletion   requests
is   returned .
    *  VertexChan  ges # getRemoved  EdgeList ()  correspond  s   to

    *  MutationCo  ntext # removeEdge  Request ( WritableCo  mparable
,  WritableCo  mparable )
    *  If   edge   objects   with   the   same   first   vertex   ID
  are   requested   to   be   deleted ,  such   edge   objects   are
  collected   to   the   return   list .

    *  By   processing   ID   changes ,  you   can   state   whether
  the   ID   participat  es   in   calculatio  n   using   the
return   value .  If   the   returned   vertex   is   not   null ,
    *  the   ID   participat  es   in   subsequent   calculatio  n .
If   the   returned   vertex   is   null ,  the   ID   does   not
participat  e   in   subsequent   calculatio  n .

    * @ param   vertexId
    *  Indicates   the   ID   of   the   vertex   requested   to   be
  added   or   first   vertex   ID   of   the   edge   requested   to
  be   added .
    * @ param   vertex
    *  Indicates   an   existing   vertex   object .  Its   value
is   always   null   in   the   data   loading   phase .
    * @ param   vertexChan  ges
    *  Indicates   the   set   of   vertices   or   edges   requested
  to   be   added / deleted   on   the   ID .
    * @ param   hasMessage  s
    *  Indicates   whether   the   ID   has   any   input   message
.  Its   value   is   always   false   in   the   data   loading
phase .

   @ Override
    public   Vertex < LongWritab  le ,  LongWritab  le ,  LongWritab
le ,  LongWritab  le >  resolve (
        LongWritab  le   vertexId ,
        Vertex < LongWritab  le ,  LongWritab  le ,  LongWritab  le
,  LongWritab  le >  vertex ,
        VertexChan  ges < LongWritab  le ,  LongWritab  le ,
LongWritab  le ,  LongWritab  le >  vertexChan  ges ,
        boolean   hasMessage  s )  throws   IOExceptio  n  {

      *  1 .  Obtain   the   vertex   object   to   participat  e
in   calculatio  n .

      MyVertex   computeVer  tex  =  null ;
      if  ( vertexChan  ges . getAddedVe  rtexList () ==  null
```

```
         || vertexChan ges . getAddedVe rtexList (). isEmpty ()) {
        computeVer tex = new MyVertex ();
        computeVer tex . setId ( vertexId );
     } else {

        * Assume that each record indicates a unique
vertex in the table storing vertex informatio n .

        computeVer tex = ( MyVertex ) vertexChan ges .
getAddedVe rtexList (). get ( 0 );


      * 2 . Add the edge requested to be added to
the vertex to the vertex object . If data may be
duplicate , perform deduplicat ion based on the algorithm
  needs .

      if ( vertexChan ges . getAddedEd geList () ! = null ) {
      for ( Edge < LongWritab le , LongWritab le > edge :
vertexChan ges
          . getAddedEd geList ()) {
         computeVer tex . addEdge ( edge . getDestVer texId (),
edge . getValue ());



      * 3 . Return the vertex object and add it to
the final graph for calculatio n .

      return computeVer tex ;



  * Determine actions of the vertex that participat es
  in calculatio n .


  public static class MyVertex extends
  Vertex < LongWritab le , LongWritab le , LongWritab le ,
LongWritab le > {

    * Write the vertex edge to the result table
according to the format of the input table . Ensure
that the format and data of the input and output
tables are the same .

    * @ param context
    * Indicates the context during running .
    * @ param messages
    * Indicates the input message .

   @ Override
    public void compute (
    ComputeCon text < LongWritab le , LongWritab le ,
LongWritab le , LongWritab le > context ,
         Iterable < LongWritab le > messages ) throws
IOExceptio n {

      * Write the vertex ID and value to the result
  table storing vertices .

      context . write (" vertex ", getId (), getValue ());
```

```
      * Write the vertex edge to the result table
storing edges .

      if ( hasEdges ()) {
      for ( Edge < LongWritab le , LongWritab le > edge :
getEdges ()) {
          context . write (" edge ", getId (), edge . getDestVer
texId (),
              edge . getValue ());



      * Perform one round of iteration .

      voteToHalt ();



  * @ param args
  * @ throws IOExceptio n

  public static void main ( String [] args ) throws
IOExceptio n {
  If ( ARGs . Length < 4 ){
      throw new IOExceptio n (
     " Usage : VertexInpu tFormat < 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
storing edge data .

    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 , resolve the
record as edges . Similar to the map , the generated
key is the vertex ID , and the value is the edge .

    job . setGraphLo aderClass ( VertexInpu tLoader . class );

    * 3 . Specify the data loading phase , and generate
  the vertex that participat es in calculatio n .
  Similar to reduce , edges generated by map are
combined to a vertex .

    job . setLoading VertexReso lverClass ( LoadingRes olver .
class );

    * 4 . Specify actions of the vertex that
participat es in calculatio n . The vertex . compute ()
method is used for each round of iteration .

    job . setVertexC lass ( MyVertex . class );
```

```
    * 5 . Specify the output table of the Graph job
, and write the calculatio n 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 ();
```

11 View Job Running Information

11.1 Logview

Logview is a tool to view and debug tasks once the MaxCompute job is submitted.

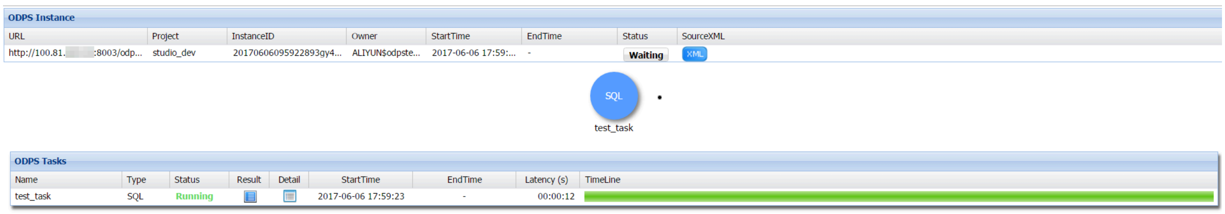
Using Logview, you can see the following details about a job:

- The Run Status of the task.
- The operation result of the task.
- Details of the task and the progress of each step.

When the job is submitted to MaxCompute, a link to the Logview is generated. You can open the Logview link directly on the browser to view information about the job for each job. The Logview page is valid for seven days.

Features

The following is a combination of a specific Logview web UI interface to introduce you to each component.



A Logview home page is divided into two upper and lower sections:

- Instance information
- Task information

Instance info

On the Logview home page, the upper half is the MaxCompute instance that you submit to generate SQL. A unique ID is generated after each SQL commit. Latency refers to the amount of time it takes to run, and the latency of other pages is similar.

The following are the four states:

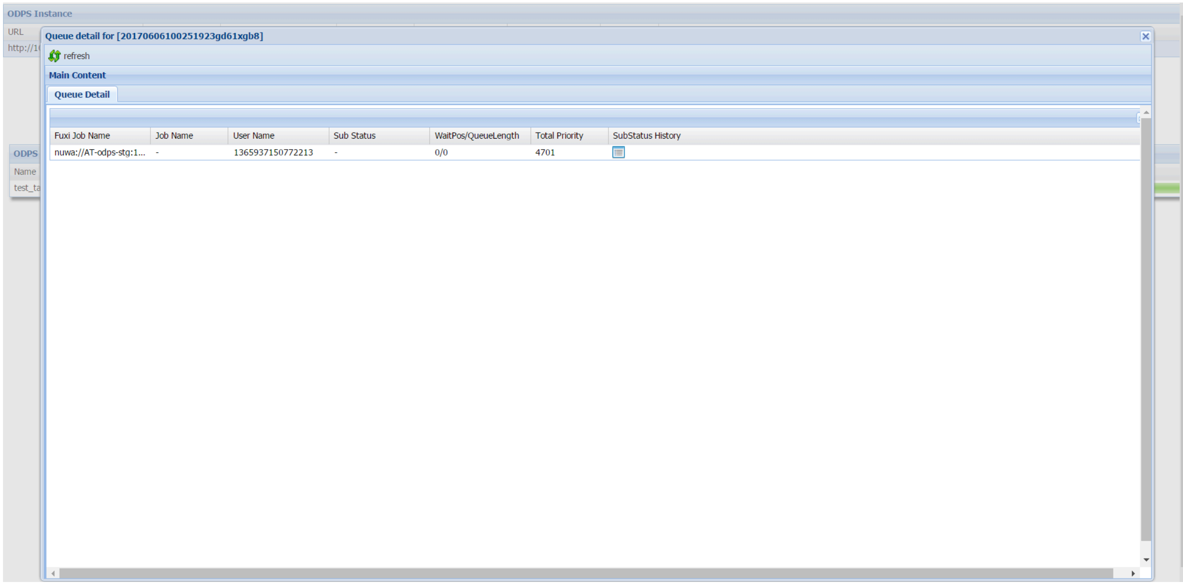
- Waiting: Indicates that the current job is being processed in MaxCompute and is not committed to Fuxi to run.

- Waiting List: N indicates that the job was submitted to Fuxi and queued in Fuxi, is in the n-bit in the queue.
- Running: The Job runs in Fuxi.
- Terminated: The job has ended with no queue information.

Click the non-terminated status of a job to view detailed queue information.

Click status to view queue details:

- Sub status: The current sub-status information.
- Waitpos: The queuing location, where 0 indicates that it is running, and (-) indicates that it has not yet arrived Fuxi.
- Queuing length: The total queue length in the Fuxi.
- Total priority: The priority granted by the job runtime after it has been judged by the system.
- SubStatus history: When clicked, you can view the detailed history of job execution. It contains status codes, status descriptions, start time, duration, and so on. (Currently, some versions have no historical information.)

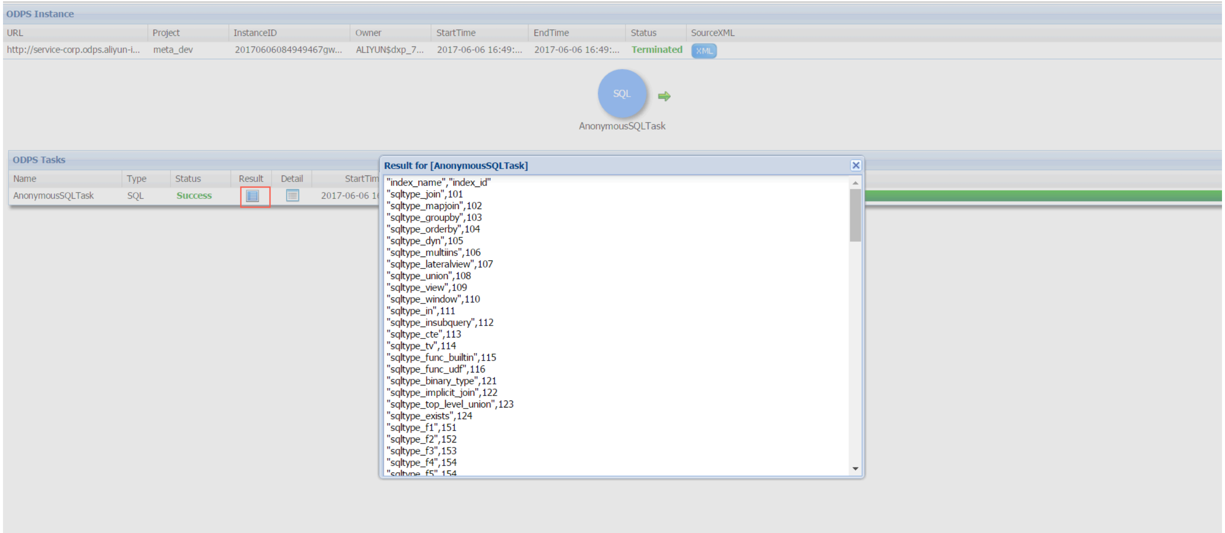


Task information

In the Logview home page, the lower section is the task description followed by the result description and other details.

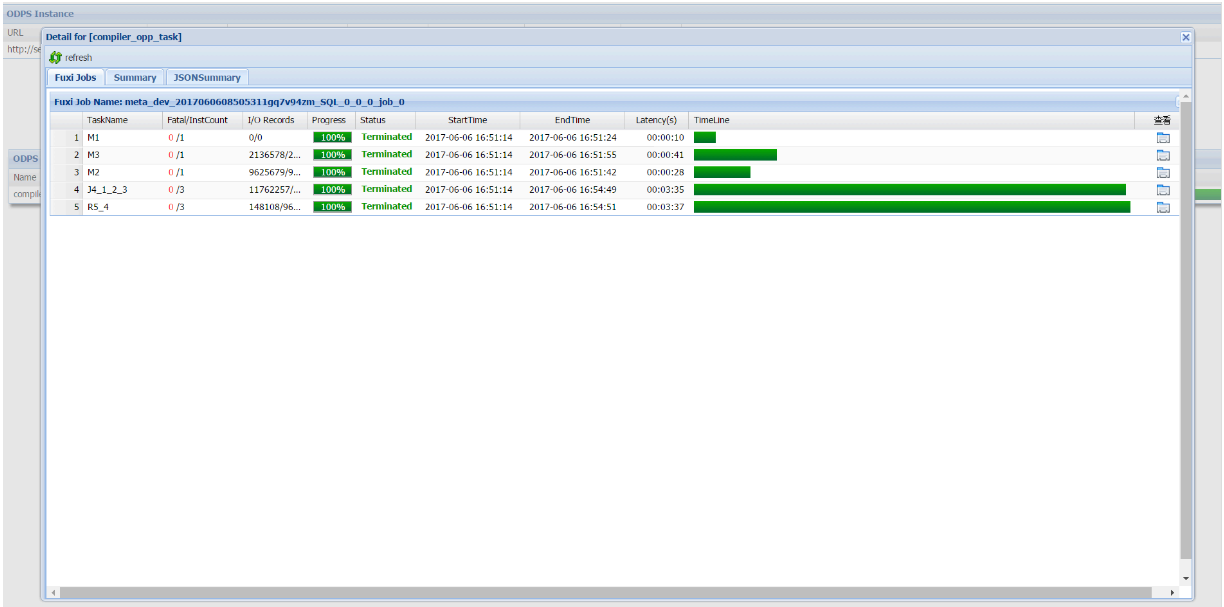
Result:

You can view the result after a job executed, such as the results of a select SQL as shown in the following figure:



Detail:

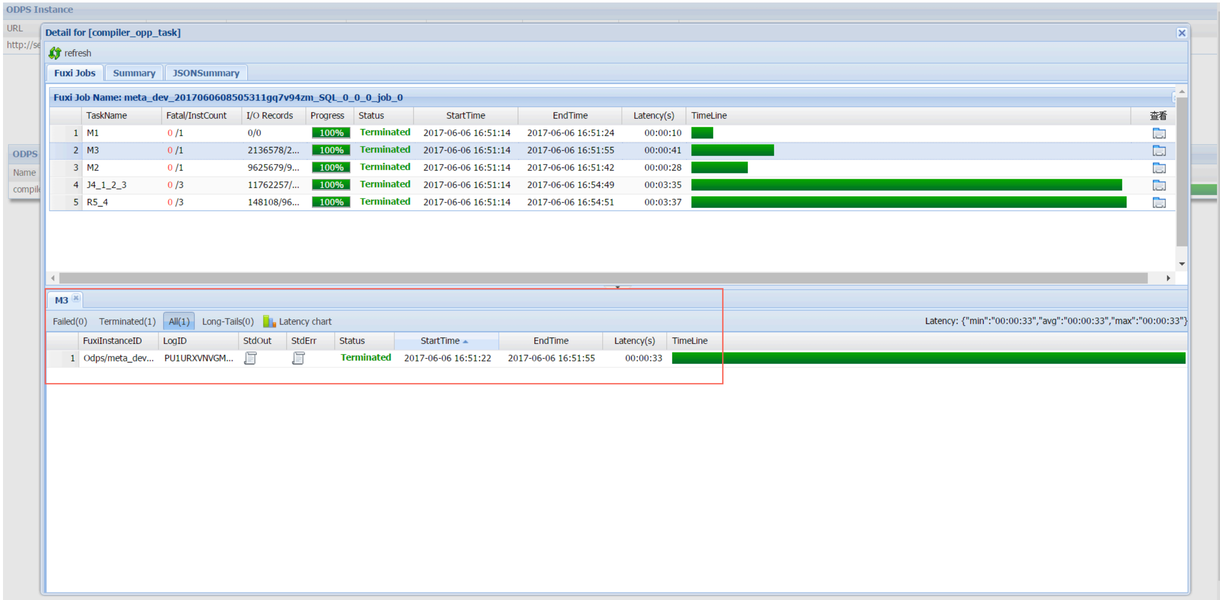
After a job is executed, click detail to view the running status of the task.



- A MaxCompute task consists of one or more Fuxi jobs. For example, when your SQL task is complex, MaxCompute goes to Fuxi and submit multiple Fuxi jobs.
- Each Fuxi job consists of one or more Fuxi tasks. Simple Map Reduce usually produces two Fuxi tasks, namely Map and Reduce. You can view the two Fuxi task names as M1 and R2, respectively. When SQL is complex, more than one Fuxi may generate Task as shown in the preceding figure.
- Each task displays name of the task. For example, M1 is a map task, 4 In r54 means that it relies on J4. Execution will not begin until the last execution is complete. Similarly, j4_1_2_3 indicates that join4 has to rely on M1, M2, M3 three tasks to start the operation completely.

- I/O Records represents the number of records for the input and output of this task.

Click any Fuxi task to view the Fuxi instance content, as shown in the following figure:



Each Fuxi task consists of one or more Fuxi instances. When your input data levels are large MaxCompute activates more nodes to process the data. Each node is a Fuxi instance. Double-click the right-side column of the Fuxi task to view, or double-click the row to open the specific Fuxi instance information.

Towards the lower-end of the page, Logview is grouped for different stages of instance . Select the failed column to view the wrong node.

In the stdout and stderr columns, you can view standard output and standard error messages along with the information to be printed.

Troubleshooting through Logview

- Wrong tasks

  When a task error occurs, a prompt message for the errors in the result on the Logview page pops up. Use the detail page Stderr for Fuxi instance to view information about a specific instance error.
- Data skew

  Slow operation is usually because of individual instances in all Fuxi instances of a certain Fuxi task. Long Tail is caused by the uneven allocation of tasks within the same task. You can view the run results in the summary tab after the task runs. The output of each task is as follows:

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

In the preceding figure, the large difference between min and max suggests that a data tilt has occurred at this stage. Meaning, if one word with high frequency appears, a tilt appears when you join this word.

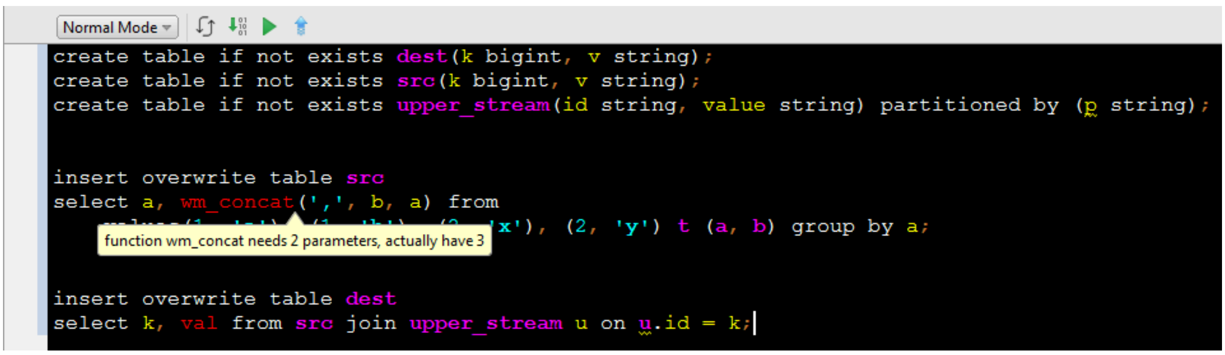
11.2 Errors and warnings using the MaxCompute compiler

The MaxCompute compiler is based on the next-generation SQL engine called MaxCompute2.0, which dramatically enhances SQL. It makes the process of language compilation and the ability of language expression easier. This article introduces you to the enhanced uses of the compiler.

Compiler ease of use improvements

To fully demonstrate the ease-of-use improvements of the MaxCompute compiler, it is recommended that you use MaxCompute studio together.

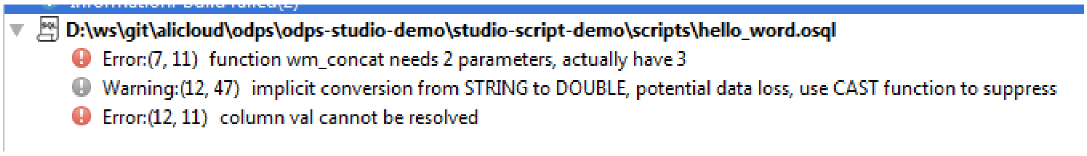
First, install MaxCompute Studio by adding a MaxCompute project and creating a project, and then creating a new MaxCompute. The script is as follows:



The following issues are detected in the preceding figure:

- An error with the wm_concat function can be seen in the First insert statement.
- When MaxCompute compares bigint and double data, it converts all data to double . This conversion from string to double, may cause error when SQL is executed. However, MaxCompute warns you whether you want to trigger this operation.

Point the mouse cursor on an error or warning prompts directly, for a specific error or warning message. If you do not modify the error and commit directly, it is blocked by MaxCompute studio, as shown in the following figure:



So, follow the prompts to modify the errors and warnings as follows:

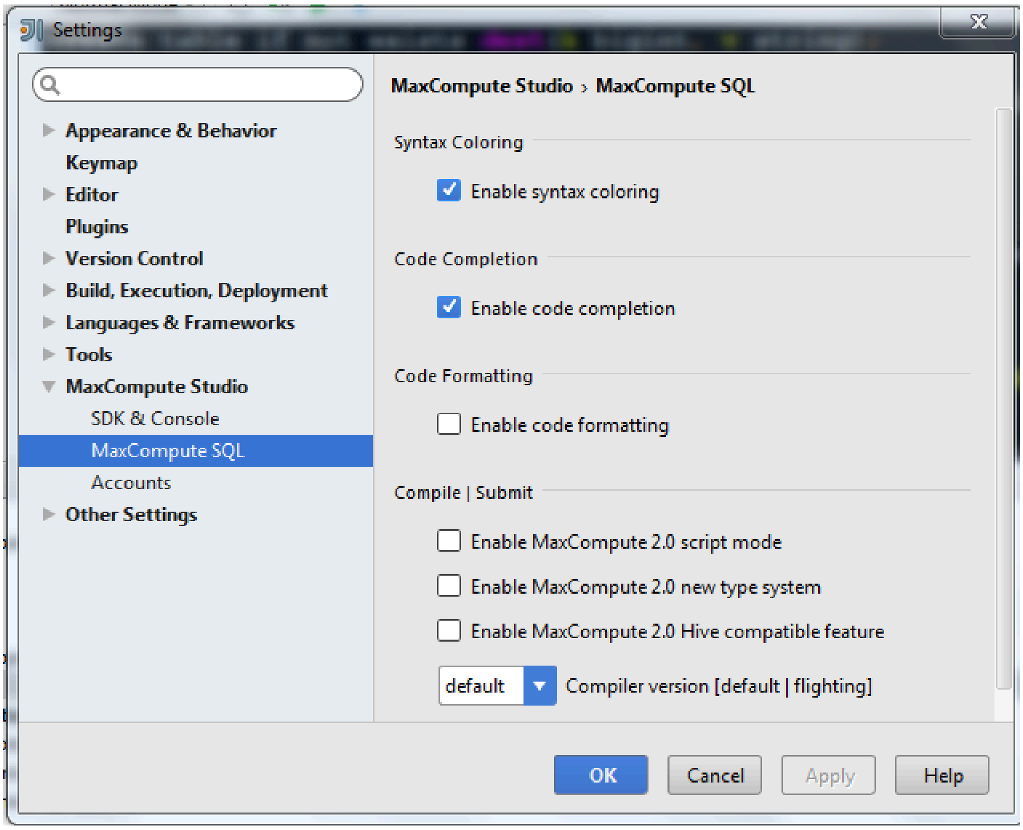
```
create table if not exists dest(k bigint, v string);
create table if not exists src(k bigint, v string);
create table if not exists upper_stream(id string, value string) partitioned by (dt string);

insert overwrite table src
select a, wm_concat(',', b) from
    values(1, 'a'), (1, 'b'), (2, 'x'), (2, 'y') t (a, b) group by a;

insert overwrite table dest
select k, value from src join upper_stream u on u.id = string(k);
```

After the modification, submit the script again, and you can now run it smoothly.

You can also use MaxCompute studio to set all warnings as errors, as shown in the following figure:



With the preceding settings, it is guaranteed that you won't accidentally miss out on any possible errors.

It is recommended that you use MaxCompute studio before submitting any scripts The script is checked for static compilation, and we strongly recommend that you set the warning as an error. Modify all warnings before you submit the script to save time and resources. In addition, when an error script is submitted, it is pushed to your calculation health score. This reduces the priority of the future tasks. Moreover , , future unmodified warnings also get incorporated into the health system. Meaning , the use of MaxCompute compiler and studio can never be degraded.

In many scenarios, you may receive warnings stating that an implicit type conversion is unsafe. However, if you need this conversion, eliminate the warnings by cast (xxx As); Use MaxCompute or a compiler to resolve this problem.