Alibaba Cloud
E-MapReduce

User Guide

Issue: 20181115

Legal disclaimer

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 information, supplementary instructions, and other content that the user must understand.	**Note:** 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]*
{} or {a|b}	It indicates that it is a required value, and only one item can be selected.	`swich` *{stand | slave}*

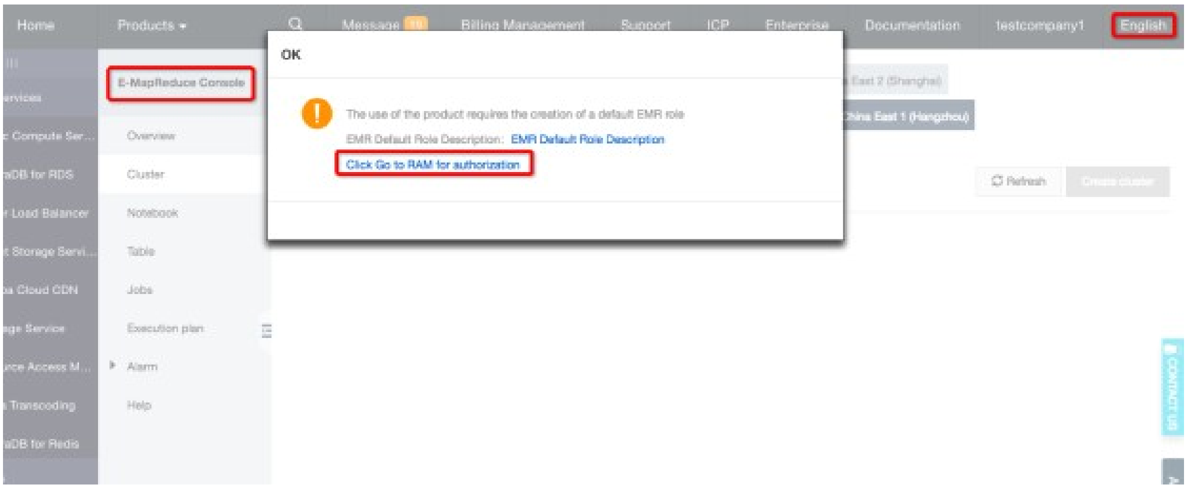
Contents

1 Role authorization

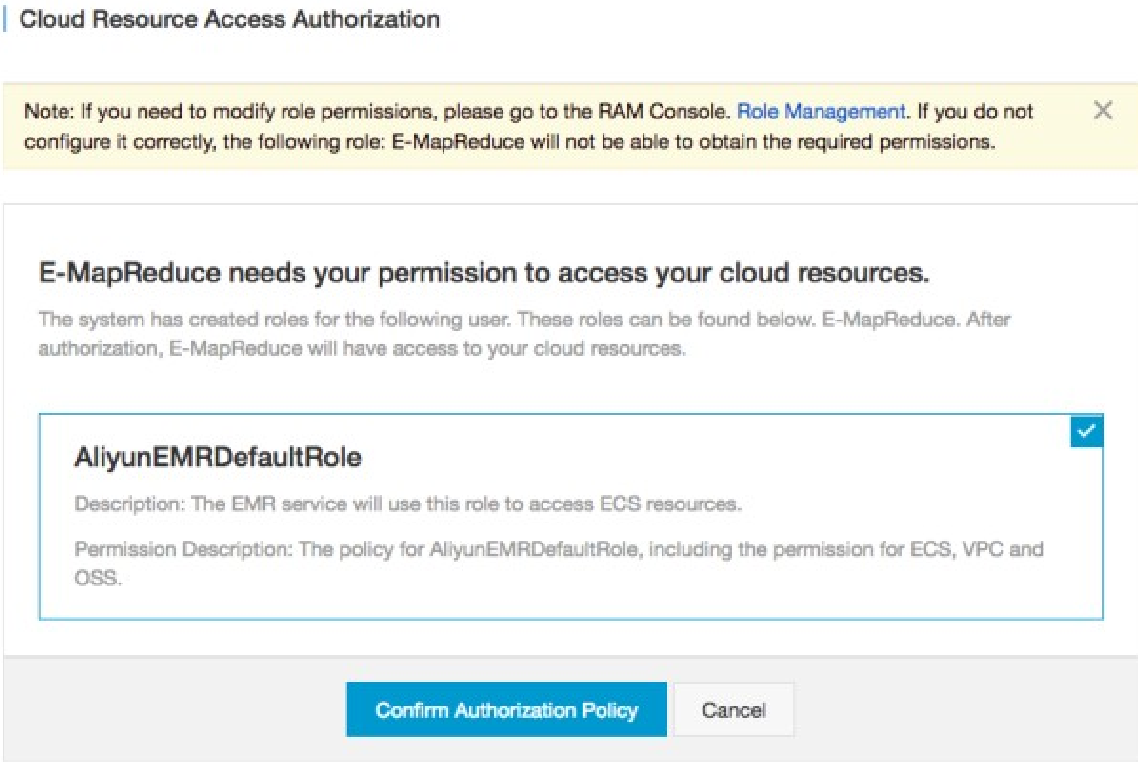
When a user activates the E-MapReduce service, a system default role named AliyunEMRDefaultRole must be granted to the E-MapReduce service account. If the role is assigned correctly, E-MapReduce can then properly call relevant services (such as ECS and OSS), create the clusters, save the logs, and perform other related tasks.

Role authorization process

1. When you create a cluster or an on-demand execution plan, if no default role is authorized correctly to the E-MapReduce service account, the following prompt is displayed. Click **Go to RAM for authorization** to perform role authorization.



2. You are directed to RAM’s authorization page. Click **Confirm Authorization Policy** to authorize the default role AliyunE-MapReduceDefaultRole to E-MapReduce service account.



3. Refresh the E-MapReduce console, and then perform relevant operations. If you want to view relevant detailed policy information of AliyunE-MapReduceDefaultRole, you can log on to the RAM console, or click *View Link*.

Default role permissions

The permissions of default role, AliyunEMRDefaultRole, include the following:

- ECS related permissions:

Permission name (Action)	Permission description
ecs: CreateInstance	Create ECS instances.
ecs: RenewInstance	Renew ECS instances.
ecs: DescribeRegions	Query ECS region information.
ecs: DescribeZones	Query Zone information.
ecs: DescribeImages	Query image information.
ecs: CreateSecurityGroup	Create security groups.
ecs: AllocatePublicIpAddress	Allocate a public network IP address.
ecs: DeleteInstance	Delete machine instances.
ecs:StartInstance	Start machine instances.

Permission name (Action)	Permission description
ecs: StopInstance	Stop machine instances.
ecs: DescribeInstances	Query machine instances.
ecs: DescribeDisks	Query relevant disk information of the machine.
ecs: AuthorizeSecurityGroup	Set security group input rules.
ecs: AuthorizeSecurityGroupEgress	Set security group output rules.
ecs: DescribeSecurityGroupAttribute	Query the security group details.
ecs: DescribeSecurityGroups	Query security group list information.

- OSS related permissions

Permission name (Action)	Permission description
oss: PutObject	Upload file or folder objects.
oss: GetObject	Get file or folder objects.
oss: ListObjects	Query file list information.

2 Configure clusters

2.1 Instance types

The EMR cluster consists of multiple different node instance types, namely the master, core, and task instances. Completely different service processes are available for different tasks when each of these instances is deployed. For example, we deploy Hadoop HDFS's Name Node service and Hadoop YARN's Resource Manager service on master instances, and Data Node service and Hadoop YARN's Node Manager service on core instances. Task instances are only used for computing. Therefore, we deploy Hadoop YARN's Node Manager service, rather than HDFS-related services for task instances.

When creating a cluster, you must determine ECS specifications for these three instance types. The ECS instances with the same instance type must be in the same instance group. The cluster can scale up at a later stage to accommodate the number of hosts in the appropriate instance groups (except master instance group).

Note:

The task instance is supported in version 3.2.0 or later.

Master instance

The master instance is the node where the cluster service's management and control components are deployed. For example, the Hadoop YARN's Resource Manager is deployed on the master instance node. You can connect to the master instance using SSH, and check the service status in the cluster by the Web UI of the software. At the same time, when you want to quickly test or run a job, you can log on to the master instance and submit jobs directly by command lines. When the high availability feature is turned on for the cluster, two master instance nodes are used (by default, only one).

Core instance

The core instance is the instance node managed by the master instance. It runs the Hadoop HDFS's Data Node service and stores all the data. It also deploys computing services, such as Hadoop YARN's Node Manager service, to perform computing tasks. To meet the needs for more data storage or heavier computing workload, the core instance can scale up at any time without affecting the normal operations of the active cluster. It can use a variety of different storage media to store data. You can refer to the discussions about disks for details.

Task instance

The task instance is an optional instance type that is specifically responsible for computing. If the core instance has sufficient computing power, task instance may not be used. The task instance can quickly add computing power to the cluster, such as Hadoop's MapReduce tasks, and Spark executors. As HDFS data is not stored on the task instance, Hadoop HDFS's Data Node service does not run on it. The task instance can scale up and down at any time without affecting the normal operations of the active cluster. Depending on the fault tolerance (or retries) of the computing service, fewer task instance nodes may cause MapReduce and Spark jobs to fail.

2.2 Gateway instances

Gateway is an independent cluster consisting of multiple nodes with same configurations.

When creating a gateway cluster, you can associate an existing Hadoop cluster on which Hadoop (HDFS+YARN), Hive, Spark, Sqoop, Pig, and other clients have been deployed to facilitate cluster operations. It is an independent submission point and does not take up the resources of the cluster, especially you submit jobs on the Master node, which can improve the stability of the Master node. If you have too many jobs to submit, you can add nodes for the cluster dynamically.

You can also create multiple gateway clusters for different users, allowing them to use their own environment to meet different business needs.

2.3 ECS instances

ECS instances

ECS instance types available for EMR

- General-purpose type

  vCPU/Memory ratio is 1:4, for example, 32 core and 128 GB. This type uses cloud disks as storage.
- Compute type

  vCPU/Memory ratio is 1:2, for example, 32 core and 64 GB. This type uses cloud disks as storage and provides more computing resources.
- Memory type

  vCPU/Memory ratio is 1:8, for example, 32 core and 256 GB. This type uses cloud disks as storage and provides more memory resources.

- Big data type

  Utilizing local SATA disks as a highly cost-effective data storage solution, it is a recommended ECS instance type applicable for use cases involving mass data volumes (TB-level).

- Ephemeral SSD type

  Utilizing ephemeral SSDs, the ECS instance type has a high local IOPS and throughput.

- Shared type (entry level)

  The ECS instance type with shared CPUs is not stable enough for use cases involving massive computing volumes. It is applicable for entry-level learning users rather than enterprise customers.

- GPU

  It is a heterogeneous GPU-based ECS instance type applicable for machine learning use cases.

ECS instances applicable for different scenarios

- Master instances

  General-purpose or memory types are applicable for master instances, where data is directly stored on Alibaba Cloud's cloud disks. It has three backups, which guarantees high data reliability.

- Core instances

  General-purpose, compute, and memory types are applicable for small data volume use cases (below TB level) or when OSS is used for primary data storage. When data volume is large (10 TB or more), we recommend that you use the big data type for great cost-effectiveness. When utilizing ephemeral disks, data reliability is challenged, but it can be maintained and guaranteed by the EMR platform.

- Task instances

  All types except the big data type are applicable for task instances to give additional computing power to the cluster. Currently, the ephemeral SSD type is not yet supported, but will be added to the task instance soon.

2.4 Storage guide

There are two types of disks on a node: one is the system disk which is used to install operating systems, the other is the data disk which is used for data storage. A node generally has one system disk by default which must be a cloud disk. However, you can have more than one data disk (currently, up to sixteen on a single node). Each piece of data disk can have different configurations, including different disk types and capacities. SSD cloud disks are defaulted in EMR as the cluster's system disks. Four cloud disks are used in EMR by default. Considering current intranet bandwidth, the default configuration is reasonable.

Cloud and ephemeral disks

Two types of disks are available for data storage.

- Cloud disks

  Include SSD, ultra, and basic cloud disks.

  Rather than being directly attached to a local computing node, cloud disks have access to a remote storage node by the network. Each piece of data has two real-time backups in the backend, thus three identical copies in total. When one of the copies is corrupted (due to disk damage, rather than damages arising from business), your backup data is automatically used for recovery.
- Ephemeral disks

  Include ephemeral SATA disks in the big data type and ephemeral SSD disks used in the ephemeral SSD type.

  Ephemeral disks are attached directly to the computing node and have better performance than cloud disks. You cannot select the number of ephemeral disks and must keep the default configurations. Similar to offline physical hosts, no data backup is in the backend, and upper-level software to guarantee data reliability is required.

Applicable use cases

In EMR, when the hosting node is released, data in all cloud and ephemeral disks is cleared. The disks cannot be kept independently or re-used. Hadoop HDFS uses all data disks for data storage . Hadoop YARN also uses all data disks as on-demand data storage for computing.

When your business does not involve large data volume (below TB level), cloud disks can be used as the IOPS and throughput are smaller than local disks. In case of large data volumes, we recommend that you use local disks whose data reliability is guaranteed by EMR. If you encounter apparently insufficient throughput, you can switch to ephemeral disks.

OSS

OSS can be used as HDFS in EMR. You can have easy read and write access to OSS. All codes using HDFS can also be simply edited to access data on OSS.

For example:

Reading data from spark

```
sc.Textfile("hdfs://user/path")
```

Replace storage type HDFS-> OSS

```
sc.Textfile("oss://user/path")
```

The same is true for Mr or hive jobs.

HDFS commands directly handle OSS data

```
hadoop fs -ls oss://bucket/path
hadoop fs -cp hdfs://user/path  oss://bucket/path
```

In this process, you do not need to enter AK and endpoint, EMR will automatically complete the user's information using the current cluster owner.

However, as OSS does not have high IOPS, it is not suitable for use cases that require high IOPS , such as Spark Streaming or HBase.

2.5 D1 Support

To meet the storage needs in the big data-type use case, Alibaba Cloud launched an instance series using ephemeral disks in the cloud: the D1 series. The D1 series uses ephemeral disks instead of cloud disks for data storage. This solves the high cost problem caused by keeping multiple copies of redundant data in the cloud disks. In addition, as no data must be transferred by the network, the disk throughput is improved. Furthermore, the series can also take advantage of Hadoop’s proximity computing.

Compared with cloud disks, the series greatly enhances storage performance and reduces storage prices, reaching nearly the same cost as offline physical hosts.

Along with numerous advantages of using ephemeral disks, the problem of data reliability occurs . For cloud disks, because of Alibaba Cloud’s default multi-disk backup policy, you do not need consider disk damages. Cloud disks automatically guarantee data reliability. However, when you use ephemeral disks, such guarantee requires upper-level software. If disk and node failures appear, manual operations and maintenance must be performed.

The EMR + D1 solution

A complete set of automated maintenance solution like D1 is available in EMR for ephemeral disks. This allows Alibaba Cloud users to utilize instances using ephemeral disks without considering the entire maintenance process, as data reliability and service availability are guaranteed.

Highlights are as follow:

- Highly reliable distribution of required nodes
- Ephemeral disk and node faults monitoring
- Automatic determination of data migration opportunities
- Automatic failed node migration and data balancing
- Automatic HDFS data detection
- Network topology optimization

With automated maintenance of the entire back-end management and control system, EMR helps you make better use of ephemeral disks, and develop cost-effective big data system.

> **Note:**
> If you want to set up a Hadoop cluster using the D1 series, open a ticket so we may assist in your operations.

2.6 Access between classic network and VPC

Currently, Alibaba Cloud provides two types of cloud networks: classic network and VPC. Many users' service systems are still using classic networks, while EMR clusters are using VPCs. This section describes how to enable inter-access between ECS on classic networks and EMR clusters on VPC networks.

ClassicLink

To solve this problem, Alibaba Cloud launches the *ClassicLink Solution*. Follow these steps:

1. Create a vSwitch according to the CIDR block specified in the ClassLink Solution.
2. When creating a cluster, use the vSwitch for the CIDR block to deploy the cluster.
3. Connect the corresponding classic network node to VPC in the ECS console.
4. Set security group rules.

This is how an inter-access between ECS on a classic network and EMR cluster on a VPC network is realized.

3 Cluster

3.1 Create a cluster

In this tutorial, you will learn how to create a cluster.

Enter the cluster creation page

1. Log on to the *Alibaba Cloud E-MapReduce console*.
2. Complete RAM authorization. For procedure, see *Role authorization*.
3. Select a region for a cluster. The region cannot be changed once the cluster is created.
4. Click **Create Cluster** to create a cluster.

Cluster creation process

Note:

Except for the name, clusters cannot be modified after creation.

To create a cluster, complete the following three steps:

1. Software configuration

   Configuration description:

   - **EMR version**: The main version of E-MapReduce represents a complete open source software environment and can be upgraded regularly based on the upgrade of internal component software. If the software related to Hadoop is upgraded, the main version of E-MapReduce is also upgraded. Earlier version clusters cannot be upgraded to a later version.
   - **Cluster type**: Currently E-MapReduce provides the following cluster types:
     - Hadoop clusters, provide semi-managed ecosystem components:
       - Hadoop, Hive, and Spark that offline store and compute distributed data at scale.
       - SparkStreaming, Flink, and Storm that are stream processing systems.
       - Presto and Impala, for running interactive analytics queries.
       - Oozie and Pig.
     - Druid clusters, provide semi-managed, real-time interactive analysis services, query large amount of data in millisecond latency, and support for multiple data intake methods . Used with services such as EMR Hadoop, EMR Spark, OSS, and RDS, Druid clusters offer real-time query solutions.

    - Data Science clusters, are mainly for big data and AI scenarios, providing Hive and Spark offline big data, and TensorFlow model training.
    - Kafka clusters, are taken as a semi-managed distributed message system of high throughput and high scalability, providing a complete service monitoring system that can keep a stable running environment.
  - **Inclusion configurations**: Displays a list of all software components under the selected cluster type, including the name and version number. You can select different components as required. The selected components start relevant service processes by default.

    Note:

    The more components you select, the higher requirements are for your computer configuration. Otherwise, there may be insufficient resources to run these services.
  - **High security mode**: In this mode, you can set the Kerberos authentication of the cluster. This feature is unnecessary for clusters used by individual users. It is turned off by default.
  - **Enable custom setting**: You can specify a JSON file to change software configuration before you start a cluster.
2. Hardware configuration

   Configuration description:

  - Billing configuration:
    - Billing method: The billing method is consistent with ECS. Both Subscription and Pay-As-You-Go modes are supported. If Subscription mode is selected, you must select the duration. It is applicable to short-term testing or flexible dynamic tasks. The payment is relatively high.
    - Purchase duration: You can select 1, 2, 3, 6, or 9 months, or 1, 2, or 3 years.
  - Cluster network configuration
    - **Zone**: Select the zone where the cluster is to be located. If better network connectivity is required, we recommend that you select the same availability zone. However, the risk of cluster creation failure increases as the storage of a single availability zone may be insufficient. If you need a large number of nodes, open a ticket to consult with us.
    - **Network type**: By default, the Virtual Private Cloud (VPC) network is selected which requires you to enter a VPC and a VSwitch. If you haven't created a network, go to the *VPC console* to create them. For more information about E-MapReduce VPC, see *VPC*.
    - **VPC**: Select the region of the VPC network.

  - **VSwitch**: Select a zone for VSwitch under the corresponding VPC. If no VSwitch is available in this zone, then you must create a new one.
  - **Security group name**: Generally, no security group exists when you create a cluster for the first time. Enter a name to create a new security group. If you already have a security group in use, you can choose to use it directly here.
- Cluster configuration
  - **High availability**: When enabled, two master instances in the Hadoop cluster are used to ensure the availability of the Resource Manager and Name Node. HBase clusters supports high availability by default. When enabled, a master instance is used to ensure high availability.
  - **Node type**:
    - Master, the master instance node is mainly responsible for the deployment of control processes such as Resource Manager and Name Node.
    - Core, the core instance node is mainly responsible for the storage of all data in the cluster, and can be scaled up as needed.
    - Task, the computing node, does not store data, and is used to adjust the computing capacity of the cluster.
  - **Node configuration**: Select different types of nodes. Different types of nodes have different application scenarios. You can select one type based on requirements.
  - **Data disk type**: The data disks used by a cluster node are ordinary cloud disks, high-efficiency cloud disks, and SSD cloud disks which may vary with machine type and region. When the user selects different regions, disks that are supported by the regions are displayed in the drop-down list. The data disk is set to release with the cluster release by default. The ephemeral disk type is set by default and cannot be changed.
  - **Data disk volume**: The recommended minimum cluster volume of a single machine is 40 G, and the maximum is 8000 G. The capacity of the ephemeral disk is set by default and cannot be changed.
  - **Instance quantity**: The quantity of instances of all required nodes. A cluster requires at least three instances (the high availability cluster requires at least four instances, adding one master node). The maximum is 50. If more than 50 instances are required, contact us by opening a ticket. While a monthly subscribed cluster can provide 100 at most. If you need more than 50 nodes, open a ticket to consult with us.

3. Basic configuration

Configuration description:

- Basic information

  Cluster name: The cluster name can contain Chinese characters, English letters (uppercase and lowercase), numbers, hyphens (-), and underscores (_), with a length limit between 1-64 characters.
- Running logs
  - **Running logs**: The function for saving running logs is turned on by default. In the default state, you can select the OSS directory location to save running logs. You must activate OSS before using this function. Cost depends on the number of uploaded files. We recommend that you open the OSS log saving function, which helps in debugging and error screening.
  - **Log path**: OSS path for saving the log.
  - **Uniform Meta Database**: Provided by E-MapReduce to store all Hive metadata in the external database of the cluster. We recommend that you use this function when the cluster uses OSS as the main storage.
- Permission settings
  - **EMR role**: You can authorize E-MapReduce with this role to use other Alibaba Cloud services, such as ECS and OSS.
  - **ECS role**: This role allows your programs running on the E-MapReduce computing nodes to access cloud services like OSS without providing the Alibaba Cloud AccessKey. E-MapReduce automatically applies for an on-demand AccessKey to authorize the access. The AccessKey permission is controlled by this role.
- Logon settings
  - **Remote logon**: It is turned on by default to enable security group port 22.
  - **Logon password**: Set the logon password at the master node. The logon password must contain English letters (both uppercase and lowercase letters), numbers, and special characters (!@#$%^&*) with a length limit between 8-30 characters.
- Bootstrap operation (optional): You can run the customized script before Hadoop is enabled in the cluster. For more information, see *Bootstrap action*.

Purchase list and cluster cost

In the **Configuration List** pane, you can see the cost of the cluster. The presented price information varies with the type of payment. For Subscription cluster, the total expense is shown. For Pay-As-You-Go cluster, hourly expense is shown.

Confirm creation

After all valid information is entered, the **Create** button is highlighted. Click **Create** to create a cluster.

Note:

- If it is a Pay-As-You-Go cluster, the cluster is created immediately, and you are taken back to the **Overivew** page where you can see a cluster in the **Initializing**status. It can take several minutes to create the cluster. After creation, the cluster is switched to Idle **Idle** status.
- Subscription clusters are not created until the order is generated and paid.

Log on to the Core Node

To log on to the Core node, take the following steps:

1. Switch to the hadoop account on the Master node.

```
su hadoop
```

2. Log on to the Core node without a key through SSH.

```
ssh emr-worker-1
```

3. Get root permissions through the sudo command.

```
sudo vi /etc/hosts
```

Creation failed

If cluster creation failed, the message **Cluster creation failed** appears on the cluster list page. The reason for the failure can be seen when the pointer is placed on the red exclamation point.

No handling is required because the corresponding computing resources are not created. The cluster is automatically hidden after three days.

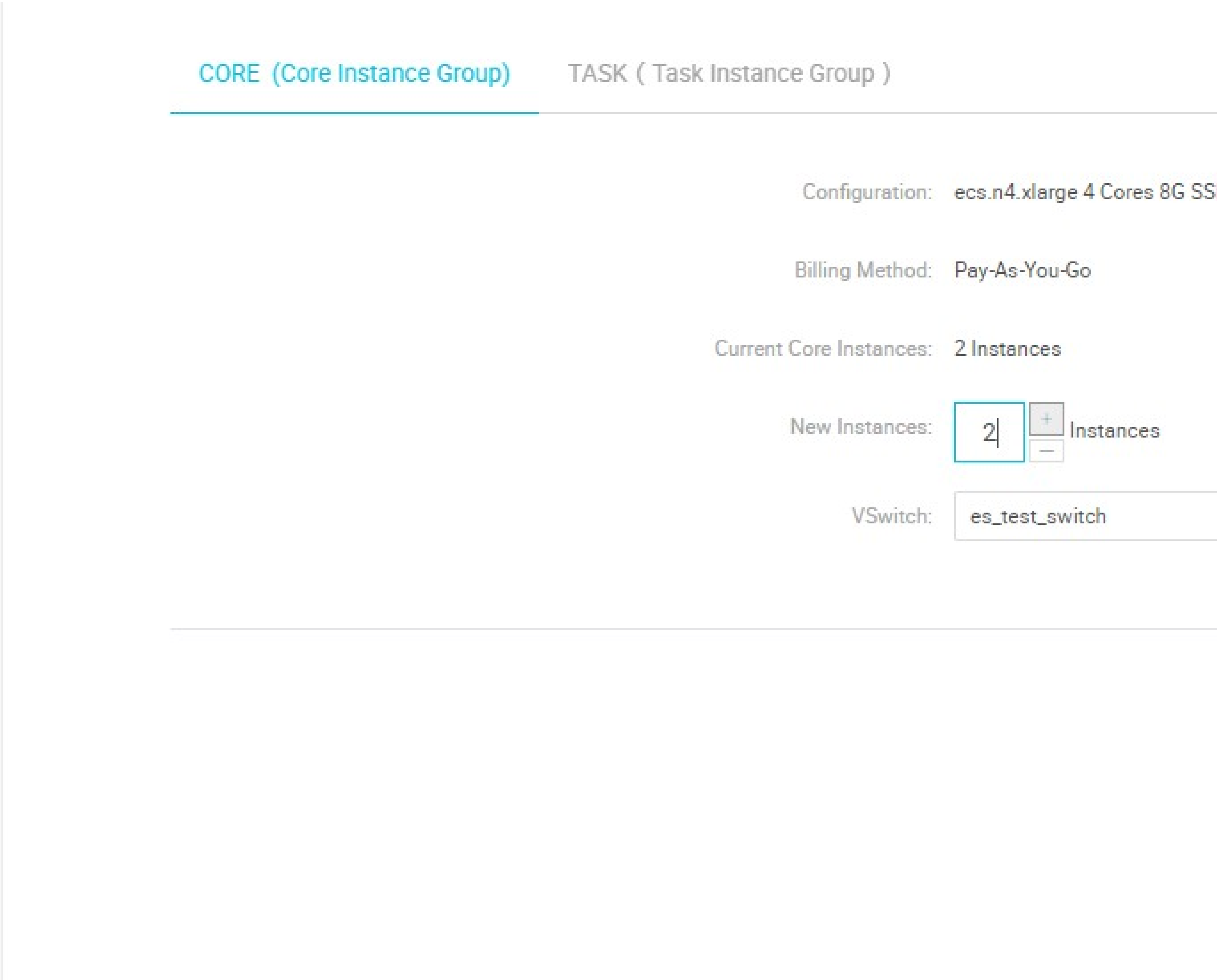
3.2 Expand a cluster

If your cluster resources (computing and storage resources) are insufficient, the cluster can be expanded horizontally. Only core and task nodes can be expanded. Configurations of expanding a cluster default to be consistent with the ECS instance purchased previously.

Expansion entry

Select the cluster to be expanded on the cluster list page, click **More**, and select **Scale Up/Out**. You can also click **View Details** on the right side of the cluster, and click **Scale Up/Out** in the upper right corner.

Expansion interface



Note:

Only expansion is supported. Reduction is not supported.

- **Configuration**: Displays configurations of the current instance.
- **Billing Method**: Displays the payment method of the current cluster.
- **Current Core Instances**: Displays the quantity of all your current core nodes.
- **New Instances**: Enter the quantity that you want to add. We recommend that you perform small-scale expansions each time, such as increasing one or two instances.
- VSwitch: Displays the VSwitch of the current cluster.

Expansion status

The figure of cluster expansion statuses is shown as follows:

Core Instance Group

ECS ID	Status	Public IP	Intranet IP	Created At
i-bp1htgltshh2o59kkxqz	Normal		192.168.0.47	2018-10-25 10:36:59
i-bp1733wjev9dzvvp62n7	Normal		192.168.0.48	2018-10-25 10:37:00
i-bp1dhriqana54rgvcfn2	Scaling Up/Out		192.168.0.50	2018-10-25 10:53:07
i-bp1c0d1hnoaicxddc57t	Scaling Up/Out		192.168.0.51	2018-10-25 10:53:09

To view the expansion status of a cluster, in the **Cluster Overview** panel, go to the **Core Instance Group (CORE)** area. The node that is being expanded is displayed as **Scaling Up/Out**. When the status of an ECS instance changes to **Normal**, the ECS has been added into the cluster and can provide services normally.

3.3 Release a cluster

On the **Cluster Management** page, you can release a cluster.

Only Pay-As-You-Go clusters in the following statuses can be released:

- Creating
- Running
- Idle

Common release

You are prompted to confirm a release before releasing a cluster. Once the release is confirmed, the following operations will happen:

- All jobs in the cluster are forcibly terminated.
- If you have selected to save the log to OSS, all current job logs are saved to OSS. It takes several minutes to uplaod logs to OSS.

- Clusters are released in seconds, up to five minutes. This process depends on the size of the cluster, the smaller the cluster will be faster. ECS clusters to be released are billed before they are released.

> **Warning:**
> If you want to save money, make sure that a cluster is released before an exact hour.

Forcible release

If you no longer need logs, and want to immediately terminate running clusters, activate the forcible release function. The process of log collection is skipped and clusters are released directly .

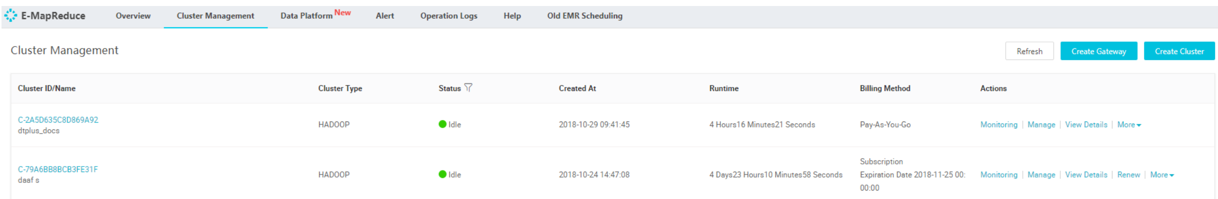
Cluster release failure

Due to system error or other causes, cluster releases may fail after confirmation. If a cluster release fails, E-MapReduce starts background protection to automatically release the cluster again until it is released successfully.

3.4 Cluster list

The **Cluster Management** page displays basic information about all of your clusters.

On the **Cluster Management** page, information of clusters are displayed as follows:



Items of the cluster list are described as follows:

- **Cluster ID/Name**: The ID and name of a cluster. Place the pointer over the cluster name to modify it.
- **Cluster Type**: Hadoop is the only cluster type available.
- **Status**: The cluster status, for more information, see *Cluster status*. In case of cluster abnormalities, such as creation failure, prompt information appears on the right side. The detailed error information can be viewed by hovering the pointer over it. You can sort the status by clicking **Status**.
- **Created At**: Time when a cluster was created.

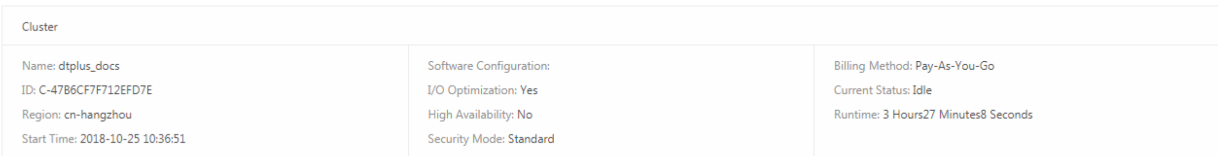
- **Runtime**: The time from the start of creation to the current run time. Once the cluster is released, the timing is terminated.
- **Billing Method**: The billing method of the cluster.
- **Actions**: Operations that can be applied to clusters, including the following:
  - **Monitoring**: Monitors the CPU usage rate, memory capacity, and disk capacity of E-MapReduce clusters to help users monitor the running status of the cluster.
  - **Manage**: Enter the **Clusters and Services** panel.
  - **View details**: Enter the **Cluster Overview** panel and view the detailed information after the cluster is created.
  - **More**:
    - **Scale Up/Out**: The entry for the cluster expansion function.
    - **Release**: Releases a cluster, see *Release a cluster*.
    - **Restart**: Restarts a cluster.

3.5 Cluster details

Cluster details display cluster detailed information.

Cluster overview includes the following four parts.

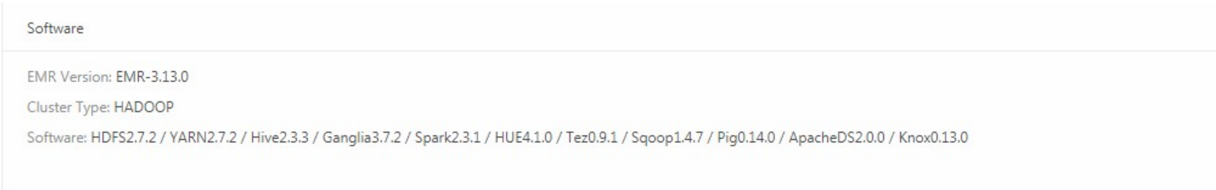
Cluster



- **Name**: The name of a cluster.
- **ID**: The instance ID of a cluster.
- **Region**: The region where a cluster is located.
- **Start Time**: The creation time of a cluster.
- **Software Configuration**: Software configurations.
- **I/O Optimization**: Whether the I/O optimization setting is enabled.
- **High Availability**: Whether high-availability clusters are enabled.
- **Security Mode**: Software in clusters is started in Kerberos secure mode. For information about Kerberos, see *Introduction to Kerberos*.
- **Billing Method**: Cluster payment type。

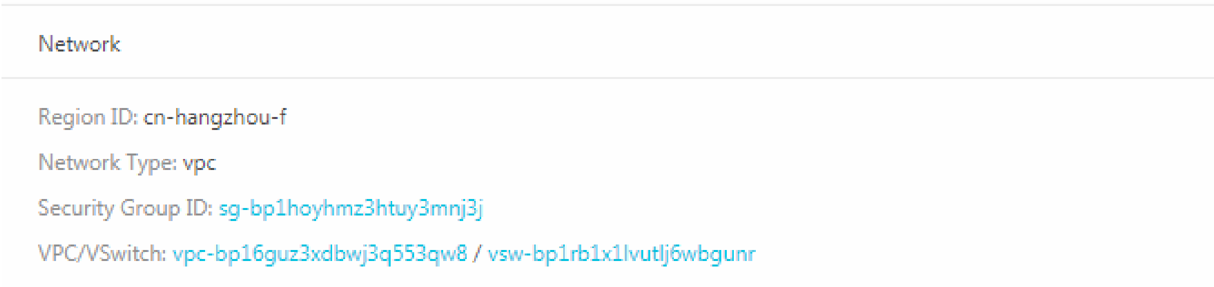
- **Current Status**: See *Cluster status*.
- **Runtime**: Clusters run time.
- **Bootstrap**: The names, paths, and parameters of all configured bootstrap actions are listed here.
- **ECS Role**: When your program runs on an EMRcompute node, you can access the related Alibaba Cloud services, such OSS, without an AccessKey. EMR automatically requests a temporary AccessKey to authorize this access. The permission control of this temporary AccessKey is controlled by this role.

Software



- **Main Version**: The main version of E-MapReduce.
- **Cluster Type**: The selected cluster type.
- **Software**: All application programs installed and their versions are listed here, such as HDFS2.7.2, Hive 2.3.3, and spark 2.3.1.

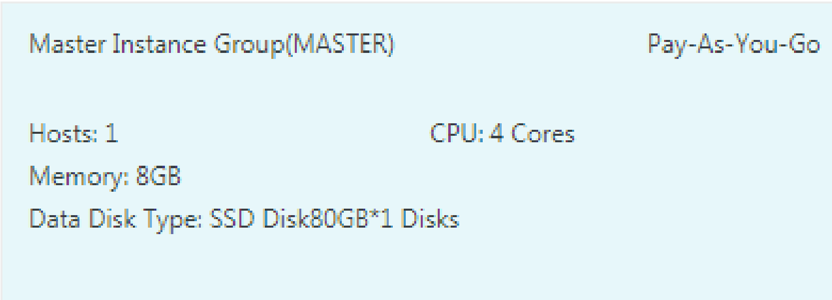
Network



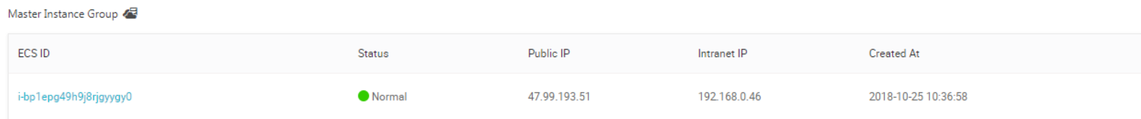
- **Region ID**: The region where a cluster is located, such as cn-hangzhou-b which is the same as ECS.
- **Network Type**: The network type of a cluster.
- **Security Group ID**: The security group ID that a cluster joined.
- **VPC/VSwitch**: The VPC and VSwitch IDs of a cluster.

Host

- **Master Instance Group (Master)**: Configurations of all master nodes.

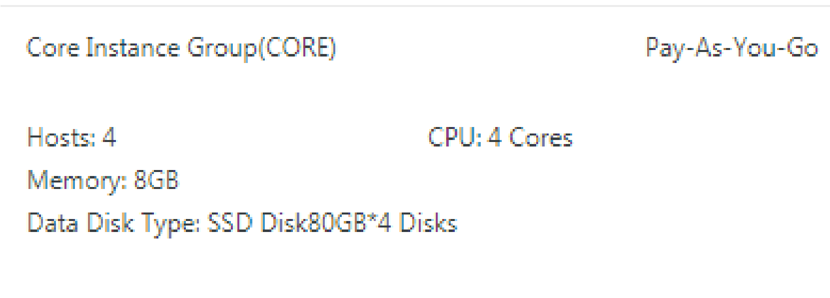


- **Hosts**: The number of the current nodes. During the creation process, the number of the current nodes is less than that of nodes you applied for until the creation is complete.
- **CPU**: The number of cores of a node's CPU.
- **Memory**: Memory capacity of a node.
- **Data Disk Type**: Data disk type and capacity of a node.
- **ECS ID**: The ID of the ECS instances purchased.



- **Status**: Includes Creating, Normal, Expanding, and Released.
- **Public IP** : The public IP of master nodes.
- **Intranet IP**: The internal network IP of the machine that can be accessed by all nodes in the cluster.
- **Created At**: The creation time of the ECS instance purchased.

• **Core Instance Group (Core)** : Configurations of all core nodes.



- **Hosts**: The number of the current nodes which is the same as that of the nodes you applied for.
- **CPU**: The number of cores of a node's CPU.
- **Memory**: Memory capacity of a node.
- **Data Disk Type**: Data disk type and capacity of a node.

- **ECS ID**: The ID of the ECS instances purchased.

Core Instance Group

ECS ID	Status	Public IP	Intranet IP	Created At
i-bp1htgltshh2o59kkxqz	Normal		192.168.0.47	2018-10-25 10:36:59
i-bp1733wjev9dzvvp62n7	Normal		192.168.0.48	2018-10-25 10:37:00
i-bp1dhriqana54rgvcfn2	Normal		192.168.0.50	2018-10-25 10:53:07
i-bp1c0d1hnoaicxddc57t	Normal		192.168.0.51	2018-10-25 10:53:09

- **Status**: Includes Creating, Normal, Expanding, and Released.
- **Intranet IP**: The internal network IP of the machine that can be accessed by all nodes in the cluster.
- **Created At**: The creation time of the ECS instance purchased.

3.6 User management

User management allows you to manage accounts which are required to create the related services on specified clusters. E-MapReduce currently supports two types of accounts: Knox accounts and Kerberos accounts.

Create a RAM account

1. Log on to the *Alibaba Cloud E-MapReduce Console*, and then go to the **Cluster Management** page.
2. Click **Manage** on the right side of the target cluster ID.
3. In the left-side navigation panel, click **User Management**.
4. In the upper-right corner of the page, click **Create RAM User**.

Add a Knox account

1. In the **User Management** page, select the account you want to add to a cluster, and then click **Set Knox Account Password** in the **Actions** column.
2. In the **Add Knox User** dialog box, enter a password to use for logon. Click **OK**.
3. Refresh the **User Management** panel. When **Synchronized** appears in the **Knox Account** column, the Knox account is successfully added.

   After the addition is successful, you can sign in to Knox using the **User Name** and the password set in *step 2*.

Delete a Knox account

1. In the **User Management** panel, select the account you want to add to a cluster, and then click **Delete Knox Account** in the **Actions** column.
2. Refresh the **User Management** page. When **Unsynchronized** appears in the Knox Account column, the Knox account is successfully deleted.

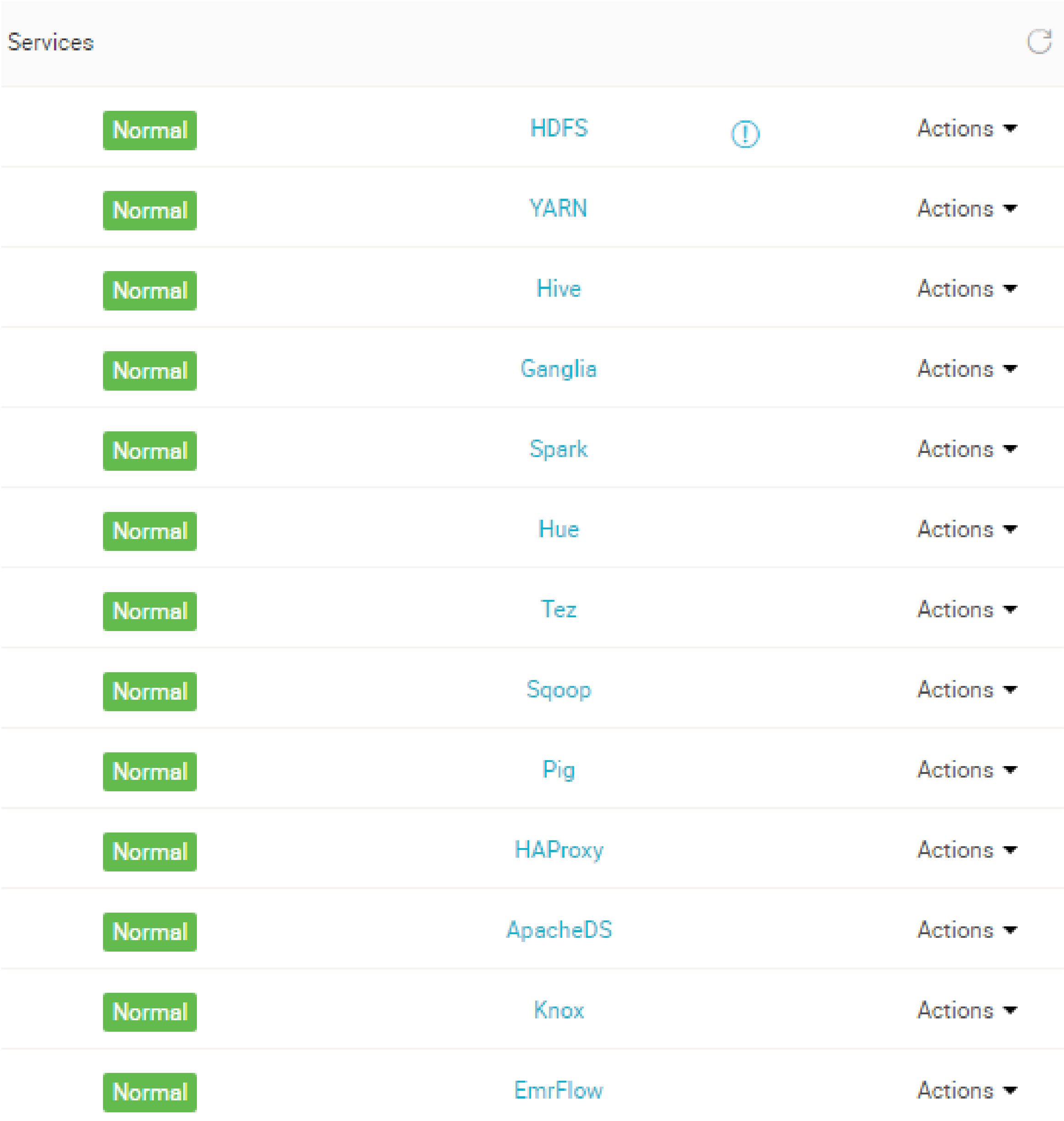
FAQs

- Different clusters cannot share the same Knox account. For example, the Knox account A you added in cluster-1 cannot be used in cluster-2. If you want to use the Knox account A in cluster-2, you must re-add the account A in cluster-2. Knox accounts are created in clusters, so the Knox accounts of each cluster are not interoperable.
- If the message **An error occurred** while synchronizing the status appears when you add a Knox account, click **Retry** to add it again.
- If you **retry** adding an account multiple times but it continues to fail, on the left side of the page, click **Clusters and Services** to check if ApacheDS is stopped. If yes, start ApacheDS and go back to **User Management** then try again.

3.7 Service list

The **Clusters and Services** tab has been added to the tab list of the cluster management page to show the running status of HDFS, YARN, and other services.

The service list shows the information as follows.



Running statuses of services are only showed for clusters that are in Idle or Running status. When creating a cluster, if the service you click is unchecked (such as Storm), it will not be listed.

Click a service to view the corresponding tabs including **Status**, **Component Topology**, **Configuration**, and **Configuration Change History**. The status is divided into **Normal** and **Error**. If the status of a service on a node is **Error**, you can use the master node to jump to the corresponding node, and check the service process.

3.8 Cluster script

To modify the cluster running environment, you can install third-party software in a cluster, especially a subscription cluster. After a cluster is created, the cluster script feature allows you to select nodes in batches and run your specified script to fulfill individual requirements.

The role of cluster scripts

A cluster script is similar to a bootstrap action. After creating a cluster, you can install software packages to your cluster, for example:

- Use Yum to install the software that has been provided.
- Directly download public software packages from the public network.
- Read your data from OSS.
- Install and run a service like Flink or Impala which requires a more complex script.

We strongly recommend that you test the cluster script on a node first. After the script is verified, you can perform operations on the whole cluster.

How to create and run a cluster script

1. A cluster script can run on an idle or running cluster. On the **Cluster Management** page, click **View Details** of the corresponding cluster.
2. On the left-side menu, click **Cluster Scripts** to enter the cluster script execution interface.
3. In the upper right corner, click **Create and Run** to enter the creation interface.
4. Enter configurations in the script creation pane. Select a node for execution and click **OK**.

You can click **View Details** to display the running status of a script on each node or click **Refresh** to update the running status of a cluster on each node.

Cluster scripts can only run on available clusters that are idle or running. Cluster scripts are applicable for long-standing clusters. For on-demand clusters, perform a bootstrap action to initialize the clusters.

The cluster script feature downloads a script from the OSS and run it on the specified node. If the returned value is 0, the execution has failed. If the execution fails, you can log on to the node to check the running log. The running log for each node is located at */var/log/cluster-scripts/clusterScriptId*. If the cluster is configured with an OSS log directory, the running log is also uploaded to *osslogpath/clusterId/ip/cluster-scripts/clusterScriptId*.

By default, the root account is used to run the specified script. In the script, you can use **su hadoop** to switch to a Hadoop account.

A cluster script can successfully run on some nodes, but fails on others. For example, the restart of a node can lead to a failure in script operation. After resolving the error, you can run the cluster script again. After a cluster is expanded, you can specify the expanded node for separate execution of the cluster script.

Only one cluster script can run on a cluster at a time. If a cluster script is running, you cannot submit a new cluster script for execution. For each cluster, you can retain up to ten cluster script records. Therefore, if you already have ten records, to create a new cluster script, you must delete the previous records first.

Script example

For a script similar to a bootstrap action, you can specify the file in the script to be downloaded from OSS. In the following example, the file *`oss://yourbucket/myfile.tar.gz`* is downloaded and decompressed to the directory *`/yourdir:`*

```
#! #!/bin/bash
osscmd --id=<yourid> --key=<yourkey> --host=oss-cn-hangzhou-internal.
aliyuncs.com get oss://<yourbucket>/<myfile>.tar.gz ./<myfile>.tar.gz
mkdir -p /<yourdir>
tar -zxvf <myfile>.tar.gz -C /<yourdir>
```

OSSCMD is pre-installed on the node and can be called directly to download the file.

Note:

The OSS host address can be an intranet address, an Internet address, or a VPC network address. If a classic network is used, you must specify an intranet address. If the network is located in Hangzhou, the intranet address is oss-cn-hangzhou-internal.aliyuncs.com. If a VPC network is used, you must specify a domain name that can be accessed from the VPC intranet. If the network is located in Hangzhou, the domain name is vpc100-oss-cn-hangzhou.aliyuncs.com.

Additional system software packages can be installed to the script using Yum, for example, ld-linux.so. 2 :

```
#! /bin/bash
```

```
yum install -y ld-linux.so. 2
```

3.9 Cluster renewal

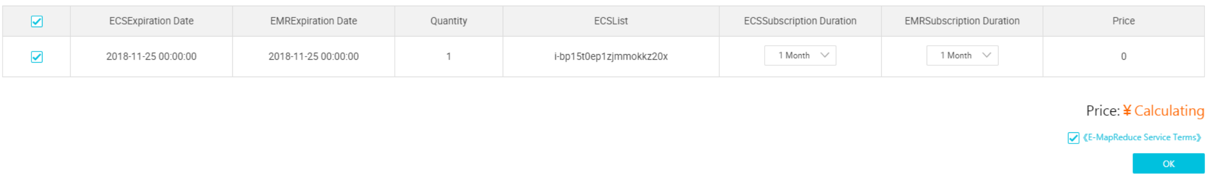
When your subscription cluster service renewal is about to expire, you must renew the cluster to continue E-MapReduce cluster services. The cluster renewal includes E-MapReduce services and ECS instances.

Renewal entrance

1. Log on to the *Alibaba Cloud E-MapReduce console*.
2. At the top of the page, click **Cluster Management**.
3. In the cluster list, target the cluster that you want to renew.
4. On the right side of the corresponding cluster, click **Renew** to enter the cluster renewal page.

Renewal page

The figure is shown as follows:



- **ECS Expiration Date**: The expiration date of an ECS instance.
- **EMR Expiration Date**: The expiration date of E-MapReduce services.
- **Quantity**: The number of machines for instance groups.
- **ECS List**: The ECS instance ID of the machine in the cluster.
- **ECS Subscription Duration**: The renewal duration for ECS (one-nine months and one-three years are supported).
- **EMR Subscription Duration**: The renewal duration for E-MapReduce. We recommend that you keep it consistent with ECS.
- **Price**: The renewal price of E-MapReduce services and ECS instances.

Pay for orders

Note:

The fees are the sum of ECS renewal price and E-MapReduce service product price. If there are unpaid orders in the cluster list, you cannot expand or renew any clusters.

1. Click **OK** to view the prompt box for successful order placement.

2. Click **Go to the payment page**. The payment page displays the total amount and order details of E-MapReduce services ECS intances.
3. Click **Confirm payment**.
4. After you make the payment, click **Payment completed** to return to the cluster list page.

The expiration time of successfully renewed clusters displayed on the cluster list page is updated to the time after renewal. For the corresponding ECS instance, the expiration time after the renewal is usually updated after about three to five minutes.

If you confirm the renewal order, but don’t pay for it, **Cancel order** and **Make the payment** are displayed on the right side of the cluster. Click **Make the payment** to complete the corresponding order payment, or click **Cancel** to cancel the renewal.

3.10 Security group

Security groups created in E-MapReduce can be used during the creation of clusters.

Only the port 22 is accessible in the cluster created by E-MapReduce. We recommend that you divide ECS instances by function, and put them into different user security groups. For example, the security group of E-MapReduce is **E-MapReduce security group**, while the security group that you have created is **User security group**. Each security group is provided with unique access control as required.

If it is necessary to link with the cluster that has been created, follow these steps.

Add E-MapReduce cluster to the existing security group

1. Log on to the*Alibaba Cloud E-MapReduce console*.
2. At the top of the page, click **Cluster Management**.
3. Click **View Details**.
4. In the **Network** tab, find **Security Group ID** and click the ID link.
5. In the left-side menu, click **Instances in Security Group** to view security group names of all ECS instances.
6. Log on to the *Alibaba Cloud ECS console*, and in the left-side navigation panel, click **Security Group** to find the security group entry in the list as viewed in the preceding step.
7. Click **Manage Instances** in a security group, and see ECS instances names starting with emr-xxx. These are the corresponding ECS instances in an E-MapReduce cluster.
8. Select all these instances, click **Move to security group**, and then select a security group to move an E-MapReduce cluster to an existing group.

Add the existing cluster into E-MapReduce security group

Find the security group where the existing cluster is located. Repeat the preceding operations, and move to the E-MapReduce security group. Select scattered machines in the ECS console directly and move the clusters to E-MapReduce security group in batch.

Security group rules

The security group rules are subject to the OR relationship when an ECS instance is in several different security groups. For example, only port 22 of the E-MapReduce security group is accessible, while all ports of the **User security group** are accessible. After the cluster of E-MapReduce is added into the **User security group**, all ports of the machine in E-MapReduce are open.

3.11 Access links and ports

Quick portal for components.

When a cluster is created, several domain names are bound to the cluster by default for you to access your open source components:

- HDFS
- YARN
- Spark
- Hue
- Ganglia

In the **Cluster Management** page, click **Manage** or **View Details**, and find the **Access Links and Ports** tab where you can see links of the preceding components.

By default, there is no username and password for accessing. Therefore, the access request cannot pass the HTTP authentication. You need to click **Set Username and Password** to set a username and password to access your component interface.

Only one username and one password can be used. Therefore, the new username and password will always replace the previous ones.

Note:

Currently, this function is only supported by version 2.3 and later.

3.12 Node upgrade

In actual use, the CPU or memory of cluster nodes, especially master nodes, may be insufficient. Currently, E-MapReduce does not support direct upgrades. We recommend that you upgrade nodes in the following way.

Note:

Only subscription clusters can be upgraded.

Procedure

1. In the **Cluster Management** panel, select a cluster, and click **View Details**.
2. In the right corner, click **Configuration Upgrade**.
3. Configure the nodes to be upgraded.
4. Click **OK**.
5. Pay for your order.

   Return to the Cluster Management page, refresh the page to make sure that the node configuration has become the target specification, for example, CPU is 4 core and memory is 16G.
6. Log on to the *ECS console*, find the upgraded instances and restart them one by one.
7. Modify cluster configurations so that Yarn can use new resources.

   a. Modify the *`yarn-site.xml file`*.

   b. Change the value of **`yarn.nodemanager.resource.memory-mb`** to `machine memory * 0.8` , the unit is MB. Change the value of **`yarn.scheduler.maximum-allocation-mb`** to `machine memory * 0.8`, the unit is MB. For example, in my new configuration, the memory is 32 GB:

   ```
   yarn.nodemanager.resource.memory-mb=26214
   yarn.scheduler.maximum-allocation-mb=26214
   ```

   If your cluster does not support page modification, you must log on to the node, and modify the corresponding configuration values in the *`/etc/emr/hadoop-conf/yarn-site.xml`* file for each node.

   c. Restart the Yarn service. Generally, you only must restart the worker node. However, after the restart, the Node Manger port is changed. Therefore, we recommend that you restart the Resource Manager.

8. Open a ticket to the E-MapReduce team for providing information about the new node configuration. The E-MapReduce team will synchronize the configuration.

3.13 Convert payment methods

There are two payment methods for EMR: Pay-As-You-Go and Subscription. We usually try to use EMR in Pay-As-You-Go method with a small cost. Once you confirm to use EMR for a long time, you can convert to the Subscription payment method.

Convert Pay-As-You-Go to Subscription

You can select the Pay-As-You-Go method at the beginning for EMR trial, and then at any time, in the **Cluster Overview** panel, click the **Switch to Subscription** button to switch the cluster payment method from Pay-As-You-Go to Subscription. The payment method of the entire cluster will be switched.

Convert Subscription to Pay-As-You-Go

Currently, converting Subscription to Pay-As-You-Go is not supported.

3.14 Remove abnormal nodes

If an ECS node of an E-MapReduce cluster is abnormal, and if you do not need this node and want to remove it, you can use the remove abnormal nodes feature.

To remove an abnormal node, follow these steps:

1. Log on to the *Alibaba Cloud E-MapReduce console*.
2. At the top of the page, click **Cluster Management**.
3. Click the ID link of the cluster that includes the node that you want to remove.
4. In the left-side navigation pane, click **Hosts**.
5. Find the instance that you want to remove, and in the action column, click **Remove**. ECS instances can be removed when they are in a stopped or released status.
6. Click **OK** to remove the instance.

4 Job

4.1 Hadoop MapReduce job configuration

Procedure

1. Log on to the *Alibaba Cloud E-MapReduce console*.
2. At the top of the navigation bar, click **Data Platform**.
3. In the **Actions** column, click **Design Workflow** of the specified project.
4. On the left side of the Job Editing page, right-click on the folder you want to operate and select **New Job**.
5. In the **New Job** dialog box, enter the job name and job description.
6. Select a Hadoop job type to create a Hadoop MapReduce job. This type of job is Hadoop job submitted in the background via the following process.

```
hadoop jar xxx.jar [MainClass] -Dxxx ....
```

7. Click **OK**.

   Note:
   You can also create subfolder, rename folder, and delete folder by right-clicking on the folder.

8. Fill in the **Content** field with command line parameters to be provided to submit this job. Please note that content to be filled in this **Content** field shall be started with the first parameter after hadoop jar. That is to say, in the content box, the address for jar to be provided to run this job shall be first followed by [MainClass], and you can provide other command line parameters themselves.

   For instance, you want to submit a Hadoop sleep job which doesn't write/read any date, then this job will succeed only by submitting mapper reducer tasks to the cluster and waiting for each task to sleep for a while. In Hadoop (e.g. hadoop-2.6.0), this job is packaged in hadoop-mapreduce-client-jobclient-2.6.0-tests.jar of the Hadoop release version. If this job is submitted from the command line, the command will be:

```
hadoop jar /path/to/hadoop-mapreduce-client-jobclient-2.6.0-tests.
jar sleep -m 3 -r 3 -mt 100 -rt 100
```

To configure this job in E-MapReduce, in the **Content** field, enter the following content:

```
/path/to/hadoop-mapreduce-client-jobclient-2.6.0-tests.jar sleep -m
3 -r 3 -mt 100 -rt 100
```

Note:

The jar package path used here is an absolute path on the E-MapReduce host. There is a problem that the user may put these jar packages anywhere, and as the cluster is created and released, these jar packages become unavailable as they are released. Therefore, upload the jar package using the following methods:

1. Users send their own jar packages to the bucket of the OSS for storage. When you configure the parameters for hadoop, click **Select OSS path** to select and execute the jar package you want from the OSS directory. System will then auto-complete the OSS address for jar packages. Be sure to switch the prefix of the jar for your code to ossref (click **switch resource type**), to ensure that the jar package is downloaded correctly by MapReduce.
2. Click **OK**, the OSS path for this package will be auto completed in the **Content** field. When a job is submitted, the system will find the corresponding jar packages automatically as per this path.
3. Behind the jar package path for this OSS, other command line parameters for running a job will be further filled in.

9. Click **Save**.

In above example, sleep job has no data input/output. If the job needs to read data and process input results (e.g. wordcount), the data input and output paths shall be specified. You can read/write data on HDFS of E-MapReduce cluster as well as data on OSS. To read/write data on OSS, it can be done only by writing the data path as the OSS path when filling input and output paths, for instance:

```
jar ossref://emr/checklist/jars/chengtao/hadoop/hadoop-mapreduce-
examples-2.6.0.jar randomtextwriter -D mapreduce.randomtextwriter.
```

```
totalbytes=320000 oss://emr/checklist/data/chengtao/hadoop/Wordcount/
Input
```

4.2 Hive job configuration

When users are applying for a cluster in E-MapReduce, they are provided with a Hive environment by default. Users can directly create and operate their tables and data by using Hive.

Procedure

1. Prepare the Hive script in advance, for example:

   ```
   USE DEFAULT;
    DROP TABLE uservisits;
    CREATE EXTERNAL TABLE IF NOT EXISTS uservisits  (sourceIP STRING,
   destURL STRING,visitDate STRING,adRevenue DOUBLE,user
    Agent STRING,countryCode STRING,languageCode STRING,searchWord
   STRING,duration INT ) ROW FORMAT DELIMITED FIELDS TERMI
    NATED BY ',' STORED AS SEQUENCEFILE LOCATION '/HiBench/Aggregation/
   Input/uservisits';
    DROP TABLE uservisits_aggre;
    CREATE EXTERNAL TABLE IF NOT EXISTS uservisits_aggre ( sourceIP
   STRING, sumAdRevenue DOUBLE) STORED AS SEQUENCEFILE LO
    CATION '/HiBench/Aggregation/Output/uservisits_aggre';
    INSERT OVERWRITE TABLE uservisits_aggre SELECT sourceIP, SUM(
   adRevenue) FROM uservisits GROUP BY sourceIP;
   ```

2. Save this script into a script file, such as *`uservisits_aggre_hdfs.hive`*, and then upload it to an OSS directory (for example, *`oss://path/to/uservisits_aggre_hdfs.hive`*).
3. Log on to the *Alibaba Cloud E-MapReduce console*.
4. At the top of the navigation bar, click **Data Platform**.
5. In the **Actions** column, click **Design Workflow** of the specified project.
6. On the left side of the Job Editing page, right-click on the folder you want to operate and select **New Job**.
7. In the **New Job** dialog box, enter the job name and description.
8. Select the Hive job type to create a Hive job. This type of job is submitted in the background using the following method:

   ```
   hive [user provided parameters]
   ```

9. Click **OK**.

   Note:

   You can also create subfolder, rename folder, and delete folder by right-clicking on the folder.

10. Enter the parameters in the **Content** field with parameters subsequent to Hive commands. For example, if it is necessary to use a Hive script uploaded to OSS, the following must be entered:

```
-f ossref://path/to/uservisits_aggre_hdfs.hive
```

You can also click **Select OSS path** to view and select from OSS, the system will automatically complete the path of Hive script on OSS. Switch the Hive script prefix to ossref (click **Switch resource type**) to guarantee this file is properly downloaded by E-MapReduce.

11. Click **Save** to complete the Hive job configuration.

4.3 Pig job configuration

When you are applying for clusters in E-MapReduce, a Pig environment is provided by default. You can create and operate tables and data by using Pig.

The procedure is as follows.

1. Prepare the Pig script in advance, for example:

````
```shell
 /*
 * Licensed to the Apache Software Foundation (ASF) under one
 * or more contributor license agreements.  See the NOTICE file
 * distributed with this work for additional information
 * regarding copyright ownership.  The ASF licenses this file
 * to you under the Apache License, Version 2.0 (the
 * "License"); you may not use this file except in compliance
 * with the License.  You may obtain a copy of the License at
 *
 *     http://www.apache.org/licenses/LICENSE-2.0
 *
 * Unless required by applicable law or agreed to in writing,
software
 * distributed under the License is distributed on an "AS IS" BASIS,
 * WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or
implied.
 * See the License for the specific language governing permissions
and
 * limitations under the License.
 */
 -- Query Phrase Popularity (Hadoop cluster)
 -- This script processes a search query log file from the Excite
search engine and finds search phrases that occur with particular
high frequency during certain times of the day.
 -- Register the tutorial JAR file so that the included UDFs can be
called in the script.
 REGISTER oss://emr/checklist/jars/chengtao/pig/tutorial.jar;
 -- Use the  PigStorage function to load the excite log file into
the “raw” bag as an array of records.
 -- Input: (user,time,query)
 raw = LOAD 'oss://emr/checklist/data/chengtao/pig/excite.log.bz2'
USING PigStorage('\t') AS (user, time, query);
 -- Call the NonURLDetector UDF to remove records if the query field
 is empty or a URL.
````
````

```
 clean1 = FILTER raw BY org.apache.pig.tutorial.NonURLDetector(query
);
 -- Call the ToLower UDF to change the query field to lowercase.
 clean2 = FOREACH clean1 GENERATE user, time, org.apache.pig.
tutorial.ToLower(query) as query;
 -- Because the log file only contains queries for a single day, we
are only interested in the hour.
 -- The excite query log timestamp format is YYMMDDHHMMSS.
 -- Call the ExtractHour UDF to extract the hour (HH) from the time
field.
 houred = FOREACH clean2 GENERATE user, org.apache.pig.tutorial.
ExtractHour(time) as hour, query;
 -- Call the NGramGenerator UDF to compose the n-grams of the query.
 ngramed1 = FOREACH houred GENERATE user, hour, flatten(org.apache.
pig.tutorial.NGramGenerator(query)) as ngram;
 -- Use the  DISTINCT command to get the unique n-grams for all
records.
 ngramed2 = DISTINCT ngramed1;
 -- Use the  GROUP command to group records by n-gram and hour.
 hour_frequency1 = GROUP ngramed2 BY (ngram, hour);
 -- Use the  COUNT function to get the count (occurrences) of each n
-gram.
 hour_frequency2 = FOREACH hour_frequency1 GENERATE flatten($0),
COUNT($1) as count;
 -- Use the  GROUP command to group records by n-gram only.
 -- Each group now corresponds to a distinct n-gram and has the
count for each hour.
 uniq_frequency1 = GROUP hour_frequency2 BY group::ngram;
 -- For each group, identify the hour in which this n-gram is used
with a particularly high frequency.
 -- Call the ScoreGenerator UDF to calculate a "popularity" score
for the n-gram.
 uniq_frequency2 = FOREACH uniq_frequency1 GENERATE flatten($0),
flatten(org.apache.pig.tutorial.ScoreGenerator($1));
 -- Use the  FOREACH-GENERATE command to assign names to the fields
.
 uniq_frequency3 = FOREACH uniq_frequency2 GENERATE $1 as hour, $0
as ngram, $2 as score, $3 as count, $4 as mean;
 -- Use the  FILTER command to move all records with a score less
than or equal to 2.0.
 filtered_uniq_frequency = FILTER uniq_frequency3 BY score > 2.0;
 -- Use the  ORDER command to sort the remaining records by hour and
 score.
 ordered_uniq_frequency = ORDER filtered_uniq_frequency BY hour,
score;
 -- Use the  PigStorage function to store the results.
 -- Output: (hour, n-gram, score, count, average_counts_among
_all_hours)
 STORE ordered_uniq_frequency INTO 'oss://emr/checklist/data/
chengtao/pig/script1-hadoop-results' USING PigStorage();
```

2. Save this script into a script file, such as *script1-hadoop-oss.pig*, and then upload it to an OSS directory(for example, *oss://path/to/script1-hadoop-oss.pig*).
3. Log on to the *Alibaba Cloud E-MapReduce Console*.
4. At the top of the navigation bar, click **Data Platform**.
5. In the **Actions** column, click **Design Workflow** of the specified project.

6. On the left side of the Job Editing page, right-click on the folder you want to operate and select **New Job**.
7. In the **New Job** dialog box, enter the job name and description.
8. Select the Pig job type to create a Pig job. This type of job is submitted in the background by using the following method:

```
pig [user provided parameters]
```

9. Click **OK**.

> **Note:**
> You can also create subfolder, rename folder, and delete folder by right-clicking on the folder.

10. Enter the parameters in the **Content** field with parameters subsequent to Pig commands. For example, if it is necessary to use a Pig script uploaded to OSS, the following must be entered:

```
-x mapreduce ossref://emr/checklist/jars/chengtao/pig/script1-hadoop
-oss.pig
```

You can click **Select OSS path** to view and select from OSS. The system will automatically complete the path of Pig script on OSS. Switch the Pig script prefix to ossref (click **Switch resource type**) to guarantee this file is properly downloaded by E-MapReduce.

11. Click **Save** to complete the Pig job configuration.

4.4 Spark job configuration

In this tutorial, you will learn how to configure a Spark job.

Procedure

1. Log on to the *Alibaba Cloud E-MapReduce Console*.
2. At the top of the navigation bar, click **Data Platform**.
3. In the **Actions** column, click **Design Workflow** of the specified project.
4. On the left side of the Job Editing page, right-click on the folder you want to operate and select **New Job**.
5. In the **New Job** dialog box, enter the job name and description.
6. Click **OK**.

> **Note:**
> You can also create subfolder, rename folder, and delete folder by right-clicking on the folder.

7. Select the Spark job type to create a Spark job. This type of job is submitted in the background by using the following method:

```
spark-submit [options] --class [MainClass] xxx.jar args
```

8. Enter the parameters in the **Content** field with command line parameters required to submit this Spark job. Only the parameters after **`spark-submit`** can be entered. The following example shows how to enter the parameters for creating Spark jobs and Pyspark jobs.

   - Create a Spark job

     Create a Spark WordCount job:

     - Job name: Wordcount
     - Type: Select Spark
     - Parameters:
       - The command is as follows:

         ```
         spark-submit --master yarn-client --driver-memory 7G --
         executor-memory 5G --executor-cores 1 --num-executors 32 --
         class com.aliyun.emr.checklist.benchmark.SparkWordCount emr
         -checklist_2.10-0.1.0.jar oss://emr/checklist/data/wc oss://
         emr/checklist/data/wc-counts 32
         ```

       - In the E-MapReduce job **Content** field enter the following:

         ```
         --master yarn-client --driver-memory 7G --executor-memory 5G
          --executor-cores 1 --num-executors 32 --class com.aliyun.emr
         .checklist.benchmark.SparkWordCount ossref://emr/checklist/
         jars/emr-checklist_2.10-0.1.0.jar oss://emr/checklist/data/wc
          oss://emr/checklist/data/wc-counts 32
         ```

     Note:

     Job jar packages are saved in OSS. The way to reference this Jar package is: *`ossref://emr/checklist/jars/emr-checklist_2.10-0.1.0.jar`*. Click **Select OSS path** to view and select from OSS, the system will automatically complete the absolute path of Spark script on OSS. Switch the default OSS protocol to ossref protocol.

   - Create a pyspark job

     Additionally to Scala and Java job types, E-MapReduce also supports Spark jobs of python type. Create a Spark Kmeans job for python script:

     - Job name: Python-Kmeans
     - Type: Spark

- Parameters:

```
--master yarn-client --driver-memory 7g --num-executors 10
 --executor-memory 5g --executor-cores 1 --jars ossref://emr/
checklist/jars/emr-core-0.1.0.jar ossref://emr/checklist/python
/wordcount.py oss://emr/checklist/data/kddb 5 32
```

- References of Python script resource are supported, and ossref protocol is used.
- For Pyspark, online Python installation kit is not supported.

9. Click **Save** to complete the Spark job configuration.

4.5 Spark SQL job configuration

In this tutorial, you will learn how to configure a Spark SQL job.

Note:

By default, the Spark SQL mode to submit a job is Yarn mode.

Procedure

1. Log on to the *Alibaba Cloud E-MapReduce console*.
2. At the top of the navigation bar, click **Data Platform**.
3. In the **Actions** column, click **Design Workflow** of the specified project.
4. On the left side of the Job Editing page, right-click on the folder you want to operate and select **New Job**.
5. In the **New Job** dialog box, enter the job name and description.
6. Click **OK**.

   Note:

   You can also create subfolder, rename folder, and delete folder by right-clicking on the folder.

7. Select the Spark SQL job type to create a Spark SQL job. This type of job is submitted in the background by using the following method:

```
spark-sql [options] [cli option]
```

8. Enter the parameters in the **Content** field with parameters subsequent to Spark SQL commands.

   - -e option

Directly write running SQL for -e options by inputting it into the **Content** field of the job, for example:

```
-e "show databases;"
```

- -f option

  -f options can be used to specify a Spark SQL script file. Loading well prepared Spark SQL script files on OSS can give more flexibility. We recommend that you use this operation mode, for example:

```
-f ossref://your-bucket/your-spark-sql-script.sql
```

9. Click **Save** to complete Spark SQL job configuration.

4.6 Shell job configuration

In this tutorial, you will learn how to configure a Shell job.

> **Note:**
> By default, Shell scripts are currently run by Hadoop. If it is required to use root user, sudo can be used. Use Shell script jobs with caution.

Procedure

1. Log on to the *Alibaba Cloud E-MapReduce console*.
2. At the top of the navigation bar, click **Data Platform**.
3. In the **Actions** column, click **Design Workflow** of the specified project.
4. On the left side of the Job Editing page, right-click on the folder you want to operate and select **New Job**.
5. In the **New Job** dialog box, enter the job name and description.
6. Select the Shell job type to create a Bash Shell job.
7. Click **OK**.

   > **Note:**
   > You can also create subfolder, rename folder, and delete folder by right-clicking on the folder.

8. Enter the parameters in the **Content** field with parameters subsequent to Shell commands.

   - -c option

-c option can be used to set Shell scripts to run by inputting it into the **Content** field of the job, for example:

```
-c "echo 1; sleep 2; echo 2; sleep 4; echo 3; sleep 8; echo 4;
sleep 16; echo 5; sleep 32; echo 6; sleep 64; echo 8; sleep 128;
echo finished"
```

- -f option

  -f option can be used to run Shell script files. By uploading a Shell script file to OSS, Shell scripts on OSS can be directly defined in the job parameters. This is more flexible than the -c option, for example:

```
-f ossref://mxbucket/sample/sample-shell-job.sh
```

9. Click **Save** to complete Shell job configurations.

4.7 Sqoop job configuration

In this tutorial, you will learn how to configure a Sqoop job.

Note:

Only E-MapReduce products version V1.3.0 and higher support the Sqoop job type. Running a Sqoop job on lower cluster versions will fail, and errlog will report “Not supported” errors. For parameter details, refer to *Data Transmission Sqoop*.

Procedure

1. Log on to the *Alibaba Cloud E-MapReduce console*.
2. At the top of the navigation bar, click **Data Platform**.
3. In the **Actions** column, click **Design Workflow** of the specified project.
4. On the left side of the Job Editing page, right-click on the folder you want to operate and select **New Job**.
5. In the **New Job** dialog box, enter the job name and description.
6. Select the Sqoop job type to create a Sqoop job. In E-MapReduce back-end, Sqoop job will submit through the following process:

```
sqoop [args]
```

7. Click **OK**.

Note:

> You can also create subfolder, rename folder, and delete folder by right-clicking on the folder.

8. Complete the **Content** field with parameters subsequent to Sqoop commands.
9. Click **Save** to complete Sqoop job definition.

4.8 Job operations

You can create, clone, modify, and delete jobs.

Job creation

A new job can be created at any time. The job created can currently only be used in the region where it is created.

Job clone

To completely clone configurations in which jobs already exist. It is also restricted to the same region.

Job modification

If it is necessary to add a job into an execution plan, then it is required to ensure that this execution plan is not under operation and its periodic scheduling is not in progress before the job can be modified.

If it is necessary to add this job into several execution plans, the modification shall be made until the executing and periodic scheduling of all these plans. Since job modification may cause changes to all execution plans using this job and also errors to execution plans under executing and periodic scheduling.

If it is necessary to conduct debugging, clone is recommended, and after debugging, original jobs in the execution plan will be replaced.

Job deletion

As with modification, jobs can be deleted only when the execution plan in which jobs are added in is not under operation and periodic scheduling is not in progress.

4.9 Job date variables

During the creation of a job, time variable wildcard settings in job parameter are supported.

Variable wildcard format

The format of variable wildcard supported by E-MapReduce is **`${dateexpr-1d}`** or **`${dateexpr-1h}`**. For example, assuming the current time is `20160427 12:08:01`:

- If it is written as **`${yyyyMMdd HH:mm:ss-1d}`** in job parameters, then this parameter wildcard will be, when executed practically, replaced with `20160426 12:08:01`, that is, the current date minus one day with accuracy to the second.
- If it is written as **`${yyyyMMdd-1d}`**, then it will be replaced with `20160426` when being executed, representing the day before current date.
- If it is written as **`${yyyyMMdd}`**, then it will be replaced with `20160427`, representing the current date.

The dateexpr represents the expression of standard time format, and corresponding time will be formatted as per this expression and followed by corresponding time to add or deduct. Following the expression, 1d (1 day) to add or deduct can be written as N days or hours, for example, **`${ yyyyMMdd-5d}`**,**`${yyyyMMdd+5d}`**,**`${yyyyMMdd+5h}`**,**`${yyyyMMdd-5h}`** are all supported, and corresponding replacing methods are consistent with the descriptions above.

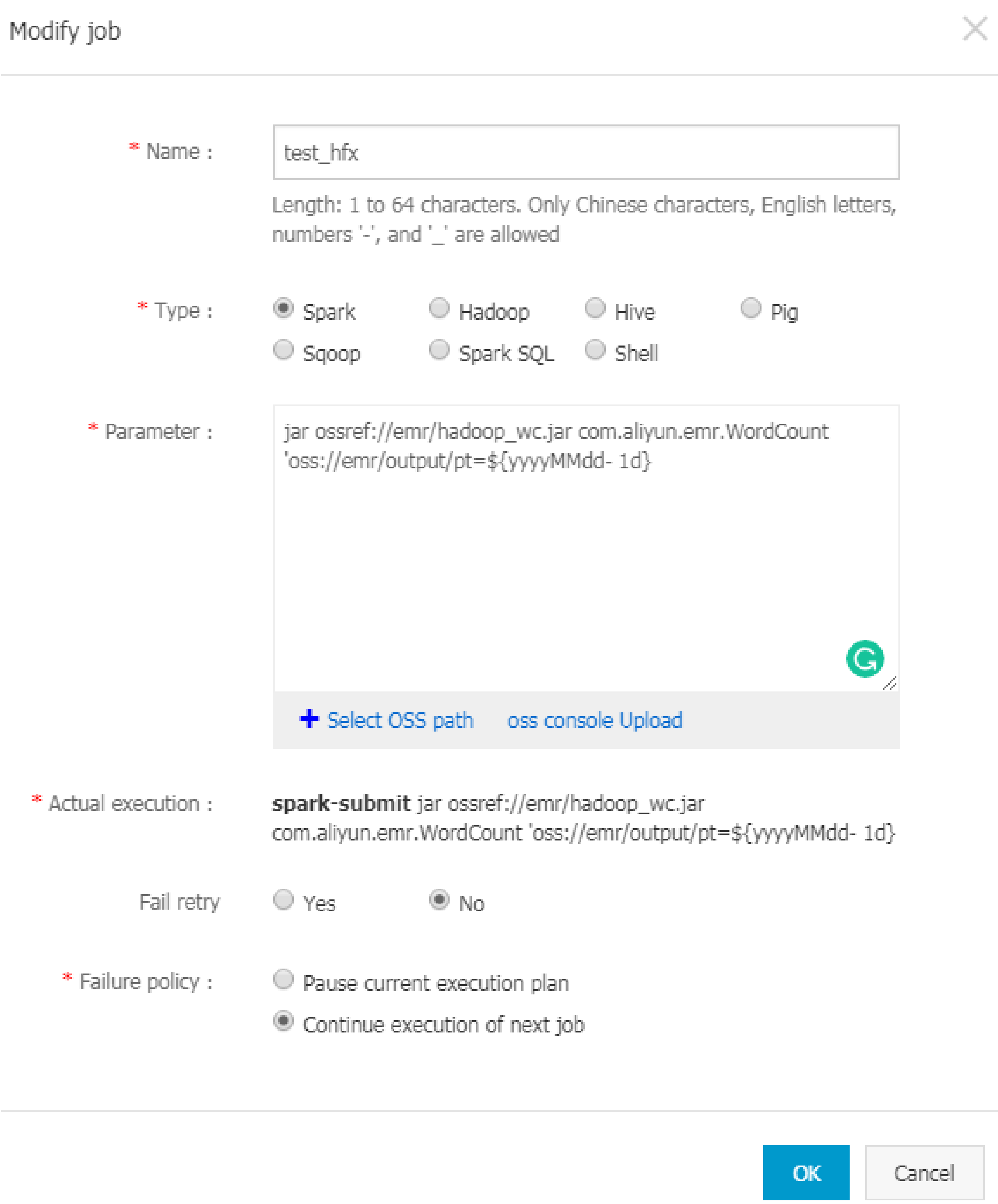
Note:

E-MapReduce currently supports addition and deduction only for “hour” and “day”, that is, the format of +Nd, -Nd, +Nh and -Nh after dateexpr (dateexpr refers to the expression of time format and N is an integer).

Example

When being executed practically, the **Parameter** in the following figure will be replaced with:

```
jar ossref://emr/jar/hadoop/hadoop_wc.jar com.aliyun.emr.WordCount oss
://emr/output/pt=20160426
```



5 Execution plan

5.1 Create an execution plan

An execution plan is a set of jobs that can be executed once or periodically through scheduling configuration. It can be executed on an existing E-MapReduce cluster and also can create a temporary cluster to execute assignment dynamically. Its biggest advantage is to use resources actually needed during execution to maximize resource savings.

To create an execution plan, follow these steps:

1. Log on to the *Alibaba Cloud E-MapReduce console* .
2. Select the region.
3. In the upper right corner, click **Old MER Scheduling** to go to the Jobs page.
4. In the left-side navigation panel, click **Execution plan**.
5. In the upper right corner, click **Create an execution plan**.
6. In the Create an execution plan page, select one mode from **Create as needed** and **Existing clusters**.

   a. **Create as needed**: Create a new cluster to run jobs.

      - Execution plan for one-time scheduling: Clusters with corresponding configuration will be created when execution starts and then released upon the completion of the operation. For specific descriptions of creation parameters, see *Create a cluster*.
      - Execution plan for periodic scheduling: A new cluster will be created as per users' settings when each scheduling period starts and then released upon the completion of the operation.

   b. **Existing clusters**: Use an existing cluster that complies with the following requirement:

      - Execution plans can only be submitted to clusters in **Running** or **Idle** status.

      Select the **Existing clusters** and then enter the Select Cluster page. You can select the cluster to associate with the execution plan.
7. Click **Next** to enter the job configuration page. All user jobs will be listed in the left table, and you can select jobs for execution. By clicking the right-facing button, the checked jobs will be added into the job queue. Jobs in the queue will be submitted to the cluster for execution as per their order. The same job can be added and executed several times. If you have not created any jobs, see operating instructions to create jobs.

8. Click **Next** to enter the scheduling mode configuration page. The configuration items are described as follows:

    a. **Name**: Must be between 1-64 characters and consist of only Chinese characters, letters, numbers, “-“, and “_”.

    b. **Scheduling policy**

        - **Manual execution**: The execution plan will not be automatically executed after creation, it must be manually executed. Once the execution is in progress, it cannot be conducted again.
        - **Periodic scheduling**: This function will be enabled immediately after the execution plan is created. The execution can begin from the configured scheduling time point. Periodic scheduling can be disabled in the list page. If a scheduling execution starts, but its last scheduling execution has not completed, this scheduling will be ignored.

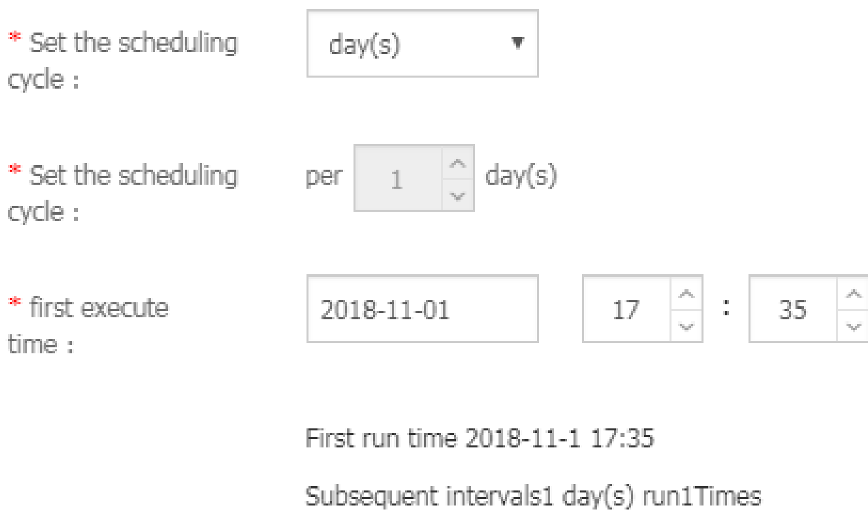
    c. **Set the scheduling cycle**: There are two scheduling periods: days and hours. The ‘day’ cycle is ‘one day’ by default and remains unchanged. However, for the hour parameter, you can set the specific time interval and the range must be 1-23.

    d. **First execution time**: The effective start time of scheduling. From this time on, periodic scheduling will be conducted as per scheduling periods. The first scheduling will be conducted from the latest time point when requirements are met as per actual time.

9. Click **OK** to complete the creation of the execution plan.

Others

- Example for periodic scheduling



These configurations indicates that the scheduling is initially started on 11/03/2016, 12:15 and then conducted every other day. The second scheduling is conducted on 11/04/2016, 12:15.

- Execution sequence of jobs

  For jobs in the execution plan, they will be executed from first to last as per the sequence of user-selected jobs in the job List.

- Execution sequence of multiple execution plans

  Each execution plan can be deemed as an integral whole. When multiple execution plans are submitted to the same cluster, each execution plan submits jobs from its internal job sequence , which is consistent with the sequence of a single execution plan. While jobs among multiple execution plans are in parallel.

- Practical example for early job debugging

  During job debugging, if the cluster is created on demand automatically, the speed will be slow and will take a long time to start the cluster. We recommend that you manually create a cluster first, and then select “Associate the cluster” in the execution plan to run jobs, and then to set the scheduling mode as Execute immediately. During debugging, results are viewed by clicking Run on the execution plan list page. Modify the execution plan once job debugging is completed, and then modify the mode of associating existing clusters into creating a new cluster on demand. Then modify the scheduling mode into periodic scheduling as needed. Tasks will be executed automatically on demand.

5.2 Manage execution plans

You can view, manage, and modify your execution plans as follows.

1. Log on to the *Alibaba Cloud E-MapReduce console* .
2. Select the region.
3. In the upper right corner, click **Old MER Scheduling** to go to the Jobs page.
4. In the left-side navigation panel, click **Execution plan**.
5. Click **Manage** of a plan to enter the execution plan detail page. On this page you can:
   - View details of the execution plan

     You can view the basic information of execution plans, such as names, associated clusters, job configurations, scheduling strategy and status, alarm information.

   - Modify the execution plan

Note:

Jobs can be modified if they are not in the process of running or being scheduled. For an execution plan to be immediately executed, it can be modified only when it is not currently running. If the execution plan is periodically scheduled, wait for the completion of its current operation, verify whether it is in periodical scheduling, and click **Stop scheduling** (if yes) before modifying it.

Each separate module can be modified independently. Click the **pen** icon to modify information.

- Configure alarm notification

  There are three types of alarm notifications:

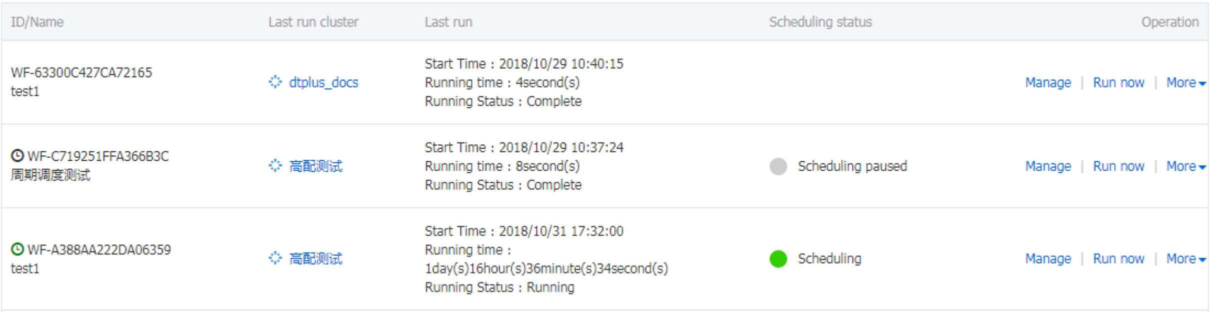
  - Notification for booting timeout: If a periodical scheduling has not been conducted properly at the specified time and is not executed within 10 minutes of timeout, an alarm will be sent.
  - Notification for failed execution: If any job in the execution plan fails, an alarm will be sent .
  - Notification for successful execution: If all jobs in the execution plan are successfully executed, a notification will be sent.
- Run and view results

  When the execution plan can be run, there will be a **Run now** button to the right of **Scheduling status** in **Basic Information**. Once this button is clicked, a schedule will be executed.

  At the bottom of the page, there are running records displaying the execution plan instances executed each time, facilitating views of the corresponding job list and logs.

5.3 Execution plan list

Displays basic information of all your execution plans.



ID/Name	Last run cluster	Last run	Scheduling status	Operation
WF-63300C427CA72165 test1	dtplus_docs	Start Time : 2018/10/29 10:40:15 Running time : 4second(s) Running Status : Complete		Manage | Run now | More
WF-C719251FFA366B3C 周期调度测试	高配测试	Start Time : 2018/10/29 10:37:24 Running time : 8second(s) Running Status : Complete	Scheduling paused	Manage | Run now | More
WF-A388AA222DA06359 test1	高配测试	Start Time : 2018/10/31 17:32:00 Running time : 1day(s)16hour(s)36minute(s)34second(s) Running Status : Running	Scheduling	Manage | Run now | More

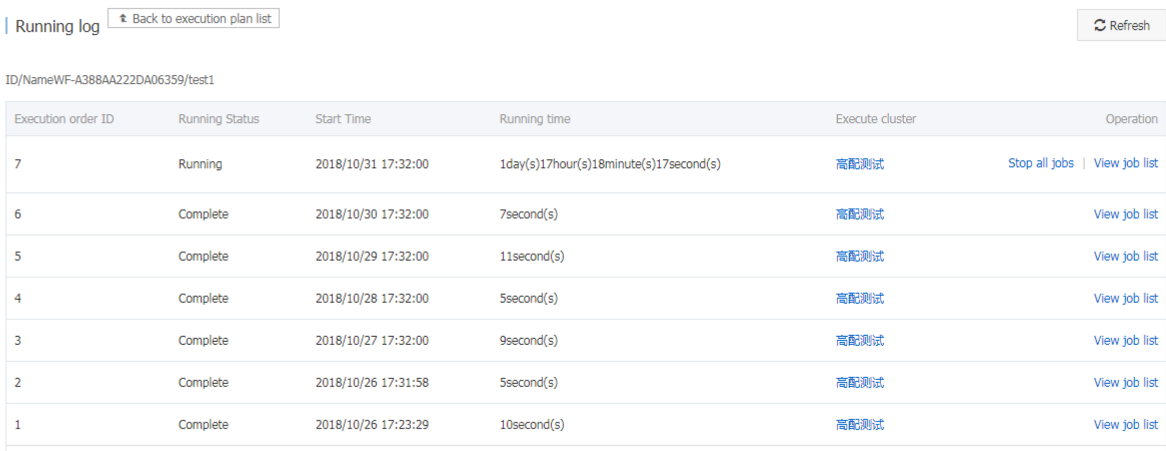
- **ID/Name**: The ID and corresponding name of the execution plan.
- **Last run cluster**: The last cluster to execute this execution plan. It is a cluster created on demand or an existing associated cluster. If a cluster is created automatically on demand, (Automatically created) will be displayed below the cluster, indicating that the cluster is created automatically by E-MapReduce on demand and will be released automatically after running.
- **Last run**: The running status of the last execution plan.
  - **Start time**: The time from which the last plan starts to run.
  - **Running time**: The duration for which the last plan is running.
  - **Running status**: The running status of the last execution plan.
- **Scheduling status**: Whether the scheduling is in progress or has been stopped. Only periodic jobs have the scheduling status.
- **Operation**
  - **Manage**: View and modify execution plans.
  - **Run now**: Manual run can be made only when the job is neither running nor being scheduled. Click it to run the execution plan immediately.
  - **More**
    - **Start/Stop scheduling**: When the scheduling is stopped, Enable scheduling will appear which can be clicked to start scheduling. When Stop scheduling is displayed during scheduling, clicking it will stop the scheduling. This button is only for periodic execution plans.
    - **Running log**: Click to enter the job log viewing page.
    - **Delete**: Deletes an execution plan. The execution plan in the process of scheduling or running cannot be deleted.

5.4 View job results and logs

View job results and logs

View execution records

1. Log on to the *Alibaba Cloud E-MapReduce console* .
2. Select the region.
3. In the upper right corner, click **Old MER Scheduling** to go to the Jobs page.
4. In the left-side navigation panel, click **Execution plan**.
5. On the right side of the execution plan, click **More** > **Running log**.



- **Execution order ID**: The sequence of execution for the corresponding record, indicating the ordinal position in the whole execution queue. For example, 1 stands for the first position of execution while n stands for the n-th position.
- **Running status**: The running status of each execution record.
- **Start time** The time when the execution plan starts to run.
- **Running time**: The total running time until the page is viewed.
- **Execute cluster**: The cluster run by the execution plan, can be either a cluster on demand or an existing associated cluster. Click to view the cluster details page.
- **Operation**

  View job list: Click this button to enter the job list page.

View job records

On the **Job list** page, you can view the job list in execution records of a single execution plan and details of each job.

Job execution order ID	Name	Status	Type	Start Time	Running time	Operation
WNE-92693C5408D39E03	test	Failed	Spark	2018/10/26 17:23:39	1second(s)	Stop Job | stdout | stderr | workers log

- **Job execution order ID**: A corresponding ID will be created after a job is executed, and this ID is different from the job ID. The job execution ID is the unique record identifier to view the logs on OSS.
- **Name**: The name of the job.
- **Status**: The running status of the job.
- **Type**: The type of job.
- **Start time**: The time when the job starts to run. It has been converted into local time.
- **Running time**: The total running time (in seconds) of this job.
- **Operation**
  - **Stop job**: A job can be stopped if it is in the process of submission or running. If a job is in submission, stopping it will cancel execution. If the job is running, it will be killed.
  - **stdout**: Records all output content from standard output (that is, Channel 1) of the master process. If log saving for the cluster where jobs are run is not enabled, this viewing function cannot be executed.
  - **stderr**: Records all output content from diagnostic output (that is, Channel 2) of the master process. If log saving for the cluster where jobs are run is not enabled, this viewing function cannot be executed.
  - **Workers log**: To view the log of all job worker nodes. If log saving for the cluster where jobs are run is not enabled, this viewing function cannot be executed.

View job worker logs

- **Cloud server instance IP**: The ECS instance ID of a running job and the corresponding intranet IP address.
- **Container ID**: The container ID of Yarn running.
- **Type**: Different log types. stdout and stderr come from different outputs.
- **Operation**

  View the log: Click different types to view the corresponding logs.

5.5 Parallel execution of multiple execution plans

To maximize the use of available computing resources of a cluster, multiple execution plans can currently be mounted to the same cluster to utilize parallel execution.

The main points are summarized as follows:

- Jobs in the same execution plan will be executed in series, and it is considered by default that subsequent jobs can be submitted and executed only after execution of preceding jobs is completed.
- In case of sufficient cluster resources, it is required to create a number of different execution plans and to associate them to the same cluster for submission and running to execute multiple jobs in parallel (a cluster is considered by default to support at most 20 execution plans for parallel execution).
- The management and control system currently supports parallel submission for execution plans associated to the same cluster to Yarn. However, if the cluster itself has insufficient resources, jobs will be congested in the Yarn queue to wait for scheduling.

For the process of creating execution plans and associating it to the cluster, refer to *Create an execution plan*.

6 Alert management

6.1 Cluster alarm management

To help you monitor the operation of clusters, CloudMonitor offers multiple monitoring metrics for E-MapReduce clusters, including CPU idleness, memory capacity, and disk capacity. It also allows you to set alarm rules for these monitoring metrics. Once an alarm rule is triggered, CloudMonitor notifies the contacts in the notification group timely so that you can deal with the problem in time.

Configure alarm rules

To set up alarm rules for E-MapReduce cluster, take the following steps:

1. Log on to *CloudMonitor console*.
2. In the left navigation panel, click **Cloud Service Monitoring** > **E-MapReduce** to go to the E-MapReduce Monitoring List page.
3. Click **Alarm Rules** tab.
4. In the upper-right corner of the page, click **Create Alarm Rule** to set an alarm rule for corresponding monitoring metrics.
5. In the **Related Resource** region, set Products and Resource Range.
    - **Products**: Select E-MapReduce in the drop-down list.
    - **Resource Range**: The scope of action of the alarm rule. It is divided into three areas: all resources, application group and cluster. When all resources is selected, the maximum number of resources that can be monitored is 1000, problem that the threshold has been reached without alarming may occur if it exceeds 1000, we recommend that you use application group to divide resources according to business before setting up alarm rules.
        - **All Resources**: Indicates that the rule works on all instances of E-MapReduce for the current account. For example, set The CPU usage is greater than 80% to alarm, as long as there is instance whose CPU usage is greater than 80% in the current account, it hits this rule.
        - ***Application Group***: Indicates that the rule works on all instances of a certain application group. For example, set the CPU usage is greater than 80% to alarm, as long as there is a host whose CPU usage is greater than 80% in this group, it hits this rule.

- **Cluster**: indicates that the rule only works on a specific E-MapReduce cluster. For example, set the CPU usage is greater than 80% to alarm, as long as there is an instance whose CPU usage is greater than 80% in this cluster, it hits this rule.

6. Configure the **Set Alarm Rules** region.

- **Alarm Rule**: Sets the name of alarm rules.
- **Rule Description**: The principal of the alarm rule that defines what conditions the item data meets, trigger alarm rules. For example, the rule is described as a 1 minute average of CPU usage >= 90%, it means that the rule is hit if the average data within 1 minute is >= 90%. For more information about monitoring metrics for E-MapReduce clusters, see *E-MapReduce monitoring*.
- **Role**: By default, any role is applicable.

  Click **Add Alarm Rule**, you can set multiple alarm rules (charge as multiple alarm rules). As long as one of the rules is triggered, the system sends notifications to the notification group.
- **Mute for**: The interval for sending the alarm notification again in case of the monitoring metrics is not restored.
- **Triggered when threshold is exceeded for**: Times that the rule is hit to send alarm notifications. For example, the rule is described as a 1 minute average of System State CPU usage >= 90% and it appears for 3 times or more continuously, it means that the rule is hit if the average data within 1 minute is >= 90% and it appears for 3 times continuously.
- **Effective Period**: The effective time of the alarm rule. CloudMonitor checks whether the monitoring metric hits the alarm rule only during the effective period. The system checks whether the monitoring data requires an alarm only during the effective time.

7. Configure the **Notification Method** region.

- **Notification Contact**: The contact group that receives the notification. Enter the keyword of the contact group in the search box to locate the contactn group you want to associate quickly, and click the right arrow icon, then the contact group is added into the right contact list. If you haven't created the appropriate contact group, click **Quickly create a contact group**. After you select a contact group in the right contact list, click the left arrow icon to delete the contact group.
- **Notification Methods**: Alarm information is divided into three levels: critical, warning, info. Different levels correspond to different notification methods. Different alarm levels correspond to different notification methods. Before Critical level is configured, you need to buy the phone alarm resource package.

- **Email Remark** (Optional): Customizes supplemental information for alarm email. When you fill in your email remarks, your comments are included in the notification message that is being sent to the contacts.
- **HTTP CallBack**(Optional): This feature allows you to integrate the alarm notifications sent by CloudMonitor into existing maintenance systems or message notification systems. CloudMonitor pushes alarm notifications to a specified public URL through the POST request of HTTP protocol. When you receive the alarm notification, you can make further process according to the notification content. For more information, see *Alarm callback*.

8. Click **Confirm** to complete the alarm rule configuration

7 Software configuration

Hadoop, Hive, Pig, and other relevant software contain numerous configurations that can be changed through the software configuration function. For example, the number of service threads in HDFS server dfs.namenode.handler.count is 10 by default and will be increased to 50, and the size of HDFS file block dfs.blocksize is 128 MB by default and will be decreased to 64 MB because the system contains only small files.

Purpose of software configuration

The function can only be performed once during the startup of a cluster.

Procedure

1. Log on to the *Alibaba Cloud E-MapReduce console*.
2. Select the region and the created cluster associated with the region is listed.
3. Click **Create Cluster** to enter the cluster creation page.
4. All contained software and corresponding versions can be seen in the software configuration of cluster creation. Change the configuration of the cluster by selecting a corresponding json format configuration file in the (optional) software configuration box. Then, override or add to the defaulted cluster parameters. The sample of a .json file is as follows:

```
{
 "configurations": [
     {
         "classification": "core-site",
         "properties": {
             "Fs. Trash. Interval": "61"
         }
     },
     {
         "classification": "hadoop-log4j",
         "properties": {
             "hadoop.log.file": "hadoop1.log",
             "hadoop.root.logger": "INFO",
             "a.b.c": "ABC"
         }
     },
     {
         "classification": "hdfs-site",
         "properties": {
             "dfs.namenode.handler.count": "12"
         }
     },
     {
         "classification": "mapred-site",
         "properties": {
             "mapreduce.task.io.sort.mb": "201"
         }
     },
```

```
    {
        "classification": "yarn-site",
        "properties": {
            "Hadoop. Security. Groups. cache. secs": 251 ",
            "yarn.nodemanager.remote-app-log-dir": "/tmp/logs1"
        }
    },
    {
        "classification": "httpsfs-site",
        "properties": {
            "a.b.c.d": "200"
        }
    },
    {
        "classification": "capacity-scheduler",
        "properties": {
            "yarn.scheduler.capacity.maximum-am-resource-percent":
 "0.2"
        }
    },
    {
        "classification": "hadoop-env",
        "properties": {
            "BC":"CD"
        },
        "configurations":[
            {
                "classification":"export",
                "properties": {
                    "AB":"${BC}",
                    "HADOOP_CLIENT_OPTS":"\"-Xmx512m -Xms512m $
HADOOP_CLIENT_OPTS\""
                }
            }
        ]
    },
    {
        "classification": "httpfs-env",
        "properties": {
        },
        "configurations":[
            {
                "classification":"export",
                "properties": {
                    "HTTPFS_SSL_KEYSTORE_PASS":"passwd"
                }
            }
        ]
    },
    {
        "classification": "mapred-env",
        "properties": {
        },
        "configurations":[
            {
                "classification":"export",
                "properties": {
                    "HADOOP_JOB_HISTORYSERVER_HEAPSIZE":"1001"
                }
            }
        ]
    },
```

```
    {
        "classification": "yarn-env",
        "properties": {
        },
        "configurations":[
            {
                "classification":"export",
                "properties": {
                    "HADOOP_YARN_USER":"${HADOOP_YARN_USER:-yarn1}"
                }
            }
        ]
    },
    {
        "classification": "pig",
        "properties": {
            "pig.tez.auto.parallelism": "false"
        }
    },
    {
        "classification": "pig-log4j",
        "properties": {
            "log4j.logger.org.apache.pig": "error, A"
        }
    },
    {
        "classification": "hive-env",
        "properties": {
            "BC":"CD"
        },
        "configurations":[
            {
                "classification":"export",
                "properties": {
                    "AB":"${BC}",
                    "HADOOP_CLIENT_OPTS1":"\"-Xmx512m -Xms512m $
HADOOP_CLIENT_OPTS1\""
                }
            }
        ]
    },
    {
        "classification": "hive-site",
        "properties": {
            "hive.tez.java.opts": "-Xmx3900m"
        }
    },
    {
        "classification": "hive-exec-log4j",
        "properties": {
            "log4j.logger.org.apache.zookeeper.ClientCnxnSocketNIO
": "INFO,FA"
        }
    },
    {
        "classification": "hive-log4j",
        "properties": {
            "log4j.logger.org.apache.zookeeper.server.NIOServerCnxn
": "INFO,DRFA"
        }
    }
 ]
```

```
}
```

The classification parameter designates the configuration file to change. The parameter **`properties`** stores the key-value pair that requires changes. When the default configuration file has a corresponding key, override the value, otherwise, add the corresponding key-value pair.

The correspondence between configuration file and classification is shown in the following table.

- Hadoop

Filename	Classification
core-site.xml	core-site
log4j.properties	Hadoop-log4j
Hdfs-site.xml	hdfs-site
mapred-site.xml	mapred-site
yarn-site.xml	yarn-site
httpsfs-site.xml	httpsfs-site
capacity-scheduler.xml	capacity-scheduler
hadoop-env.sh	hadoop-env
httpfs-env.sh	httpfs-env
mapred-env.sh	mapred-env
yarn-env.sh	yarn-env

- Pig

Filename	classification
pig.properties	pig
log4j.properties	pig-log4j

- Hive

Filename	classification
hive-env.sh	hive-env
hive-site.xml	hive-site
hive-exec-log4j.properties	hive-exec-log4j
hive-log4j.properties	hive-log4j

The core-site and other flat XML files only have one layer. All configurations are put in **`properties`**. The hadoop-en v and other sh files may have two layers of structures and can be set in the embedded configurations mode. See hadoop-env in the example where `-Xmx512m -Xms512m` setting is added for **`HADOOP_CLIENT_OPTS`** property of export.

After setting, confirm and click **Next** step.

8 Bootstrap action

Bootstrap action is used to run your customized script before the cluster starts up Hadoop. The customized script is used to install your required third-party software or change the cluster operating environment.

Function of bootstrap operation

With bootstrap action, you can install many things to your cluster that are not currently supported by clusters. For example:

- Install provided software with Yum.
- Directly download open software from a public network.
- Read your data from OSS.
- Install and operate a service, such as Flink or Impala, but the script to be compiled is more complex.

We strongly recommend that you test the bootstrap action with a Pay-As-You-Go cluster and create a subscription cluster only after the test is successful.

How to use

1. Log on to the *Alibaba Cloud E-MapReduce console*.
2. Select the region where the created cluster associated with the region is listed.
3. Click **Create Cluster** to enter the cluster creation page.
4. At the end of the basic configuration page, click **Add** to enter the operation page.
5. Enter the configuration items.

You can add up to 16 bootstrap actions to be performed during cluster initialization in the designated sequence. By default, your designated script is run with the root account. You can switch to a Hadoop account with **su hadoop** in the script.

It is possible that the bootstrap action fails. For ease of use, bootstrap action failure does not affect the creation of the cluster. After the cluster is created successfully, you can view any abnormality in the Bootstrap/software configuration column of cluster information in the cluster details page. In case of any abnormality, you can log on to all nodes to view the operation logs in the directory of `/var/log/bootstrap-actions`.

Bootstrap action type

The bootstrap action is categorized into customized bootstrap action and operating-condition bootstrap action. The main difference is that the operating-condition bootstrap action can only operate your designated operation in the node that meets the requirements.

Customized bootstrap action

For the customized bootstrap action, the position of the bootstrap action name and the execution script in OSS must be designated and the optional parameters are set as required. During cluster initialization, all nodes download the designated OSS scripts to run them directly or after adding the optional parameters.

You can designate the files that need to be downloaded from OSS in the script. The following example downloads the file *oss://yourbucket/myfile.tar.gz* locally and extract it to the directory of */yourdir*:

```
#! #!/bin/bash
osscmd --id=<yourid> --key=<yourkey> --host=oss-cn-hangzhou-internal.
aliyuncs.com get oss://<yourbucket>/<myfile>.tar.gz ./<myfile>.tar.gz
mkdir -p /<yourdir>
tar -zxvf <myfile>.tar.gz -C /<yourdir>
```

The osscmd has been preinstalled on the node and can be invoked directly to download the file.

Note:

OSS address host contains intranet address, Internet address, and VPC network address. For the classic network, the intranet address is designated. The address in Hangzhou is oss-cn-hangzhou-internal.aliyuncs.com. For VPC network, the domain name that VPC intranet can visit is designated. The name in Hangzhou is vpc100-oss-cn-hangzhou.aliyuncs.com.

The bootstrap action can install additional system software packages through Yum. The following example shows the installation of ld-linux.so. 2:

```
#! #!/bin/bash
yum install -y ld-linux.so. 2
```

Operating-condition bootstrap action

The execution script of an operating-condition bootstrap action is predefined, you do not need to make additional designations. You do need to designate the name and optional parameters. The operating-condition bootstrap action must provide the optional parameters, including the spaced operation conditions and commands. The operation conditions support instance.isMaster=true/

false and is designated to only operate on the master or non-master nodes. The following example shows that the optional parameters of an operating-condition bootstrap action are only designated to create the directory on the master node.

```
instance.isMaster=true mkdir -p /tmp/abc
```

If multiple operation commands are designated, you can divide several statements with the semicolon “;”. For example: `instance.isMaster=true mkdir -p /tmp/abc;mkdir -p /tmp/def`.

9 VPC

Virtual Private Cloud (VPC) creates an isolated network environment for users. You can select an IP address range, divide networks, and configure the routing list and gateway.

For more information, see *What is VPC*. The interflow of VPC intranet and between VPC and physical IDC machine rooms can be realized among regions or users through *Express Connect*.

Create a VPC cluster

E-MapReduce can select the type of network during cluster creation, classic network or VPC. For VPC, the following operations are required:

- Subordinate VPC: Select a VPC where the current E-MapReduce cluster is located. If no creation is made, log on to *VPC console* to create a VPC.
- VSwitch: ECS instance in E-MapReduce cluster communicates through VSwitch. If no creation is made, log on to *VPC console* to create a VPC. The VSwitch has the property of availability zone. Therefore, the created VSwitch must also belong to the availability zone selected during cluster creation in E-MapReduce.
- Safety group creation: Once enabled, enter the name of the created security group.
- Owner security group: The security group the cluster belongs to. The security group of a classic network cannot be used in VPC. The security group of VPC can only be used in current VPC. Here only the security group created in E-MapReduce product by the user is shown. For safety reasons, a security group created outside the E-MapReduce cannot be selected. To create a security group, select New security group and enter the name of security group.

Example

E-MapReduce cluster communication in different VPCs (Hive visits HBase)

1. Create clusters.

   Create two clusters in E-MapReduce. Hive Cluster C1 is located in VPC1 while HBase Cluster C2 is located in VPC2. Both clusters are located in the cn-hangzhou region.

2. Configure the high-speed channel.

   See *Establish an intranet connection between VPCs under the same account*. Select the same region.

3. Log on to HBase cluster through SSH and a table is created through HBase Shell.

```
hbase(main):001:0> create 'testfromHbase','cf'
```

4. Log on to Hive through SSH.

a. Change hosts and add a line as follows.

```
$zk_ip emr-cluster //$zk_ip is the zk node IP of Hbase cluster.
```

b. Visit HBase through Hive Shell.

```
hive> set hbase.zookeeper.quorum=172.16.126.111,172.16.126.112,172
.16.126.113;
hive> CREATE EXTERNAL TABLE IF NOT EXISTS testfromHive (rowkey
STRING, pageviews Int, bytes STRING) STORED BY 'org.apache.hadoop
.hive.hbase.HBaseStorageHandler' WITH SERDEPROPERTIES ('hbase.
columns.mapping' = ':key,cf:c1,cf:c2') TBLPROPERTIES ('hbase.table
.name' = 'testfromHbase');
```

The abnormality of java.net.SocketTimeoutException is reported here because the security group where the ECS of HBase cluster is located limits the E-MapReduce visit at relevant ports. Port 22 is only opened by default in the security group created by E-MapReduce. Therefore, the security group rules need to be added into the security group of HBase cluster to open a port for Hive cluster, as shown in the following figure.

Authorization policy	Protocol type	Port range	Authorization type	Authorization object
Allow	TCP	2181/2181	Address field access	192.168.1.0/16
Allow	TCP	22/22	Address field access	0.0.0.0/0
Allow	TCP	16000/16000	Address field access	192.168.1.0/16
Allow	TCP	16020/16020	Address field access	192.168.1.0/16

10 Python instructions

Python instructions

Python 2.7

Supported Python 2.7 in E-MapReduce 2.0.0 and later versions.

Python files location: usr/local/Python-2.7.11/ included Numpy.

Python 3.6

EMR 2.10.0, 3.10.0 and later versions support Python 3.6.4 and the installation directory of Python is /usr/bin/python3. The earlier versions do not support Python 3 by default, and you have to download and install the package through the following link:

- *Download Python 3 package*.
- Unzip the downloaded file by using the following commands:

```
tar zxvf Python-3.6.4.tgz
cd Python-3.6.4 ./configure --prefix=/usr/local/Python-3.6.4
make && make install
ln -s /usr/local/Python-3.6.4/bin/python3.6 /bin/python3
ln -s /usr/local/Python-3.6.4/bin/pip3 /bin/pip3
```

- Verify the environment:

```
[root@emr-header-1 bin]# python3
```

```
Python 3.6.4 (default, Mar 12 2018, 14:03:26)
[GCC 4.8.5 20150623 (Red Hat 4.8.5-16)] on linuxType “help”, “
copyright”, “credits” or “license” for more information.
```

```
[root@emr-header-1 bin]# pip3 -V
```

```
pip 9.0.1 from /usr/local/Python-3.6.4/lib/python3.6/site-packages (
python 3.6)
```

Install successfully if you see these messages.

11 Open source components

11.1 Hue

E-MapReduce currently supports Hue. You can access *Hue* by Apache Knox.

Preparation

In the *Security group* cluster, *set security group rules*, and open the 8888 port.

Note:
Set security group rules for limited IP ranges. It is prohibited to open rules to 0.0.0.0/0 when configuring.

Access Hue

To accesss Hue, take the following steps:

1. Click **Manage** on the right side of the cluster ID in the EMR console.
2. On the left side of the Configuration page, click **Access Links and Ports**.

Access password

If Hue has no administrator after the first running, the first login user is set to administrator by default. EMR will generate an administrator account and password by default for security. The administrator account is admin. You can view the password through the following way:

1. On the right-side of the cluster ID, click **Manage**.
2. In the Clusters and Services panel, click **Hue**.
3. Click the **Configuration** tab to go to the parameter **`admin_pwd`**. It is a random password.

Forgot password

If you forget the password corresponding to your Hue account, you can recreate an account by the following method:

1. Click **Manage** of the specific cluster in the cluster list page.
2. In the left-side navigation panel, click **Cluster Overview**.
3. In the **Core Instance Group**, obtain public network IPs of some master nodes.
4. Log on to the master node through SSH.

5. Create a new account by executing the following command.

```
/opt/apps/hue/build/env/bin/hue createsuperuser
```

6. Enter a new user name, e-mail, password, and enter the password again, press Enter.

   If **Superuser created successfully** is prompted, it means the new account is created successfully, and you can log on to Hue with the new account later.

Add/modify configuration

1. On the right-side of the cluster list panel, click **Manage**.
2. In the service list, click **Hue**, and then click the **Configuration** tab.
3. At the right-side corner of the page, click **Custom Configuration**, configure the Key and Value fields. The Key needs to follow the following specifications:

```
$section_path.$real_key
```

Note:

- **`$real_key`** is the actual key to be added, such as `hive_server_host`.
- You can view **`$section_path`**before **`$real_key`**, in *`hue.ini`* file, for example,

  You can see `hive_server_host` belongs to the **`[beeswax]`** section in *hue.ini* file. That is, **`$section_path`** is `beeswax`.
- In conclusion, the key to be added is `beeswax.hive_server_host`.
- If you need to modify the multilevel section **`[desktop] -> [[ldap]] -> [[[ldap_servers]]] -> [[[[users]]]] ->user_name_attr`** value in the *`hue.ini`* file, the key to be configured is `desktop.ldap.ldap_servers.users.user_name_attr`.

11.2 Oozie

Oozie Instructions

Note:
Alibaba Cloud E-MapReduce version 2.0.0 and the later versions support Oozie. If it is necessary to use Oozie in a cluster, make sure that the cluster version is higher than 2.0.0.

Preparations

Before you create a cluster, it is required to open an SSH tunnel. For detailed steps, see *Connect to clusters using SSH*.

Take the MAC environment as an example. Assuming the IP address of the public network for the master node of the cluster is **xx.xx.xx.xx**):

1. Log on to the master node.

```
ssh root@xx.xx.xx.xx
```

2. Enter your password.
3. Check **`id_rsa.pub`** content of the local machine (note that this will be executed on the local machine rather than the remote master node).

```
cat ~/.ssh/id_rsa.pub
```

4. Write **`id_rsa.pub`** content of the local machine in *`~/.ssh/authorized_keys`* on the local master node to execute on the far-end master node.

```
mkdir ~/.ssh/
vim ~/.ssh/authorized_keys
```

5. Paste the content observed in *Step 2*. Now, `ssh root@xx.xx.xx.xx` can be used directly to log on to the master node without a password.
6. Execute the below commands on the local machine for port forwarding.

```
ssh -i ~/.ssh/id_rsa -ND 8157 root@xx.xx.xx.xx
```

7. Enable Chrome to execute in the new terminal on the local machine.

```
/Applications/Google\ Chrome.app/Contents/MacOS/Google\ Chrome --
proxy-server="socks5://localhost:8157" --host-resolver-rules="MAP *
0.0.0.0 , EXCLUDE localhost" --user-data-dir=/tmp
```

Access Oozie UI interface

Access in Chrome browser for port forwarding: “xx.xx.xx.xx:11000/oozie”, “localhost:11000/oozie ”, or intranet “ip: 11000/oozie”.

Submit workflow job

Before running Oozie, it is required to install the sharelib: *https://oozie.apache.org/docs/4.2.0/WorkflowFunctionalSpec.html#ShareLib*.

In E-MapReduce clusters, Oozie users are installed with sharelib by default, and there is no need to install sharelib again even though users using Oozie are to submit workflow job.

Since clusters with and without enabled HA have different modes to access NameNode and ResourceManager, when submitting an oozie workflow job, it is required to specify different NameNode and JobTracker (ResourceManager) in job.properties files. Specific steps are as follows:

- Non-HA cluster

```
nameNode=hdfs://emr-header-1:9000
jobTracker=emr-header-1:8032
```

- HA cluster

```
nameNode=hdfs://emr-cluster
jobTracker=rm1,rm2
```

For the following operation examples, configurations are made for both non-HA and HA clusters, and the sample code can be used directly for operations without any modification. For the specific format of a workflow file, see the official documents for Oozie at *https://oozie.apache.org/docs/4.2.0/*.

- **Submit a workflow job on a non-HA cluster**

  1. Log on to the main master node of the cluster.

  ```
  ssh root@publicIp_of_master
  ```

  2. Download sample code.

  ```
  [root@emr-header-1 ~]# su oozie
  [oozie@emr-header-1 root]$ cd /tmp
  [oozie@emr-header-1 tmp]$ wget http://emr-sample-projects.oss-cn-hangzhou.aliyuncs.com/oozie-examples/oozie-examples.zip
  [oozie@emr-header-1 tmp]$ unzip oozie-examples.zip
  ```

  3. Synchronize Oozie workflow code to hdfs.

  ```
  [oozie@emr-header-1 tmp]$ hadoop fs -copyFromLocal examples/ /user/oozie/examples
  ```

  4. Submit an Oozie workflow sample job.

  ```
  [oozie@emr-header-1 tmp]$ $OOZIE_HOME/bin/oozie job -config examples/apps/map-reduce/job.properties -run
  ```

  After a successful execution, a jobId will be returned and is similar to:

  ```
  job: 0000000-160627195651086-oozie-oozi-W
  ```

  5. Visit the Oozie UI page to see the submitted Oozie workflow job.

- **Submit a workflow job on an HA cluster**

1. Log on to the main master node of the HA cluster.

```
ssh root@main_master_ip
```

The current main master node can be determined by checking whether the Oozie UI can be accessed or not. By default, the Oozie server service is enabled on the main master node `xx.xx.xx.xx:11000/oozie`.

2. Download sample codes of HA cluster.

```
[root@emr-header-1 ~]# su oozie
[oozie@emr-header-1 root]$ cd /tmp
[oozie@emr-header-1 tmp]$ wget http://emr-sample-projects.oss-cn-
hangzhou.aliyuncs.com/oozie-examples/oozie-examples-ha.zip
[oozie@emr-header-1 tmp]$ unzip oozie-examples-ha.zip
```

3. Synchronize Oozie workflow code to hdfs.

```
[oozie@emr-header-1 tmp]$ hadoop fs -copyFromLocal examples/ /user
/oozie/examples
```

4. Submit Oozie workflow sample job.

```
[oozie@emr-header-1 tmp]$ $OOZIE_HOME/bin/oozie job -config
examples/apps/map-reduce/job.properties -run
```

After a successful execution, a jobId will be returned and is similar to:

```
job: 0000000-160627195651086-oozie-oozi-W
```

5. Visit the Oozie UI page to see the submitted Oozie workflow job.

11.3 Presto

Presto Instructions

E-MapReduce versions 2.0 and higher support *Presto*. Presto can be used in E-MapReduce by checking presto software when selecting the mirror image.

After cluster creation, log on to the master node. Presto software will be installed in the directory *`/usr/lib/presto-current`*, and PrestoServer process can be seen by command jps.

Presto service process can be divided into coordinator and worker. Coordinator is started on the master (the HA cluster is the master node of hostname starting with emr-header-1), and worker process is started on the core node. The service process configuration is under the directory *`/usr/lib/presto-current/etc`*, and coordinator uses coordinator-config.properties while worker uses worker-config.preperties, and other configuration files are used for public. The web port is set as 9090.

By default, presto service is set with support from Hive. Connect the metastore of Hive on the cluster to read the table information of Hive and perform querying. The cluster is pre-installed with presto cli and can directly execute the following command to check Hive tables:

```
presto -server localhost:9090 -catalog hive -schema default -user
hadoop -execute 'show tables'
```

Note:
There is a delay of several seconds when Hive tables are synchronized.

11.4 Zeppelin

Alibaba Cloud E-MapReduce can access Zeppelin through Apache Knox.

Preparation

1. In the *Security group* cluster, *set security group rules*, and open the 8080 port.
2. In Knox, add user name and password. For details, see *Knox guide* to set Knox users. The user name and password are used only to log on to Knox's various services which have no relationship with Alibaba Cloud Ram user names.

Note:
Set security group rules for limited IP ranges. It is prohibited to open rules to 0.0.0.0/0 when configuring.

Access zzeppelin

Access links can be viewed as follows:

1. On the right-side of the cluster list page, click **Manage**.
2. In the left-side pane, click **Access Links and Ports**.

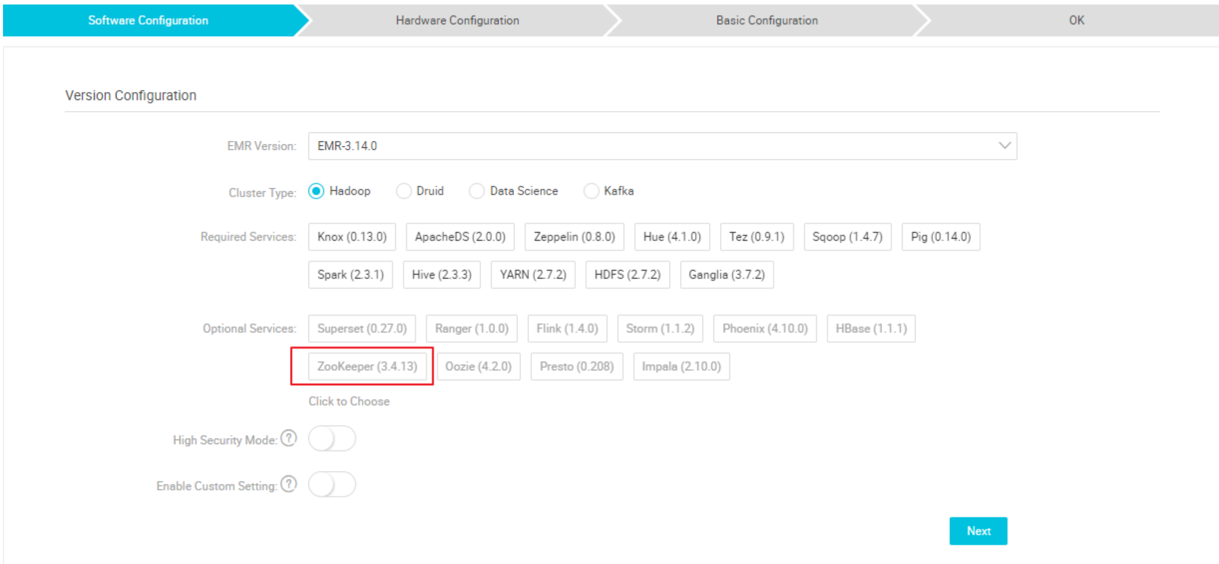
11.5 ZooKeeper

The *ZooKeeper* service is currently enabled in E-MapReduce clusters by default.

Note:
ZooKeeper will have only 3 nodes no matter how many machines are currently in the cluster. More nodes are not supported currently.

Create a cluster

Select the Zookeeper service in the software configuration page when you create a cluster.



Node information

After the cluster is successfully created and the status is idle, in the **Clusters and Services** page, select ZooKeeper, and then click **Component Topology** to view ZooKeeper nodes. E-MapReduce enables 3 ZooKeeper nodes. Corresponding intranet IP address (2181 for port by default) of ZooKeeper nodes are indicated in the IP column for the access to the ZooKeeper service.

11.6 Kafka

11.6.1 Quick start with Kafka

E-MapReduce 3.4.0 and later versions support the Kafka service.

Create a Kafka cluster

Set the cluster type to Kafka when creating a cluster on E-MapReduce. Then, a cluster containing only Kafka components is created by default. The components include the basic components and the Zookeeper, Kafka, and KafkaManager components. Only one Kafka broker is deployed on each node. We recommend you use a dedicated Kafka cluster, not mixing with Hadoop services.

Ephemeral disk Kafka clusters

To better reduce unit costs and respond to larger storage needs, E-MapReduce 3.5.1 supports Kafka clusters on local disks (D1 cluster models. For more information, see *ECS models*). Compared to cloud disks, local disk Kafka clusters have the following features:

- High-volume local SATA HDD disks with high I/O throughput, 190 MB/s of sequential read and write performance on a single disk, and up to 5 GB/s of storage I/O ability.
- Price of local storage is 97% lower than that of SSD cloud disks.
- Higher network performance, up to 17 Gbit/s instances of network bandwidth which meet data interaction needs among business peak instances.

Local disk models also have the following features:

Operation	Ephemeral disk data status	Description
Restart within the operating system/restart or force restart in the ECS console	Retained	The local ephemeral disk's storage volume is retained and data is also retained.
Shut down within the operating system/Stop or force stop in the ECS console	Retained	The local ephemeral disk's storage volume is retained and data is also retained.
Release (instances) on the console	Erased	The local ephemeral disk's storage volume is erased and data is not retained.

Note:

- When the host is down or the disk is corrupted, the data on the disk is lost.
- Do not store business data on an local ephemeral disk for a long time period. Back up data in a timely manner and adopt high-availability architecture. For long-term storage, you are advised to store data on a cloud disk.

To be able to deploy the Kafka service on a local disk, E-MapReduce has default requirements:

1. **`default.replication.factor`** = 3 indicates that the number of the topic's partitions and replicas is at least three. If a smaller number of replicas is set, the risk of data loss is increased.
2. **`min.insync.replicas`** = 2 indicates that when the producer is required to set acks to all (-1), it is considered a successful writing to write at least two replicas at a time.

When a local disk corruption occurs, E-MapReduce performs:

1. Remove the bad disk from the Broker configuration, restart Broker, and recover the lost data from the bad disk on the other available local disks. Data recovery time varies according to the amount of data that have been written on the broken disk.

2. When the number of machine disks damaged (over 20%), E-MapReduce takes the initiative to migrate the machine and restore the abnormal disk.
3. If there is not enough disk space available on the current machine to recover loss data on the damaged disk, Broker will be shut down abnormally. In this case, you can choose to clean up some data, free up disk space and restart the Broker service. You can also contact E-MapReduce for machine migration and recover abnormal disks.

Parameter description

You can check Kafka software configurations on the E-MapReduce cluster configuration management interface.

Configuration Item	Description
zookeeper.connect	Zookeeper connection address configured on Kafka
kafka.heap.opts	Size of the heap memory of the Kafka broker
num.io.threads	Number of I/O threads of the Kafka broker, which is twice the number of CPU cores by default
num.network.threads	Number of network threads of the Kafka broker, which is the same as the number of CPU cores by default

11.6.2 Cross-cluster access to Kafka

An independent Kafka cluster is deployed to provide the Kafka service. Therefore, you may need to access this service across clusters.

Cross-cluster access to Kafka

Cross-cluster access to Kafka consists of two common types:

- Access E-MapReduce Kakfa clusters from Alibaba Cloud intranet network.
- Access E-MapReduce Kakfa clusters from the public network.

Different solutions are prepared for different E-MapReduce versions.

EMR-3.11.x and Later Versions

- Access Kafka from the Alibaba Cloud intranet network

  You can access Kafka service directly by using the intranet IP address of a Kakfa cluster node. Use port 9092 to access Kafka from the intranet network.

  Make sure that the networks are accessible before you access Kafka service:

    - For more information about how to access a VPC from a classic network, see *Access between classic network and VPC* here.
    - For more information about how to access a VPC from another VPC, see *here*.
- Access Kafka in the public network

  The Core node of the Kafka cluster is unable to access to the public network by default. To access the Kafka cluster in the public network, perform the following steps:

  1. Interconnect Kafka clusters with the public network.
     - If Kafka clusters are deployed in a VPC environment, there are two ways:
       - Deploy Express Connect to interconnect the VPC with the public network. For details, see *Express Connect* document.
       - Bind EIPs to cluster core nodes. For details, see *EIP documents*). Perform the following steps to bind the EIP to the ECS:
     - If Kafka is deployed in a classic network, there are two ways:
       - To create a Pay-As-You-Go cluster, use ECS APIs. For details, see *API documents*.
       - To create a cluster through the Subscription method, you can directly assign a public IP address to relevant host in the ECS console.
  2. Create an EIP in the *VPC console*, and purchase relevant EIPs based on the number of Core nodes in the Kafka cluster.
  3. Configure security group rules for the Kafka cluster to control public network access to the IP addresses of the Kafka cluster. The objective is to improve the security of the Kafka cluster exposed in the public network. You can view the security group to which the cluster belongs in the EMR console, and configure security group rules based on security group IDs. For more information, see *here* .
  4. On the **Cluster Management** page of the E-MapReduce console, click **Manage** after the specified cluster, select **Cluster Overview** on the left side of the page, and then click the **Sync Cluster Host Info** button in the upper right corner.
  5. Restart the cluster Kafka service.
  6. Use the EIP of the Kafka cluster node to access Kafka service in the public network. Use port 9093 to access Kafka service from the public network.

Versions earlier than EMR-3.11.x

- Access Kafka from the Alibaba Cloud intranet network

In this case, you must configure the host information of the Kafka cluster node on the client host. **Long domain** of the Kafka cluster node must be configured. Example:

```
/etc/hosts
# kafka cluster
10.0.1.23 emr-header-1.cluster-48742
10.0.1.24 emr-worker-1.cluster-48742
10.0.1.25 emr-worker-2.cluster-48742
10.0.1.26 emr-worker-3.cluster-48742
```

- Access Kafka in the public network

  The Core node of the Kafka cluster is unable to access to the public network by default. To access the Kafka cluster in the public network, perform the following steps:

  1. Interconnect Kafka clusters with the public network.
     - If Kafka clusters are deployed in a VPC environment, there are two ways:
       - Deploy Express Connect to interconnect the VPC with the public network. For details, see *Express Connect* document.
       - Bind EIPs to cluster Core nodes. For details, *EIP documents*. Perform the following steps to bind the EIP to the ECS.
     - If Kafka is deployed in a classic network, there are two ways:
       - To create a Pay-As-You-Go cluster, use ECS APIs. For details, see *API documents*.
       - To create a cluster through the Subscription method, you can directly assign a public IP address to relevant host in the ECS console.
  2. Create an EIP in the *VPC console*, and purchase relevant EIPs based on the number of Core nodes in the Kafka cluster.
  3. Configure security group rules for the Kafka cluster to control public network access to the IP addresses of the Kafka cluster. The objective is to improve the security of the Kafka cluster exposed in the public network. You can view the security group to which the cluster belongs in the EMR console, and configure security group rules based on security group IDs. For more information, see *here*.
  4. Modify the software configuration of the Kafka cluster **`listeners.address.principal`** to `HOST`, and restart the Kafka cluster.
  5. Configure the *`hosts`* file on the local client host.

11.6.3 Kafka Ranger

Starting from EMR-3.12.0 version, E-MapReduce Kafka allows you to configure permissions with Ranger.

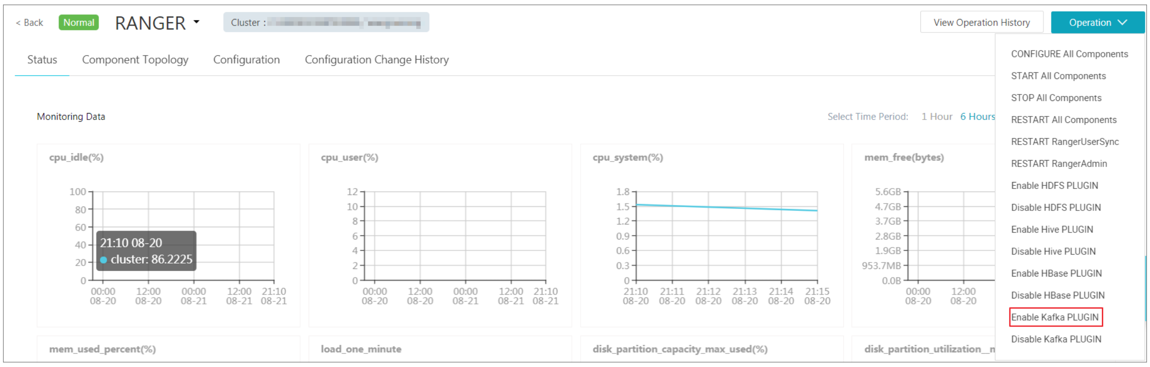
Integrate Ranger into Kafka

The previous section introduced how to create a cluster with Ranger service in E-MapReduce and some preparation work. This section describes the step-by-step process for integrating Ranger into Kafka.

- **Enable Kakfa Plugin**

1. On **Cluster Management** page, click **Ranger** in the service list to enter the Ranger Management page. Click **Operation** in the upper right corner of the page and select **Enable Kafka PLUGIN**.

2. You can check the progress by clicking **View Operation History** at the upper right corner of the page.

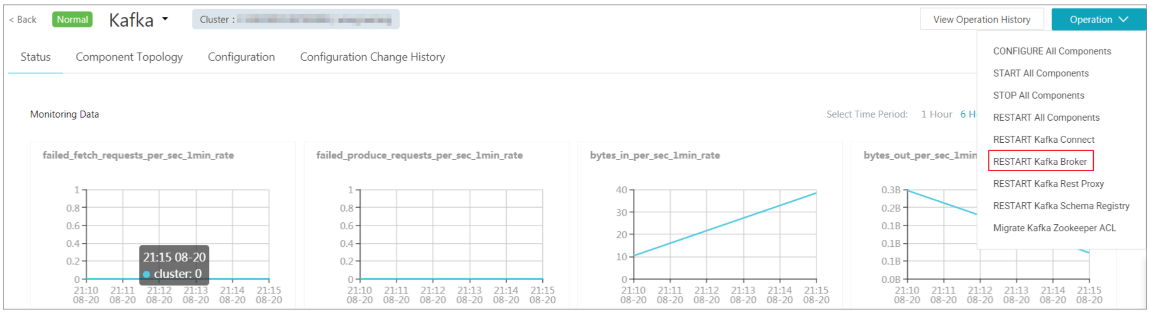


- Restart Kafka Broker

After the preceding task is completed, it is necessary to restart the broker to make it take effect.

1. On the **Cluster Management** page, click the inverted triangle icon behind **RANGER** in the upper left corner to switch to **Kafka**.
2. Click **Actions** at the upper right corner of the page and select **RESTART Broker**.

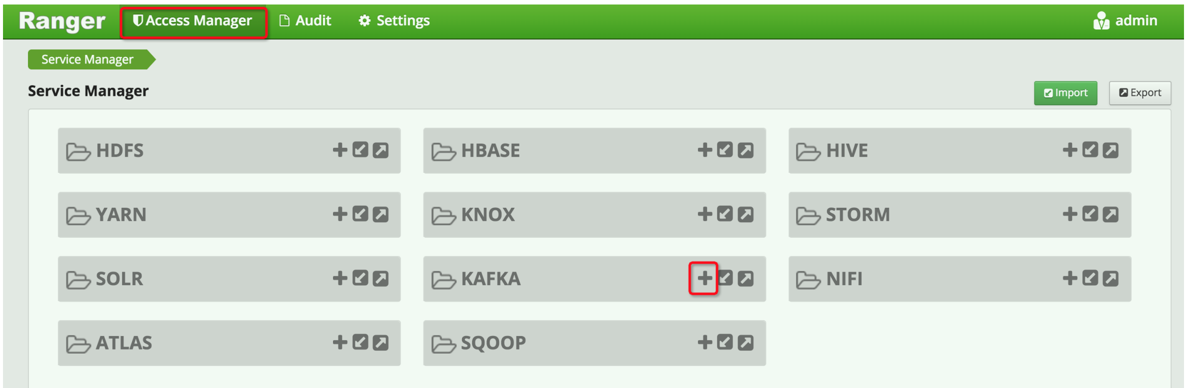
3. You can check the progress by clicking **View Operation History** at the upper right corner of the page.



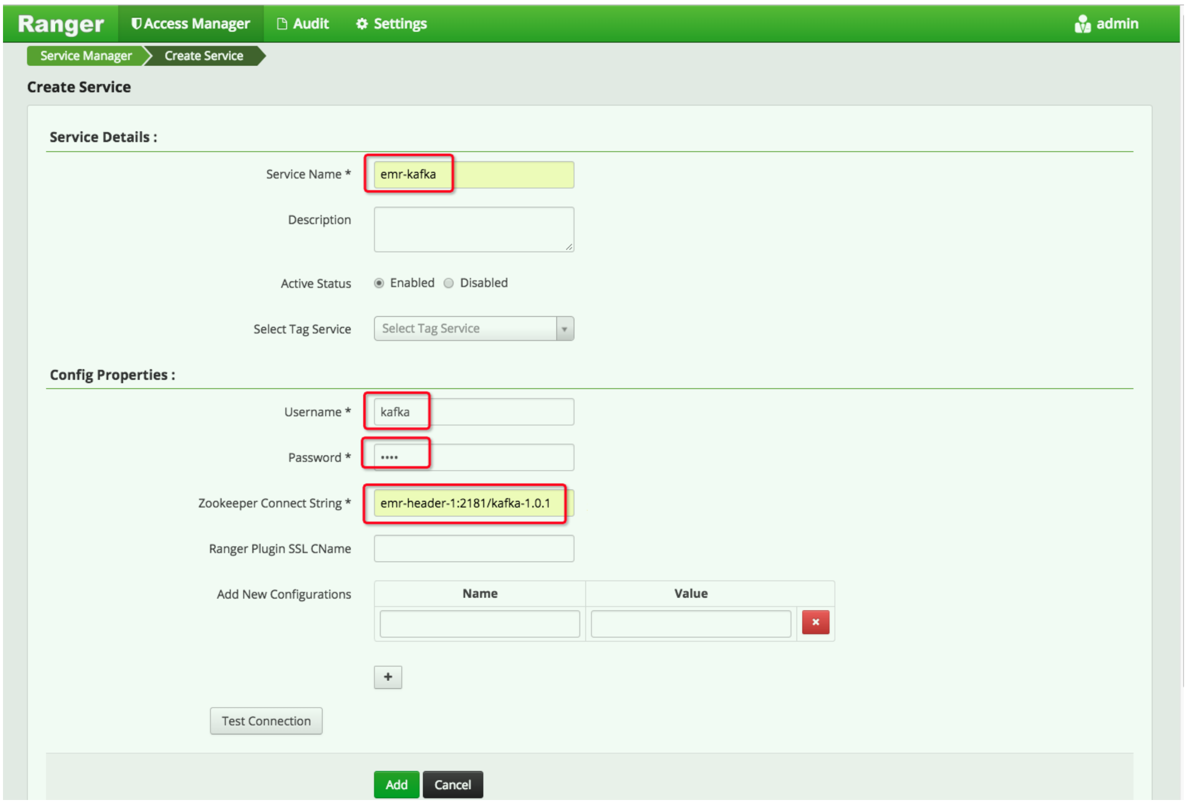
- **Add Kafka service on Ranger WebUI**

For information about how to go to Ranger WebUI, see *Ranger Introdcution*.

Add the Kafka service on **Ranger** WebUI:



Configure Kafka Service:



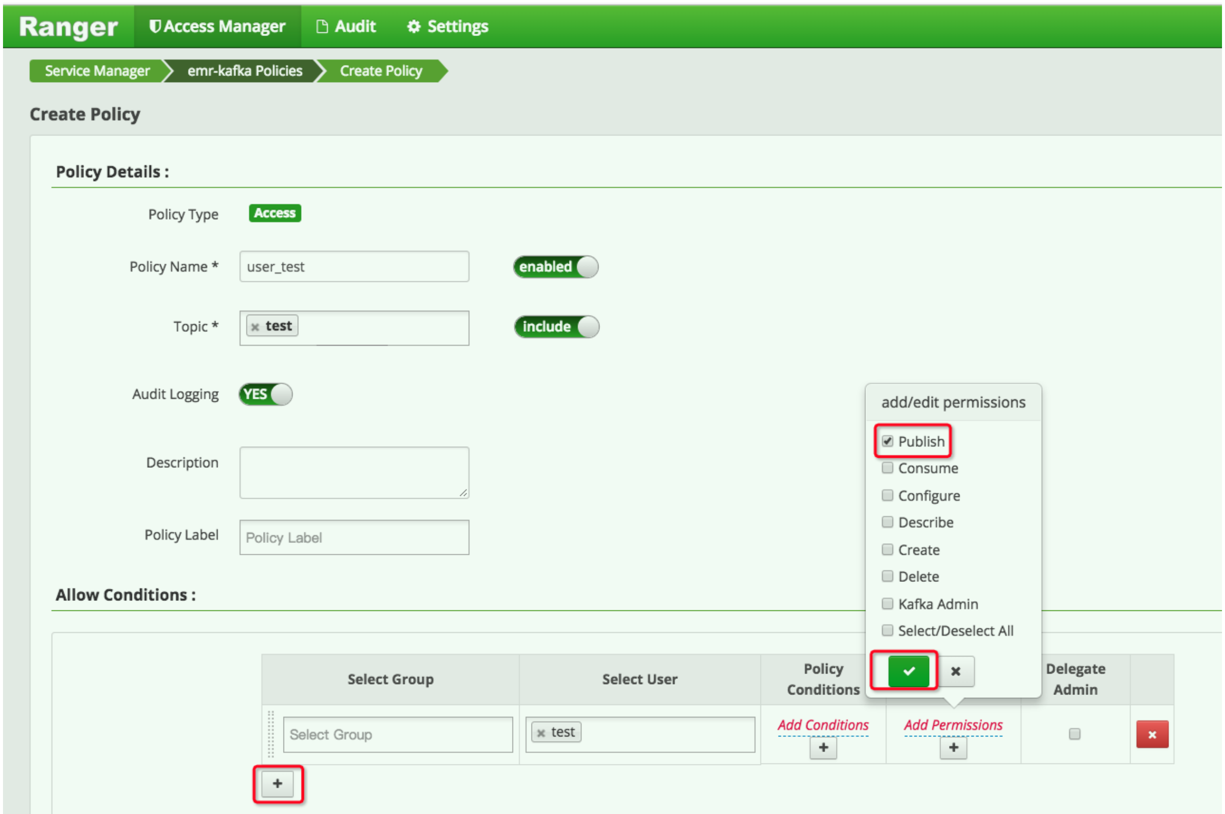
Permissions configuration examples

The preceding section has integrated Ranger into Kafka, which allows you to set relevant permissions.

Note:

In a standard cluster, Ranger generates the **all - topic** rule by default after the Kafka service is added. This rule means no restriction on permissions (that is, allow all users to perform all actions). In this case, Ranger cannot identify permissions through the user.

Use user test as an example to add the Publish permission:



After you add a policy by following the preceding steps, the permissions are granted to user `test`. The `test` user can perform the write operation on the topic of `test`.

Note:

The policy takes effect 1 minute later after it is added.

11.6.4 Kafka SSL

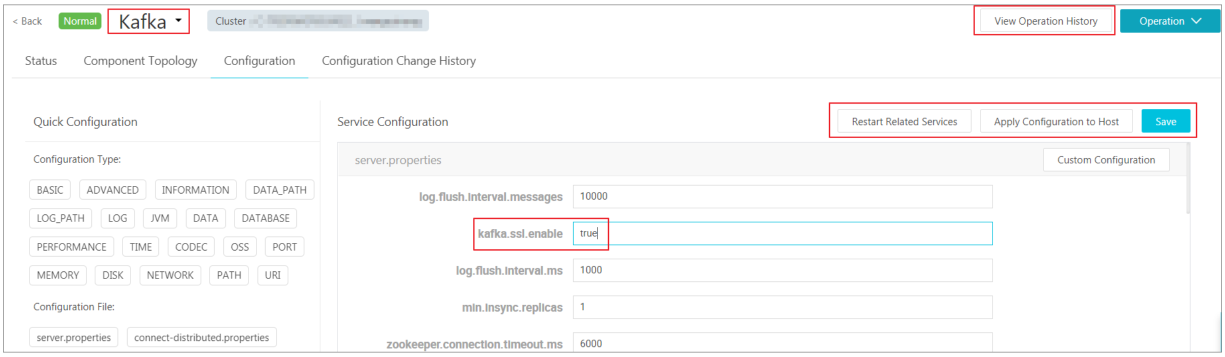
E-MapReduce Kafka supports the SSL function in EMR-3.12.0 and later versions.

Create a cluster

For details about how to create a cluster, see *Create a cluster*Create a cluster.

Enable the SSL service

The SSL function is not enabled for the Kafka cluster by default. You can enable SSL on the configuration page of the Kafka service.



As shown in the preceding figure, change **`kafka.ssl.enable`** to `true` and then restart the component.

Access Kafka from the client

You need to configure **`security.protocol`**, **`truststore`**, and **`keystore`** when you access Kafka through SSL. Use a standard mode cluster as an example. To run a job in a Kafka cluster, you can configure the cluster as follows:

```
security.protocol=SSL
ssl.truststore.location=/etc/ecm/kafka-conf/truststore
ssl.truststore.password=${password}
ssl.keystore.location=/etc/ecm/kafka-conf/keystore
ssl.keystore.password=${password}
```

If you are running a job in an environment other than a Kafka cluster, copy the truststore and keystore files (in the */etc/ecm/kafka-conf/* directory on any node of the cluster) in the Kafka cluster to the running environment and add configurations accordingly.

Use the producer and consumer programs in the Kafka as an example.

1. Create the configuration file *ssl.properties*, and add configuration items.

   ```
   security.protocol=SSL
    ssl.truststore.location=/etc/ecm/kafka-conf/truststore
    ssl.truststore.password=${password}
    ssl.keystore.location=/etc/ecm/kafka-conf/keystore
    ssl.keystore.password=${password}
   ```

2. Create a topic.

   ```
   kafka-topics.sh --zookeeper emr-header-1:2181/kafka-1.0.1 --
   replication-factor 2 --
   ```

```
partitions 100 --topic test --create
```

3. Use an SSL configuration file to generate data.

```
kafka-producer-perf-test.sh --topic test --num-records 123456 --
throughput 10000 --record-size 1024 --producer-props bootstrap.
servers=emr-worker-1:9092 --producer.config ssl.properties
```

4. Use an SSL configuration file to consume data.

```
kafka-consumer-perf-test.sh --broker-list emr-worker-1:9092 --
messages 100000000 --topic test --consumer.config ssl.properties
```

11.6.5 Kafka Manager guide

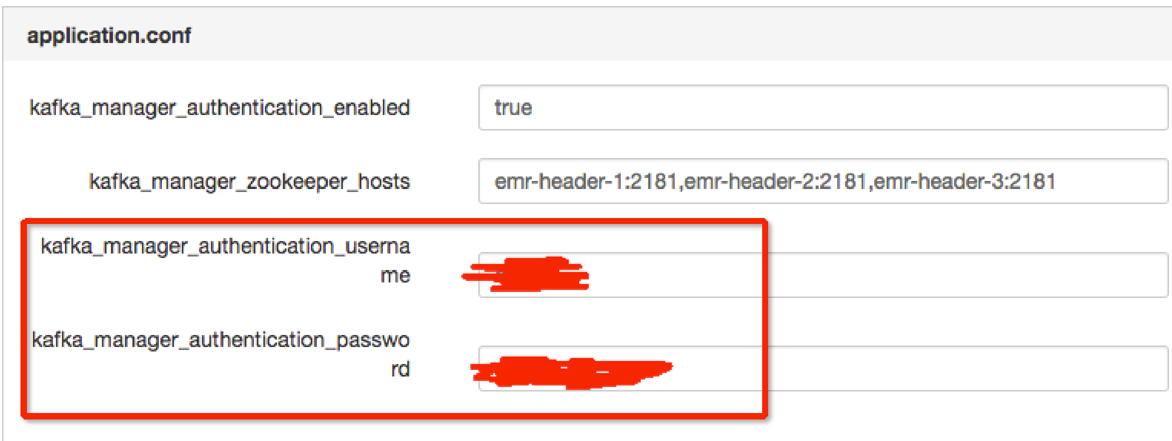
E-MapReduce 3.4.0 and later versions support the Kafka Manager service for managing Kafka clusters.

Procedure

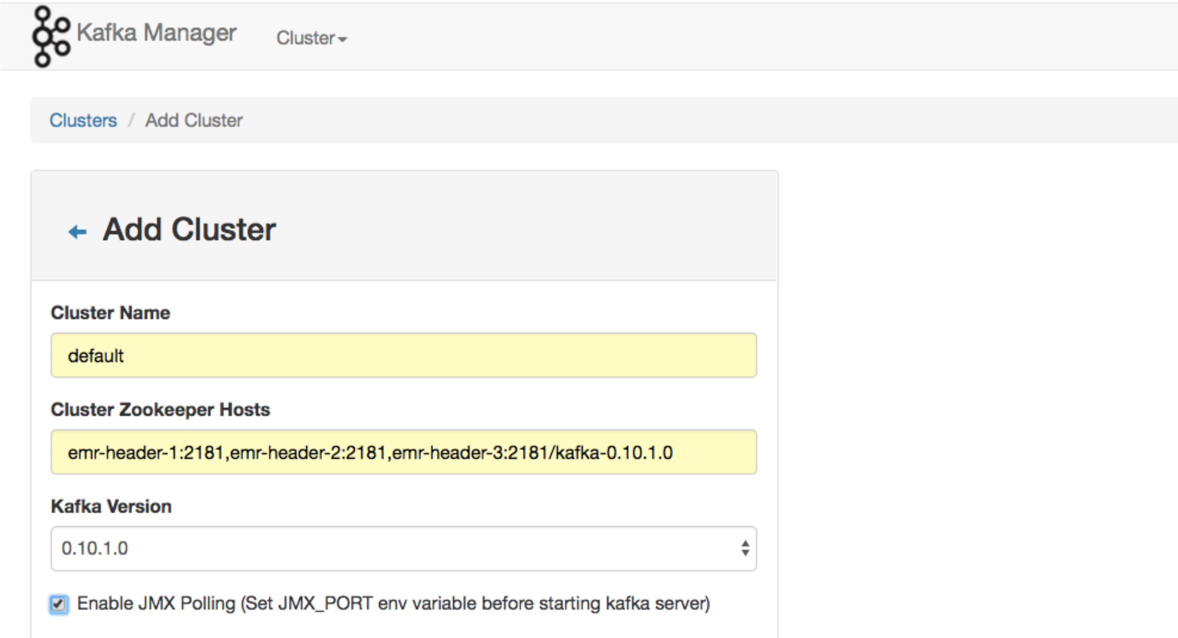
Note:

By default, the Kafka Manager software is installed and the Kafka Manager authentication function is enabled when a Kafka cluster is created. We strongly recommend that you change the default password when using Kafka Manager for the first time and access Kafka Manager through the SSH tunnel. We do not recommend that you expose Port 8085 to the public network unless an IP address whitelist is configured to avoid data leakage.

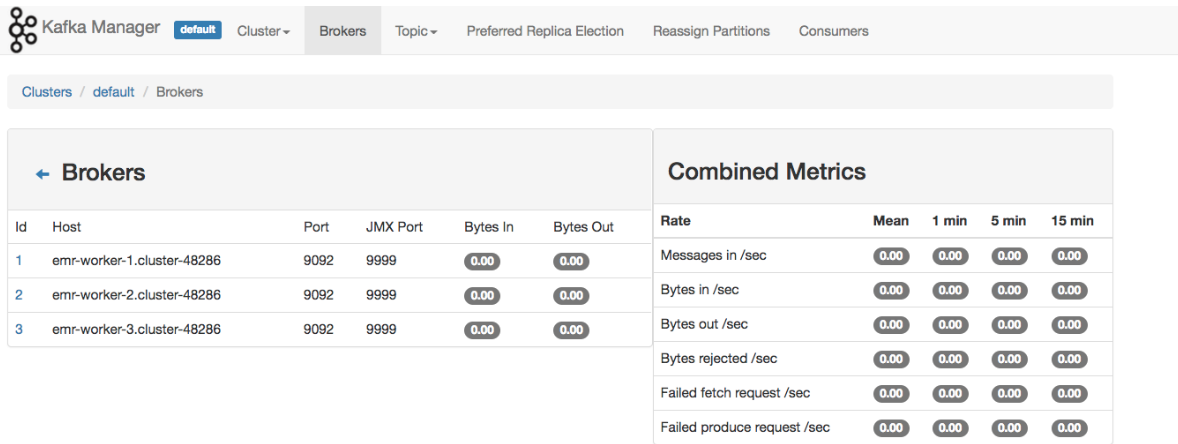
- We recommend you access the web page through the SSH tunnel. See *Connect to clusters using SSH* User Guide > Connect to Cluster through SSH for more information.
- Access *Cite Lefthttp://localhost:8085Cite Right*.
- Enter your username and password. Refer to the configuration information of Kafka Manager.



- Add an existing Kafka cluster and make sure that the Zookeeper address of the Kafka cluster is correct. For more information, see the configuration information of Kafka Manager. Select the corresponding Kafka version. We recommend you enable the JMX function.



- Common Kafka functions are available immediately after you create a Kafka cluster.



11.6.6 Kafka common problems

This section describes Kafka common problems.

- `Error while executing topic command : Replication factor: 1 larger than available brokers: 0.`

  Common causes:

  - A fault occurs in the Kafka service, and the cluster broker process exits. You need to use logs to troubleshoot the fault.

- The ZooKeeper address of the Kafka service is incorrect. View and use the Zookeeper. connect configuration item on the Kafka service configuration management page.

- `java.net.BindException: Address already in use (Bind failed)`

  When you use the Kafka command line tools, you sometimes encounter the `java.net.BindException: Address already in use (Bind failed)` exception. This is typically caused by the unavailability of the JMX port. You can specify a JMX port manually before using the command line. For example:

```
JMX_PORT=10101 kafka-topics --zookeeper emr-header-1:2181/kafka-1.0.
0 --list
```

11.7 Druid

11.7.1 Druid Introduction

Druid is a distributed real-time memory analysis system launched by Metamarkets, a company that provides data analysis services to online media or advertising companies. Druid is used to resolve fast and interactive queries and analyse issues in large datasets.

Basic features

Druid has the following features:

- Sub-second OLAP queries, including multi-dimensional filtering, ad-hoc attribute grouping, and fast data aggregation.
- Real-time data consumption, real-time data collection, and real-time data query.
- Efficient multi-tenant capability, which enables thousands of users to perform searches online at the same time.
- Strong scalability, which supports fast processing of PB-level data and 100 billion-level events, and thousands of concurrent queries per second.
- Extremely high availability and support for rolling upgrades.

Scenarios

Real-time data analysis is the most typical usage scenario for Druid. This scenario can cover a wide range of areas, such as:

- Real-time indicator monitoring
- Recommendation of model
- Advertisement platforms

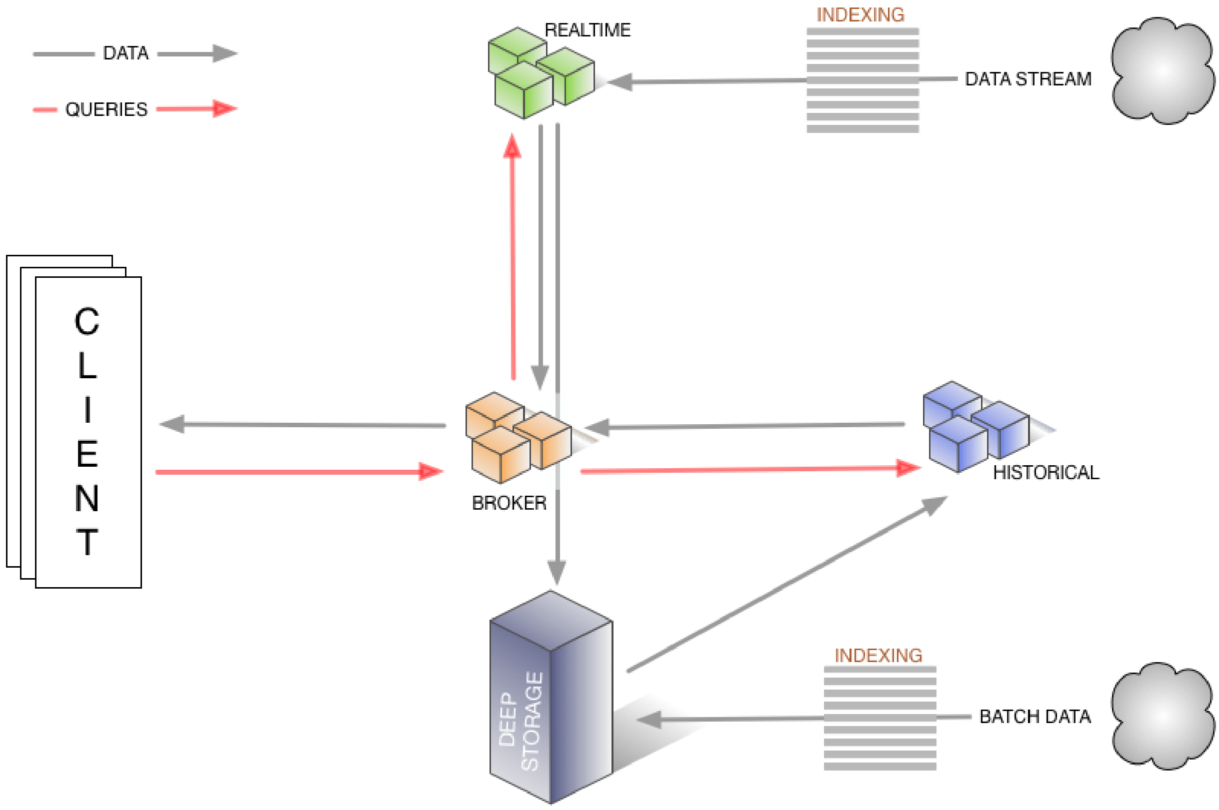
- Search for models

In these scenarios, there are large amounts of data, and the requirement for time delay of data query is high. In real-time indicator monitoring, system problems need to be detected at the moment of occurrence so the user can be warned. In the recommendation model, the user behavior data needs to be collected in real time, and be timely sent to the recommendation system. After a few clicks, the system will be able to identify your search intent and recommend more reasonable results in subsequent searches.

Druid architecture

Druid has an excellent architectural design with multiple components working together to complete a series of processes such as data collection, data indexing, data storage, and data query.

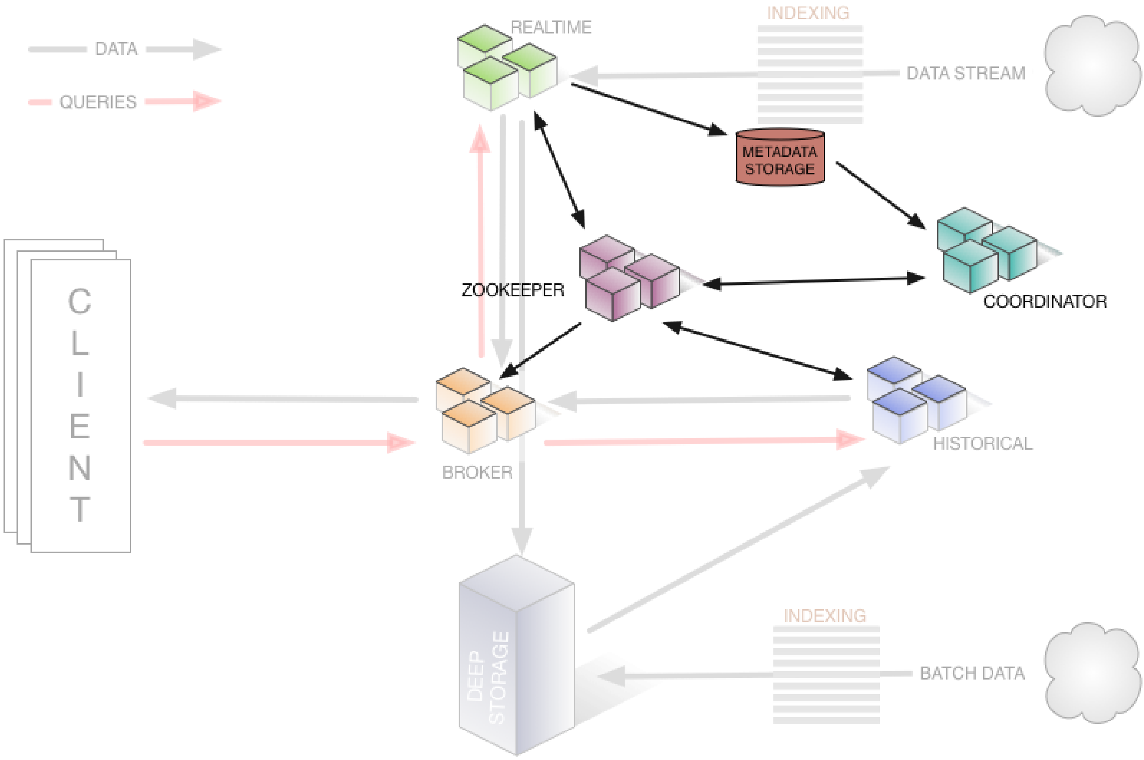
The following figure shows the components contained in the Druid working-layer (data indexing as well as data query).



- The real-time component is responsible for the real-time data collection.
- In the broker phase, query tasks are distributed, and query results are collected and returned to users.

- The historical node is responsible for the storage of the historical data after the indexing. The data is stored in deep storage. Deep storage can be either local or a distributed file system, such as HDFS.
- The indexing service consists of two components (not shown in the figure).
  - The Overlord component is responsible for managing and distributing indexing tasks.
  - The MiddleManager component is responsible for executing indexing tasks.

The following figure shows the components involved in the management layer of Druid segments (Druid index file).



- The ZooKeeper component is responsible for storing the status of the cluster and discovering components, such as the topology information of the cluster, election of the Overlord leader, and management of the indexing task.
- The Coordinator component is responsible for managing the segments, such as the download and deletion of the segments and balancing with historical components.
- The Metadata storage component is responsible for storing the meta-information of segments and managing all kinds of persistent or temporary data in the cluster, such as configuration information and audit information.

Product advantages

E-MapReduce Druid is improved a lot based on the open source Druid, including integration with E-MapReduce and the peripheral ecology of Alibaba Cloud, easy monitoring and operation support, and easy-to-use product interfaces. After buying it, you can use immediately. It does not need operation and maintenance for 7x24 hours.

E-MapReduce Druid supports the following features:

- Using OSS as deep storage
- Using OSS files as data sources for indexing in batches
- Using RDS to store metadata
- Integrating with Superset tools
- Easy scale up and scale down (scale down is for task node)
- diversified monitoring indicators and alarm rules
- Bad node migration
- High-security mode
- Supporting HA

11.7.2 Quick start

E-MapReduce-3.11.0 and later versions support Druid as a cluster type.

The use of Druid as a separate cluster type (instead of adding Druid service to the Hadoop cluster) is mainly based on the following reasons:

- Druid can be used independently of Hadoop.
- Druid has high memory requirements when there is a large amount of data, especially for Broker and Historical nodes. Druid is not controlled by Yarn, and will compete for resources during multi-service operation.
- As the infrastructure, the node number of a Hadoop cluster can be relatively large, whereas a Druid cluster can be relatively small. The work is more flexible if they work together.

Create a Druid cluster

Select the Druid cluster type when you create a cluster. You can check HDFS and Yarn when creating a Druid cluster. The HDFS and Yarn in the Druid cluster are for testing only, as described at the beginning of this guide. We strongly recommend that you use a dedicated Hadoop cluster as the production environment.

Configure a cluster

- Configure the cluster to use HDFS as the deep storage of Druid

  For a standalone Druid cluster, you may need to store your index data in the HDFS of another Hadoop cluster. Therefore, you need to complete related settings for the connectivity between the two clusters (for details, see Interaction with *Hadoop clusters*). Then you need to configure the following items on the configuration page of Druid and restart the service. (The configuration items are in common.runtime of the configuration page.)

  - druid.storage.type: hdfs
  - druid.storage.storageDirectory: (the hdfs directory must be a full one, such as hdfs://emr-header-1.cluster-xxxxxxxx:9000/druid/segments.)

  Note:
  If the Hadoop cluster is an HA cluster, you must change emr-header-1.cluster-xxxxx:9000 to emr-cluster, or change port 9000 to port 8020.

- Use OSS as the deep storage of Druid

  E-MapReduce Druid supports the use of OSS as deep storage. Due to the AccessKey-free capability of E-MapReduce, Druid can automatically get access to OSS without the need to configure the AccessKey. Because the OSS function of HDFS enables Druid to have access to OSS, druid.storage.type still needs to be configured as HDFS: during the configuration process

  .

  - druid.storage.type: hdfs
  - druid.storage.storageDirectory: (such as oss://emr-druid-cn-hangzhou/segments)

  Because the OSS function of HDFS enables Druid to have access to OSS, you need to select one of the following two scenarios:

  - Choose to install HDFS when you create a cluster. Then the system is automatically configured. (After HDFS is installed, you can choose not to use it, disable it, or use it for testing purposes only.)
  - Create *hdfs-site.xml* in the configuration directory of Druid */etc/ecm/druid-conf/druid/_common/*, the content is as follows, and then copy the file to the same directory of all nodes:

    ```
    <? xml version="1.0"? >
      <configuration>
        <property>
    ```

```
      <name>fs.oss.impl</name>
      <value>com.aliyun.fs.oss.nat.NativeOssFileSystem</value>
    </property>
    <property>
      <name>fs.oss.buffer.dirs</name>
      <value>file:///mnt/disk1/data,...</value>
    </property>
    <property>
      <name>fs.oss.impl.disable.cache</name>
      <value>true</value>
    </property>
  </configuration>
```

The **`fs.oss.buffer.dirs`** can be set to multiple paths.

- Use RDS to save Druid metadata

  Use the MySQL database on header-1 node to save Druid metadata. You can also use the Alibaba Cloud RDS to save the metadata.

  The following uses RDS MySQL as an example to demonstrate the configuration. Before you configure it, make sure that:

  - The RDS MySQL instance has been created.
  - A separate account has been created for Druid to access RDS MySQL (root is not recommended). This example uses account name druid and password druidpw.
  - Create a separate MySQL database for Druid metadata. Suppose the database is called druiddb.
  - Make sure that account Druid has permission to access druiddb.

  In the E-MapReduce console, click Manage behind the Druid cluster you want to configure. Click the Druid service, and then select the **Configuration** tab to find the *`common.runtime`* configuration file. Click **Custom Configuration** to add the following three configuration items:

  - druid.metadata.storage.connector.connectURI, where the value is: jdbc:mysql://rm-xxxxx.mysql.rds.aliyuncs.com:3306/druiddb
  - druid.metadata.storage.connector.user, where the value is druid.
  - druid.metadata.storage.connector.password, where the value is druidpw.

  Click the **Save**, **Configuration to Host**, and **Restart Related Services** buttons in turn in the upper right corner to make the configuration take effect.

  Log on to the RDS console to view the tables created by druiddb. You will find tables automatically created by druid.

- Service memory configuration

The memory of the Druid service consists of the heap memory (configured through jvm. config), and direct memory (configured through jvm. config and runtime. properteis). E-MapReduce will automatically generate a set of configurations when you create a cluster. However, in some cases, you may still need to configure the memory.

To adjust the service memory configuration, you can access the cluster services through the E-MapReduce console, and perform related operations on the page.

Note:

For direct memory, make sure that

```
-XX:MaxDirectMemorySize is greater than or equal to druid.
processing.buffer.sizeBytes * (druid.processing.numMergeBuffers +
druid.processing.numThreads + 1).
```

Batch index

- Interaction with Hadoop clusters

  If you select HDFS and Yarn (with their own Hadoop clusters) when creating Druid clusters, the system will automatically configure the interaction between HDFS and Yarn. The following example shows how to configure the interaction between a standalone Druid cluster and a standalone Hadoop cluster. It is assumed that the Druid cluster ID is 1234, and the Hadoop cluster ID is 5678. In addition, read through and follow the instructions strictly. The clusters may not work as expected because of a slightly improper operation.

  For the interaction with standard-mode Hadoop clusters, perform the following operations:

  1. Ensure the communication between the two clusters. (Each cluster is associated with a different security group, and access rules are configured for the two security groups.)
  2. Put core-site.xml, hdfs-site.xml, yarn-site.xml, mapred-site.xml of `/etc/ecm/hadoop-conf` of the Hadoop cluster in the `/etc/ecm/duird-conf/druid/_common` directory on each node of the Druid cluster. (If you select the built-in Hadoop when you create the cluster, several soft links in this directory will map to the configuration of the Hadoop service of E-MapReduce. Remove these soft links first.)
  3. Write the hosts of the Hadoop cluster to the hosts list on the Druid cluster. Note that the hostname of the Hadoop cluster should be in the form of a long name, such as emr-

header-1.cluster-xxxxxxxx. You are advised to put the hosts of Hadoop behind the hosts of the Druid cluster, such as:

```
...
10.157.201.36   emr-as.cn-hangzhou.aliyuncs.com
10.157.64.5     eas.cn-hangzhou.emr.aliyuncs.com
192.168.142.255 emr-worker-1.cluster-1234 emr-worker-1 emr-header-
2.cluster-1234 emr-header-2 iZbp1h9g7boqo9x23qbifiZ
192.168.143.0   emr-worker-2.cluster-1234 emr-worker-2 emr-header-
3.cluster-1234 emr-header-3 iZbp1eaa5819tkjx55yr9xZ
192.168.142.254 emr-header-1.cluster-1234 emr-header-1 iZbp1e3zwu
vnmakmsjer2uZ
For Hadoop clusters in high-security mode, perform the following
operations:
192.168.143.6   emr-worker-1.cluster-5678 emr-worker-1 emr-header-
2.cluster-5678 emr-header-2 iZbp195rj7zvx8qar4f6b0Z
192.168.143.7 emr-worker-2.cluster-5678 emr-worker-2 emr-header-3.
cluster-5678 emr-header-3 iZbp15vy2rsxoegki4qhdpZ
192.168.143.5 emr-header-1.cluster-5678 emr-header-1 iZbp10tx4e
gw3wfnh5oii1Z
```

For Hadoop clusters in high security mode, perform the following operations:

1. Ensure the communication between the two clusters. (Each cluster is associated with a different security group,and access rules are configured for the two security groups.)
2. Put core-site.xml, hdfs-site.xml, yarn-site.xml, mapred-site.xml of */etc/ecm/hadoop-conf* of the Hadoop cluster in the */etc/ecm/duird-conf/druid/_common* directory on each node of the Druid cluster. (If you select the built-in Hadoop when creating a cluster, several soft links in this directory will point to the configuration with Hadoop. Remove these soft links first.) Modify **hadoop.security.authentication.use.has** in core-site.xml to `false`. (This configuration is completed on the client to enable AccessKey authentication for users. If Kerberos authentication is used, disable AccessKey authentication.)
3. Write the hosts of the Hadoop cluster to the hosts list of each node on the Druid cluster. Note that the hostname of the Hadoop cluster should be in the form of a long name, such as emr-header-1.cluster-xxxxxxxx. You are advised to put the hosts of Hadoop behind the hosts of the Druid cluster.
4. Set Kerberos cross-domain mutual trust between the two clusters. (For more details, see *Cross-region access* here.
5. Create a local Druid account (useradd-m-g hadoop) on all nodes of the Hadoop cluster, or set druid.auth.authenticator.kerberos.authtomate to create a mapping rule for the Kerberos account to the local account. For specific pre-release rules, see *here*. This method is recommended because it is easy to operate without errors.

Note:

In Hadoop cluster of the high-security mode , all Hadoop commands must be run from a local account. By default, this local account needs to have the same name as the principal. Yarn also supports mapping a principal to a local account.

6. Restart the Druid service.

- Use Hadoop to index batch data

  Druid has an example named wikiticker and located in *${DRUID_HOME}/quickstart*. (*${DRUID_HOME}* is /usr/lib/ druid-current by default.) Each line of the wikiticke document (wikiticker-2015-09-12-sampled.json.gz) is a record. Each record is a json object. The format is as follows:

```
```json
{
    "Time": "2015-09-12T00: 46: 58.771Z ",
    "channel": "#en.wikipedia",
    "cityName": null,
    "comment": "added project",
    "countryIsoCode": null,
    "countryName": null,
    "isAnonymous": false,
    "isMinor": false,
    "isNew": false,
    "isRobot": false,
    "isUnpatrolled": false,
    "metroCode": null,
    "namespace": "Talk",
    "page": "Talk:Oswald Tilghman",
    "regionIsoCode": null,
    "regionName": null,
    "user": "GELongstreet",
    "delta": 36,
    "added": 36,
    "deleted": 0
}
```
```

  To use Hadoop to create index for batch data, perform the following steps:

1. Decompress the compressed file and place it in a directory of HDFS (such as: *hdfs://emr-header-1.cluster-5678:9000/druid*). Run the following command on the Hadoop Cluster.

```
### If you are operating on a standalone Hadoop cluster, copy
 a druid.keytab to Hadoop cluster after the mutual trust is
established between the two clusters, and run the kinit command.
 kinit -kt /etc/ecm/druid-conf/druid.keytab druid
 ###
 hdfs dfs -mkdir hdfs://emr-header-1.cluster-5678:9000/druid
```

```
 hdfs dfs -put ${DRUID_HOME}/quickstart/wikiticker-2015-09-16-
sampled.json hdfs://emr-header-1.cluster-5678:9000/druid
```

Note:

- Modify **`hadoop.security.authentication.use.has`** in *`/etc/ecm/hadoop-conf/core-site.xml`* to `false` before running HDFS command for a high-security mode cluster.
- Make sure that you have created a Linux account named Druid on each node of the Hadoop cluster.

2. Modify Druid cluster *`${DRUID_HOME}/quickstart/wikiticker-index.json`*, as shown below:

```
{
     "type" : "index_hadoop",
     "spec" : {
         "ioConfig" : {
             "type" : "hadoop",
             "inputSpec" : {
                 "type" : "static",
                 "paths" : "hdfs://emr-header-1.cluster-5678:9000/
druid/wikiticker-2015-09-16-sampled.json"
             }
         },
         "dataSchema" : {
             "dataSource" : "wikiticker",
             "granularitySpec" : {
                 "type" : "uniform",
                 "segmentGranularity" : "day",
                 "queryGranularity" : "none",
                 "intervals" : ["2015-09-12/2015-09-13"]
             },
             "parser" : {
                 "type" : "hadoopyString",
                 "parseSpec" : {
                     "format" : "json",
                     "dimensionsSpec" : {
                         "dimensions" : [
                             "channel",
                             "cityName",
                             "comment",
                             "countryIsoCode",
                             "countryName",
                             "isAnonymous",
                             "isMinor",
                             "isNew",
                             "isRobot",
                             "isUnpatrolled",
                             "metroCode",
                             "namespace",
                             "page",
                             "regionIsoCode",
                             "regionName",
                             "user"
                         ]
```

```
                     },
                     "timestampSpec" : {
                         "format" : "auto",
                         "column" : "time"
                     }
                 }
             },
             "metricsSpec" : [
                 {
                     "name" : "count",
                     "type" : "count"
                 },
                 {
                     "name" : "added",
                     "type" : "longSum",
                     "fieldName" : "added"
                 },
                 {
                     "name" : "deleted",
                     "type" : "longSum",
                     "fieldName" : "deleted"
                 },
                 {
                     "name" : "delta",
                     "type" : "longSum",
                     "fieldName" : "delta"
                 },
                 {
                     "name" : "user_unique",
                     "type" : "hyperUnique",
                     "fieldName" : "user"
                 }
             ]
         },
         "tuningConfig" : {
             "type" : "hadoop",
             "partitionsSpec" : {
                 "type" : "hashed",
                 "targetPartitionSize" : 5000000
             },
             "jobProperties" : {
                 "mapreduce.job.classloader": "true"
             }
         }
     },
     "hadoopDependencyCoordinates": ["org.apache.hadoop:hadoop-
client:2.7.2"]
 }
```

Note:

- **`spec.ioConfig.type`** is set to hadoop.
- **`spec.ioConfig.inputSpec.paths`** is the path of the input file.
- **`tuningConfig.type`** is hadoop.
- **`tuningConfig.jobProperties`** sets the classloader of the mapreduce job.
- **`hadoopDependencyCoordinates`** develops the version of Hadoop client.

3. Run the batch index command on the Druid cluster.

```
cd ${DRUID_HOME}
 curl --negotiate -u:druid -b ~/cookies -c ~/cookies -XPOST -H '
Content-Type:application/json' -d @quickstart/wikiticker-index.
json http://emr-header-1.cluster-1234:18090/druid/indexer/v1/task
```

Note that the items such as `- -negotiate`、`-u`、`-b`、`-c` are for high-security mode Druid clusters. The Overlord port number is 18090 by default.

4. View the running state of the jobs.

Access http://emr-header-1.cluster-1234:18090/console.html in the browser to view how the jobs run. To access the page properly, you need to open an SSH tunnel in advance (see *Connect to clusters using SSH* View WebUI of system such as Hadoop, Spark, Ganglia section in SSH tunnel), and start an agent chrome. If the high-security mode is enabled for the Druid cluster, you have to configure your browser to support the Kerberos authentication process. For more information, see *here*.

5. Query the data based on Druid syntax.

Druid has its own query syntax. You need to prepare a json-formatted query file that describes how you want to query. A topN query to the wikiticker data is as follows *`${DRUID_HOME}/quickstart/wikiticker-top-pages.json`*):

```
{
     "queryType" : "topN",
     "dataSource" : "wikiticker",
     "intervals" : ["2015-09-12/2015-09-13"],
     "granularity" : "all",
     "dimension" : "page",
     "metric" : "edits",
     "threshold" : 25,
     "aggregations" : [
         {
             "type" : "longSum",
             "name" : "edits",
             "fieldName" : "count"
         }
     ]
 }
```

You can check the results of the query by running the following command:

```
cd ${DRUID_HOME}
 curl --negotiate -u:druid -b ~/cookies -c ~/cookies -XPOST -H '
Content-Type:application/json' -d @quickstart/wikiticker-top-pages
.json 'http://emr-header-1.cluster-1234:18082/druid/v2/?pretty'
```

Note that the items such as`- -negotiate`、`-u`、`-b`、`-c` are for Druid clusters in the high-security mode. You can check the results of a specific query in normal cases.

- Real-time index

  We recommend that you use *Tranquility client* to send real-time data to Druid. Tranquility supports sending data to Druid in a variety of ways, such as Kafka, Flink, Storm, Spark Streaming. For the information about Kafka method, see *Tranquility*. Druid uses Tranquility Kafka section in Tranquility. For more information about how to use Tranquility and SDK, see *Tranquility Help Document*.

  For Kafka, you can also use the kafka-indexing-service extension. For details, see *Kafka indexing service*.

- Troubleshoot index failures

  When the index fails, troubleshoot the failure as follows:

  - **For the index of batch data**

    1. If the curl command output displays an error or does not display any information, check the file format. Or add the `-v` parameter to the curl command to check the value returned from the REST API.
    2. Observe the execution of jobs on the Overlord page. If the execution fails, view the logs on the page.
    3. In many cases, logs are not generated. In the case of a Hadoop job, open the Yarn page to check whether there is an index job generated, and view the job execution log.
    4. If no errors are found, you need to log on to the Druid cluster, and view the execution logs of Overlord (at *`/mnt/disk1/log/druid/overlord—emr-header-1.cluster-xxxx.log`*). In the case of an HA cluster, check the Overlord that you submitted the job to.
    5. If the job has been submitted to Middlemanager, but a failure is returned from Middlemanager, you need to view the worker that the job is submitted to in Overlord, and log on to the worker to view the Middlemanager logs (at *`/mnt/disk1/log/druid/middleManager-emr-header-1.cluster-xxxx.log`*).

  - For real-time index of Tranquility

    View the Tranquility log to check whether the message was received or dropped.

    The remaining troubleshooting steps are the same as two-five of batch index.

    Most of the errors are about cluster configurations and jobs. Cluster configuration errors are about memory parameters, cross-cluster connection, access to clusters in high-security mode, and principals. Job errors are about the format of the job description files, input data parsing, and other job-related configuration issues (such as ioConfig).

11.7.3 Ingestion Spec

This section briefly introduces Ingestion Spec, the description file of the index data.

Ingestion Spec is a unified description of the format of the data to be indexed and how that data format is indexed by Druid. It is a JSON file, which consists of three parts:

```
{
    "dataSchema" : {...},
    "ioConfig" : {...},
    "tuningConfig" : {...}
}
```

Key	Format	Description	Required
dataSchema	JSON object	Describes the schema information of the data you want to consume. dataSchema is fixed and does not change with the way in which data is consumed	Yes
ioConfig	JSON object	Describe the source and destination of the data you want to consume. If the consumption method of the data is different, ioConfig is also different.	Yes
tuningConfig	JSON object	Configure the parameters of the data you want to consume. If the consumption method of the data is different, the adjustable parameters are also different.	No

dataSchema

dataSchema describes the format of the data and how to parse the data. The typical structure is as follows:

```
{
    "dataSrouce": <name_of_dataSource>,
    "parser": {
        "type": <>,
        "parseSpec": {
            "format": <>,
            "timestampSpec": {},
            "dimensionsSpec": {}
        }
    },
    "metricsSpec": {},
```

```
    "granularitySpec": {}
}
```

Key	Format	Description	Required
dataSource	String	Name of the data source	Yes
parser	JSON object	How the data is parsed	Yes
metricsSpec	Array of JSON objects	Aggregator list	Yes
granularitySpec	JSON object	Data aggregation settings, such as creating segments and aggregation granularity	Yes

- **parser**

  parser determines how your data is parsed correctly. metricsSpec defines how the data is clustered for calculation. granularitySpec defines the granularity of the data fragmentation and the granularity of the query.

  For the parser, there are two types: string and hadoopstring. The latter is used for Hadoop index jobs. ParseSpec is a specific definition of data format resolution.

Key	Format	Description	Required
type	String	The data format can be "json", " jsonLowercase", "csv", or "tsv".	Yes
timestampSpec	JSON object	Timestamp and timestamp type	Yes
dimensionsSpec	JSON object	The dimension of the data (which columns are included)	Yes

  For different data formats, additional parseSpec options may exist. The following table describes timestampSpec and dimensionsSpec.

Key	Format	Description	Required
column	String	Columns corresponding to the timestamp	Yes
format	String	The timestamp type can be "ISO", "millis", "POSIX ", "auto", or that supported by *joda time*.	Yes

Key	Format	Description	Required
dimensions	JSON array	Describes which dimensions the data contains. Each dimension can be just a string. In addition, you can specify the attribute for the dimension. For example, the type of “dimensions”: [“dimenssion1”, “dimenssion2”, “{“type”: “long”, “ name”: “dimenssion3”}] is string by default.	Yes
dimensionExclusions	Array of JSON strings	Dimension to be deleted when data is consumed	No
spatialDimensions	Array of JSON objects	Spatial dimension	No

- **metricsSpec**

  MetricsSpec is an array of JSON objects. It defines several aggregators. Aggregators typically have the following structures:

````
```json
{
    "type": <type>,
    "name": <output_name>,
    "fieldName": <metric_name>
}
```
````

  The following commonly used aggregators are provided by the authority:

Type	Type optional
count	count
sum	longSum, doubleSum, floatSum
min/max	longMin/longMax, doubleMin/doubleMax, floatMin/floatMax
first/last	longFirst/longLast, doubleFirst/doubleLast, floatFirst/floatLast
javascript	javascript
cardinality	cardinality
hyperUnique	hyperUnique

Note:

The last three are the advanced aggregators. For information about how to use them, see *Druid official documents*.

- **granularitySpec**

  Two aggregation modes are supported: “uniform” and “arbitrary”. The uniform mode aggregates data with a fixed interval of time. The arbitrary mode tries to make sure that each of the segments has the same size, but the time interval for aggregation is not fixed. “Uniform” is the default option at present.

Key	Format	Description	Required
segmentGranularity	String	Segments granularity Uniform type	No, the default is “DAY”
queryGranularity	String	Minimum data aggregation granularity for query	No
rollup	Bool value	Aggregate or not	No, the default is “true”
intervals	String	Time interval of data consumption	It is Yes for batch and No for realtime.

ioConfig

ioConfig describes the data source. Here is an example of Hadoop index:

```
{
    "type": "hadoop",
    "inputSpec": {
        "type": "static",
        "paths": "hdfs://emr-header-1.cluster-6789:9000/druid/
quickstart/wikiticker-2015-09-16-sampled.json"
    }
}
```

This part is not required for streaming data that is processed through Tranquility.

Tunning Config

TuningConfig refers to some additional settings. For example, you can specify some MapReduce parameters to use Hadoop to create index for batch data. The contents of tunningConfig may vary based on the data source. For details about examples, see the example file or official document of this service.

11.7.4 Tranquility

Tranquility is an application that sends data to Druid in real-time in push mode. It solves many issues, such as multiple partitions, multiple copies, service discovery, and data loss. It simplifies the usage of Druid for users. It supports a wide range of data sources, including Samza, Spark, Storm, Kafka, and Fink. This section uses Kafka as an example, and describes how to use Tranquility in the EMR to capture data from the Kafka cluster and push the data to the Druid cluster in real time.

Interaction with the Kafka cluster

The first is the interaction between the Druid cluster and Kafka cluster. The interaction configuration of the two clusters is similar to that of the Hadoop cluster. You have to set the connectivity and hosts. For standard mode Kafka clusters, perform the following steps:

1. Ensure the communication between clusters. (The two clusters are in the same security group . Or each cluster is associated with a different security group, and access rules are configured for the two security groups.)
2. Write the hosts of the Kafka cluster to the hosts list of each node on the Druid cluster. Note that the hostname of the Kafka cluster should be in the form of a long name, such as emr-header-1 .cluster-xxxxxxxx.

For high-security mode Kafka clusters, you need to perform the following operations (the first two steps are the same as those for standard mode clusters):

1. Ensure the communication between the two clusters (The two clusters are in the same security group. Or each cluster is associated with a different security group, and access rules are configured for the two security groups).
2. Write the hosts of the Kafka cluster to the hosts list of each node on the Druid cluster. Note that the hostname of the Kafka cluster should be in the form of a long name, such as emr-header-1 .cluster-xxxxxxxx.
3. Set Kerberos cross-domain mutual trust between the two clusters. (For details, see *Cross-region access* here. The bidirectional mutual trust is preferred.
4. Prepare a client security configuration file:

```
KafkaClient {
      com.sun.security.auth.module.Krb5LoginModule required
      useKeyTab=true
      storeKey=true
      keyTab="/etc/ecm/druid-conf/druid.keytab"
      principal="druid@EMR. 1234. COM";
```

```
  };
```

Synchronize the configuration file to all nodes in the Druid cluster, and place it to a specific directory such as */tmp/kafka/kafka_client_jaas.conf*.

5. In overlord.jvm of the Druid configuration page:

```
Add Djava.security.auth.login.config=/tmp/kafka/kafka_client_jaas.
conf
```

.

6. Configure the following option in middleManager.runtime on the Druid configuration page: `druid.indexer.runner.javaOpts=-Djava.security.auth.login.confi=/tmp/kafka/kafka_client_jaas.conf` and other jvm startup parameters.
7. Restart the Druid service.

Use Tranquility Kafka

Because Tranquility is a service, it is a consumer for Kafka and a client for Druid. You can use a neutral machine to run Tranquility, as long as this machine is able to connect to the Kafka cluster and the Druid cluster simultaneously.

1. Create a topic named pageViews on the Kafka side.

```
--If the Kafka high-security mode is enabled:
 export KAFKA_OPTS="-Djava.security.auth.login.config=/etc/ecm/kafka
-conf/kafka_client_jaas.conf"
 --
 ./bin/kafka-topics.sh --create --zookeeper emr-header-1:2181,
emr-header-2:2181,emr-header-3:2181/kafka-1.0.1 --partitions 1 --
replication-factor 1 --topic pageViews
```

2. Download the Tranquility installation package and decompress it to a path.
3. Configure the dataSource.

It is assumed that your topic name is pageViews, and each topic is a JSON file.

```
{"time": "2018-05-23T11:59:43Z", "url": "/foo/bar", "user": "alice",
 "latencyMs": 32}
 {"time": "2018-05-23T11:59:44Z", "url": "/", "user": "bob", "
latencyMs": 11}
 {"time": "2018-05-23T11:59:45Z", "url": "/foo/bar", "user": "bob",
 "latencyMs": 45}
```

The configuration of the corresponding dataSource is as follows:

```
{
   "dataSources" : {
     "pageViews-kafka" : {
       "spec" : {
         "dataSchema" : {
```

```
            "dataSource" : "pageViews-kafka",
            "parser" : {
              "type" : "string",
              "parseSpec" : {
                "timestampSpec" : {
                  "column" : "time",
                  "format" : "auto"
                },
                "dimensionsSpec" : {
                  "dimensions" : ["url", "user"],
                  "dimensionExclusions" : [
                    "timestamp",
                    "value"
                  ]
                },
                "format" : "json"
              }
            },
            "granularitySpec" : {
              "type" : "uniform",
              "segmentGranularity" : "hour",
              "queryGranularity" : "none"
            },
            "metricsSpec" : [
              {"name": "views", "type": "count"},
              {"name": "latencyMs", "type": "doubleSum", "fieldName":
 "latencyMs"}
            ]
          },
          "ioConfig" : {
            "type" : "realtime"
          },
          "tuningConfig" : {
            "type" : "realtime",
            "maxRowsInMemory" : "100000",
            "intermediatePersistPeriod" : "PT10M",
            "windowPeriod" : "PT10M"
          }
        },
        "properties" : {
          "task.partitions" : "1",
          "task.replicants" : "1",
          "topicPattern" : "pageViews"
        }
      }
    },
    "properties" : {
      "zookeeper.connect" : "localhost",
      "druid.discovery.curator.path" : "/druid/discovery",
      "druid.selectors.indexing.serviceName" : "druid/overlord",
      "commit.periodMillis" : "15000",
      "consumer.numThreads" : "2",
      "kafka.zookeeper.connect" : "emr-header-1.cluster-500148518:
2181,emr-header-2.cluster-500148518:2181,   emr-header-3.cluster-
500148518:2181/kafka-1.0.1",
      "kafka.group.id" : "tranquility-kafka",
    }
```

```
}
```

4. Run the following command to start Tranquility.

```
./bin/tranquility kafka -configFile
```

5. Start the producer and configure it to send some data.

```
./bin/kafka-console-producer.sh --broker-list emr-worker-1:9092,emr-
worker-2:9092,emr-worker-3:9092 --topic pageViews
```

Enter the following codes:

```
{"time": "2018-05-24T09:26:12Z", "url": "/foo/bar", "user": "alice",
 "latencyMs": 32}
 {"time": "2018-05-24T09:26:13Z", "url": "/", "user": "bob", "
latencyMs": 11}
 {"time": "2018-05-24T09:26:14Z", "url": "/foo/bar", "user": "bob",
 "latencyMs": 45}
```

You can view specific information in Tranquility log. At the same time, the corresponding real-time indexing task has been started on the Druid side.

11.7.5 Kafka indexing service

Kafka indexing service is a plug-in launched by Druid to consume Kafka data in real time using druid's indexing service. The plug-in will enable a supervisor in Overlord. The supervisor starts some indexing tasks in Middlemanager after it starts. These tasks will connect to the Kafka cluster to consume the topic data and complete the index creation. You need to prepare a data consumption format file and manually start the supervisor through the REST API.

Interaction with the Kafka cluster

See the introduction in *Tranquility*.

Use Druid Kafka indexing service to consume Kafka data in real time

1. Run the following command on the Kafka cluster (or gateway) to create a topic named metrics.

```
--If the Kafka high-security mode is enabled:
 export KAFKA_OPTS="-Djava.security.auth.login.config=/etc/ecm/kafka
-conf/kafka_client_jaas.conf"
 --
 kafka-topics.sh --create --zookeeper emr-header-1:2181,emr-header-
2,emr-header-3/kafka-1.0.0 --partitions 1 --replication-factor 1 --
topic metrics
```

You can adjust the parameters based on your needs. The `/kafka-1.0.0` section of the **`--zookeeper`** parameter is path, and you can see the value of the zookeeper.connect on the

Kafka service **Configuration** page of the Kafka cluster. If you build your own Kafka cluster, the parmname **–`zookeeper`** parameter can be changed according to your actual configuration.

2. Define the data format description file for the data source. You can name it as metrics-kafka.json and place it in the current directory (or another directory that you specified).

```
{
     "type": "kafka",
     "dataSchema": {
         "dataSource": "metrics-kafka",
         "parser": {
             "type": "string",
             "parseSpec": {
                 "timestampSpec": {
                     "column": "time",
                     "format": "auto"
                 },
                 "dimensionsSpec": {
                     "dimensions": ["url", "user"]
                 },
                 "format": "json"
             }
         },
         "granularitySpec": {
             "type": "uniform",
             "segmentGranularity": "hour",
             "queryGranularity": "none"
         },
         "metricsSpec": [{
                 "type": "count",
                 "name": "views"
             },
             {
                 "name": "latencyMs",
                 "type": "doubleSum",
                 "fieldName": "latencyMs"
             }
         ]
     },
     "ioConfig": {
         "topic": "metrics",
         "consumerProperties": {
             "bootstrap.servers": "emr-worker-1.cluster-xxxxxxxx:
9092 (the bootstrap.servers of your Kafka clusters)",
             "group.id": "kafka-indexing-service",
             "security.protocol": "SASL_PLAINTEXT",
             "sasl.mechanism": "GSSAPI"
         },
         "taskCount": 1,
         replicas: 1
         "taskDuration": "PT1H"
     },
     "tuningConfig": {
         "type": "Kafka",
         "maxRowsInMemory": "100000"
     }
```

```
}
```

Note:

`ioConfig.consumerProperties.security.protocol` and **`ioConfig.consumerProperties.sasl.mechanism`** are security-related options (not required for standard mode Kafka clusters).

3. Run the following command to add a Kafka supervisor.

```
curl --negotiate -u:druid -b ~/cookies -c ~/cookies -XPOST -H '
Content-Type: application/json' -d @metrics-kafka.json http://emr-
header-1.cluster-1234:18090/druid/indexer/v1/supervisor
```

The options `–negotiate`, `-u`, `-b`, and `-c` are for high-security mode Druid clusters.

4. Enable a console producer on the Kafka cluster.

```
--If the high-security mode of Kafka is enabled:
 export KAFKA_OPTS="-Djava.security.auth.login.config=/etc/ecm/kafka
-conf/kafka_client_jaas.conf"
 echo -e "security.protocol=SASL_PLAINTEXT\nsasl.mechanism=GSSAPI"
 > /tmp/Kafka/producer.conf
 --
 Kafka-console-producer.sh --producer.config /tmp/kafka/producer.
conf --broker-list emr-worker-1:9092 , emr-worker-2:9092 , emr-worker-3
:9092 --topic metrics
 >
```

–`producer.config /tmp/Kafka/producer.conf` is an option for high-security mode Kafka clusters.

5. Enter some data at the command prompt of kafka_console_producer.

```
{"time": "2018-03-06T09:57:58Z", "url": "/foo/bar", "user": "alice",
 "latencyMs": 32}
 {"time": "2018-03-06T09:57:59Z", "url": "/", "user": "bob", "
latencyMs": 11}
 {"time": "2018-03-06T09:58:00Z", "url": "/foo/bar", "user": "bob",
 "latencyMs": 45}
```

The timestamp can be generated with the following Python command:

```
python -c 'import datetime; print(datetime.datetime.utcnow().
strftime("%Y-%m-%dT%H:%M:%SZ"))'
```

6. Prepare a query file named metrics-search.json.

```
{
     "queryType" : "search",
     "dataSource" : "metrics-kafka",
     "intervals" : ["2018-03-02T00:00:00.000/2018-03-08T00:00:00.000
"],
     "granularity" : "all",
     "searchDimensions": [
```

```
            "url",
            "user"
        ],
        "query": {
            "type": "insensitive_contains",
            "value": "bob"
        }
    }
```

7. Execute the query on the master node of Druid cluster.

```
curl --negotiate -u:Druid -b ~/cookies -c ~/cookies -XPOST -H '
Content-Type: application/json' -d @metrics-search.json http://emr-
header-1.cluster-1234:8082/druid/v2/?pretty
```

The options `—negotiate`, `-u`, `-b`, and `-c` are for high-security mode Druid clusters.

8. You will see a query result similar to the following in normal cases.

```
[ {
    "timestamp" : "2018-03-06T09:00:00.000Z",
    "result": {
      "dimension" : "user",
      "value" : "bob",
      "count": 2,
    } ]
  } ]
```

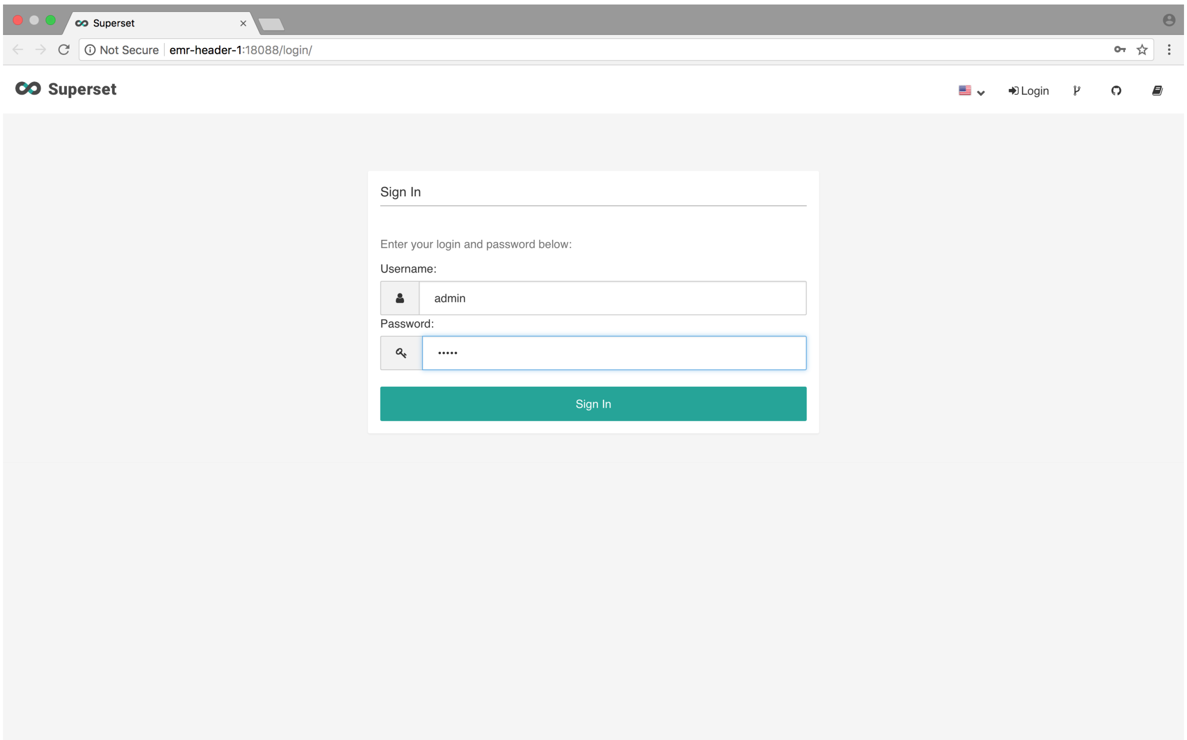
11.7.6 Superset

The Druid cluster integrates the Superset tool. Superset provides deep integration to Druid, and supports a variety of relational databases. Because Druid supports SQL, you can access Druid in two ways through Superset, that is, Druid native query language or SQL.

Superset is installed in emr-header-1 by default, and does not support high availability at present. Before you use this tool, make sure that your host can access emr-header-1. You can connect to the host by establishing the *SSH tunnel*.

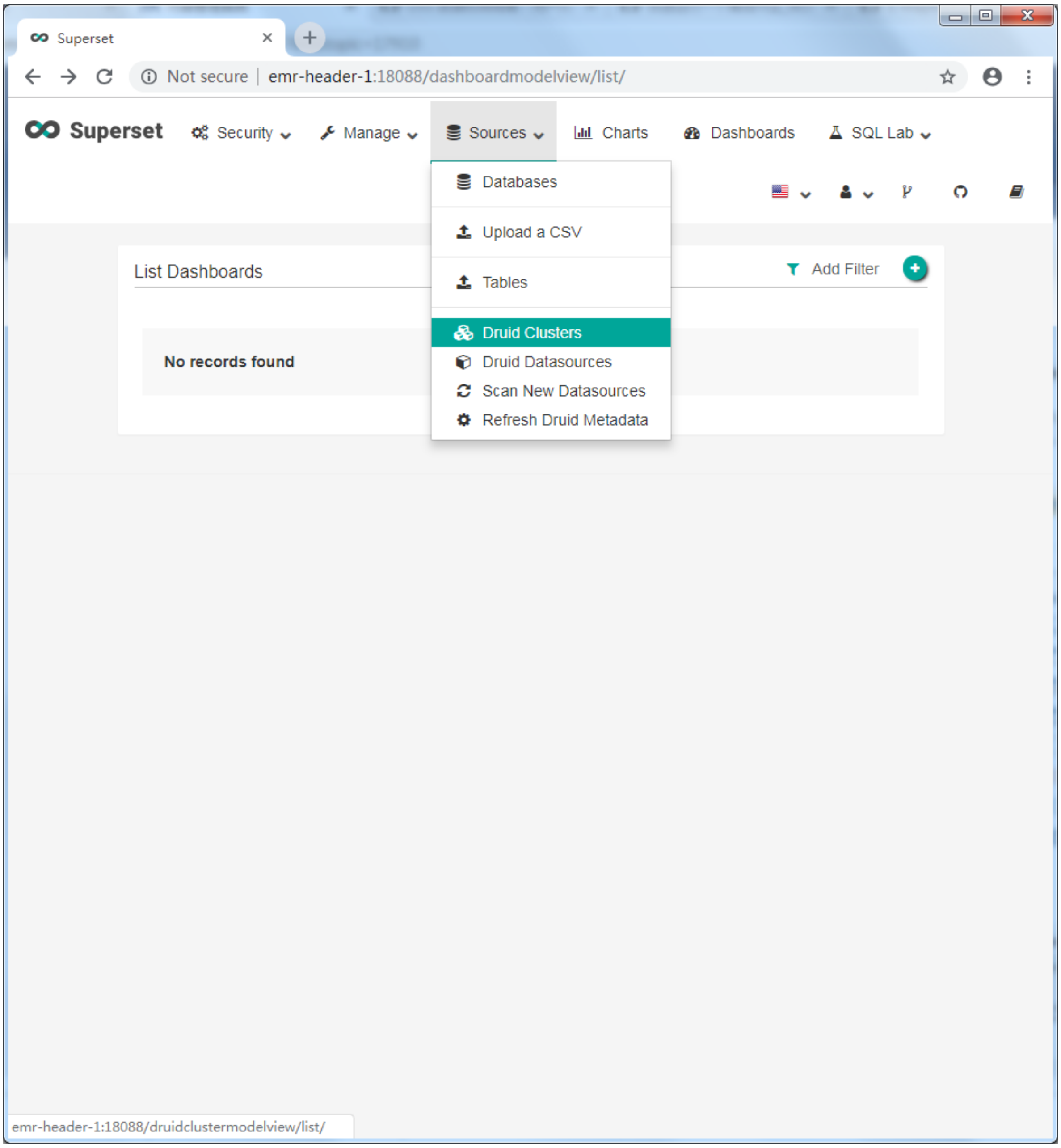
1. Log on to the Superset.

   Visit http://emr-header-1:18088 in the browser to enter the Superset logon page. The default username is admin, and the default password is admin. Change your password upon logon.

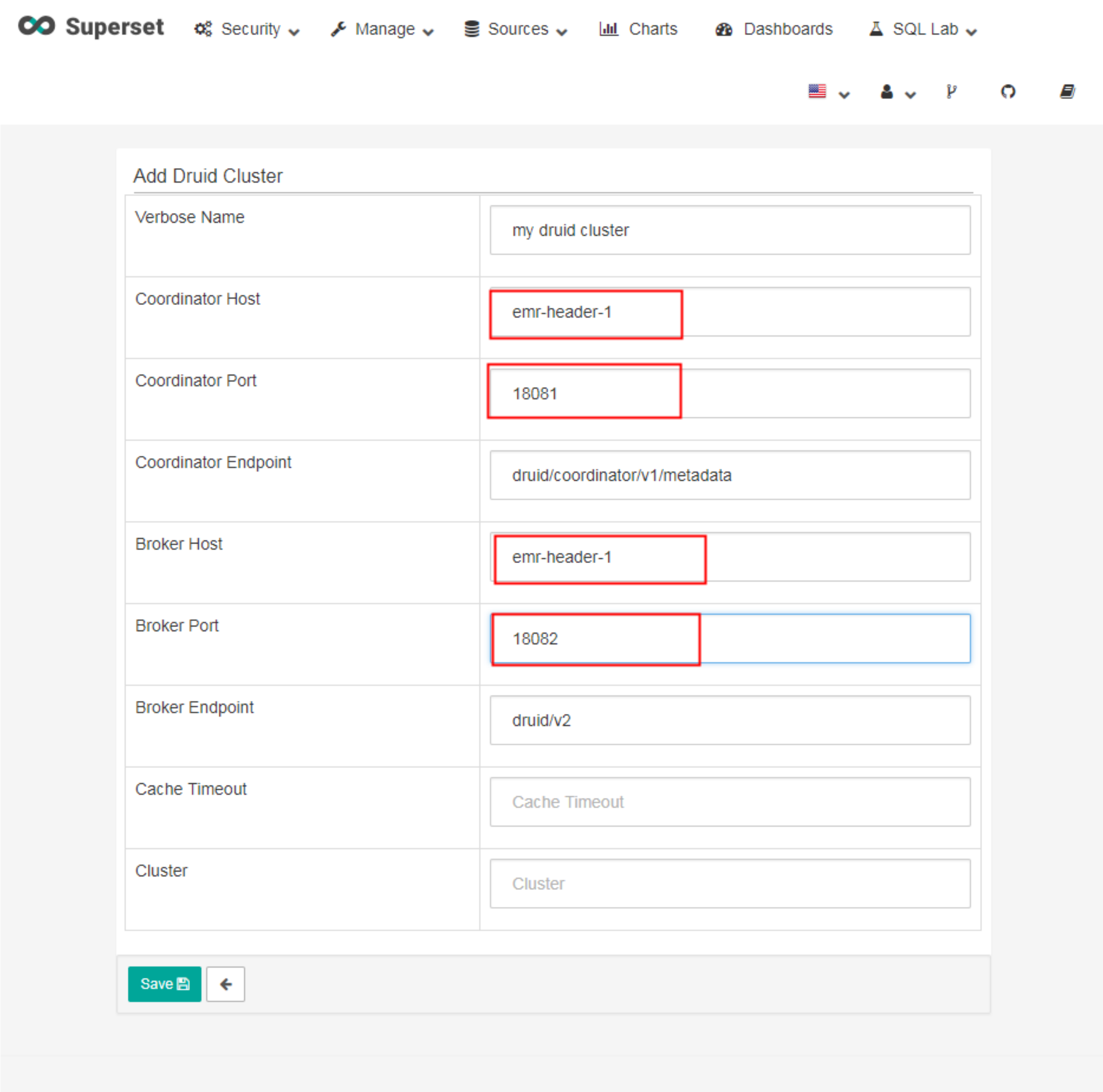


2. Add a Druid cluster.

The English interface is displayed by default. You can select the appropriate language by clicking the flag icon in the upper right corner. In the top menu bar, select **Data Source** > **Druid Cluster** to add a Druid cluster.



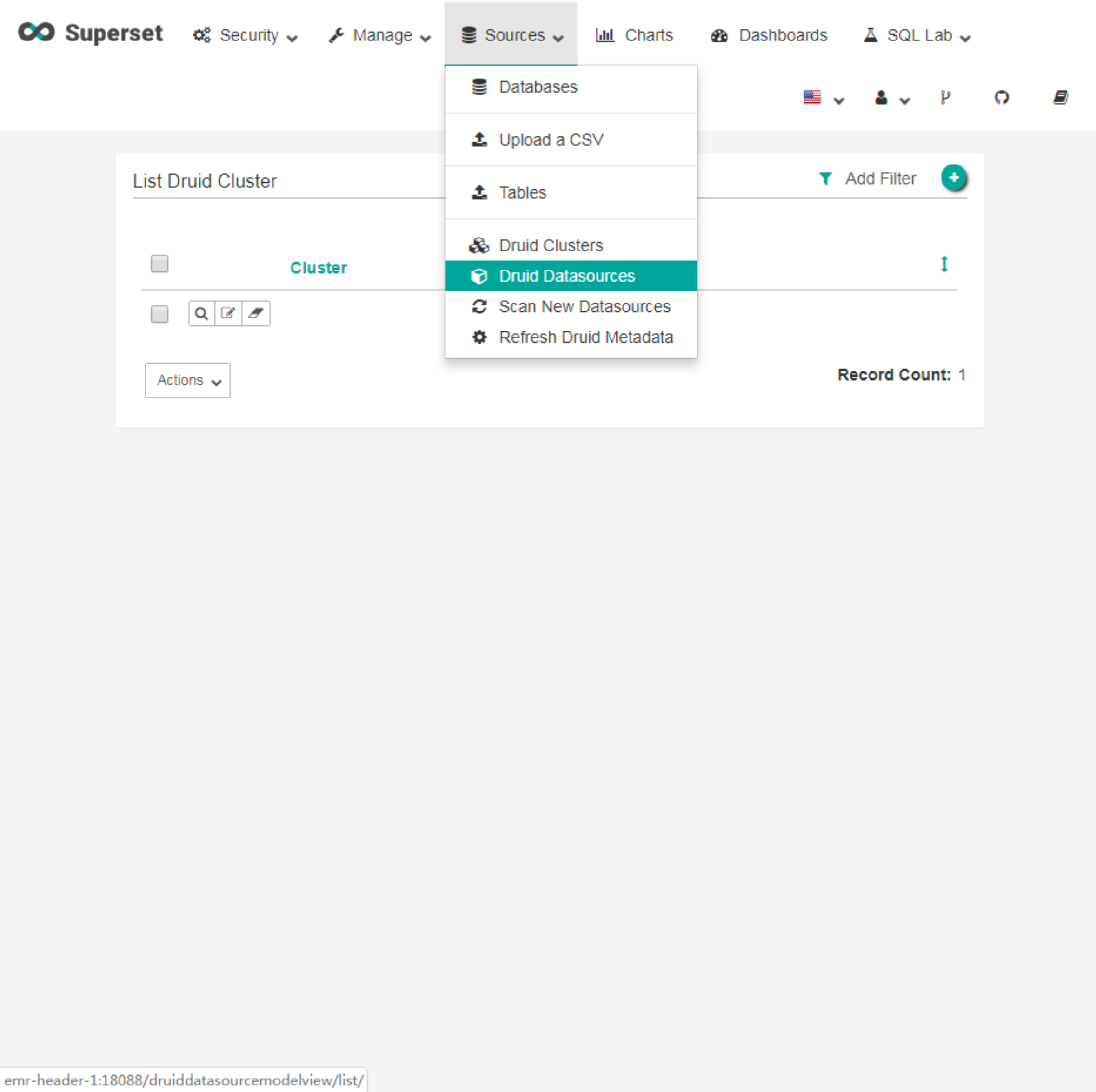
Configure the addresses of the coordinator and broker. The default port number in E-MapReduce is the corresponding open source port number with “1” added in front. For example , the open source broker port number is 8082, and the port number in E-MapReduce is port 18082.



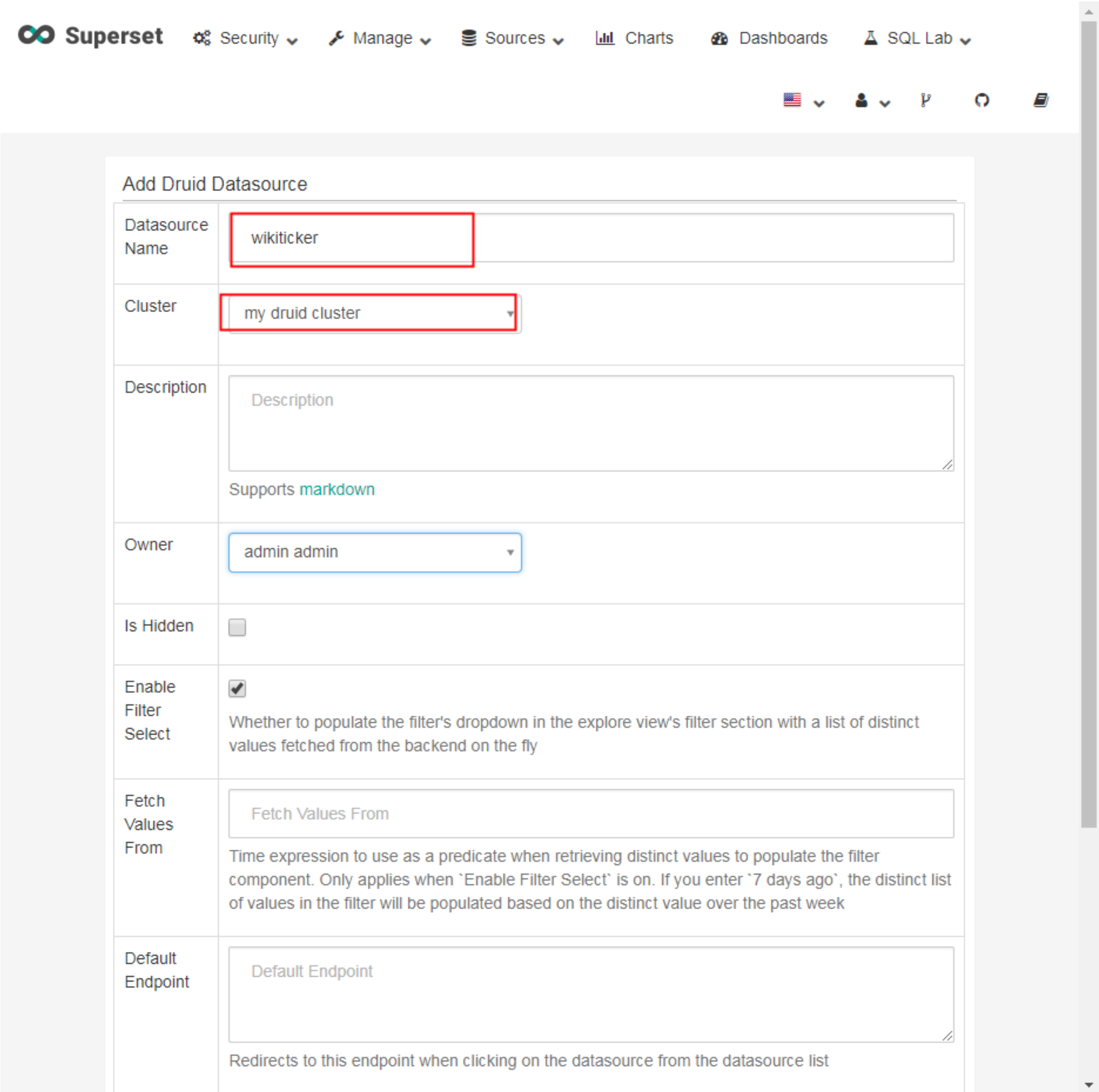
3. Refresh or add a new data source.

   After adding the Druid cluster, you can click **Data Source** > **Scan** for new data sources. The data sources on the Druid cluster can be automatically loaded.

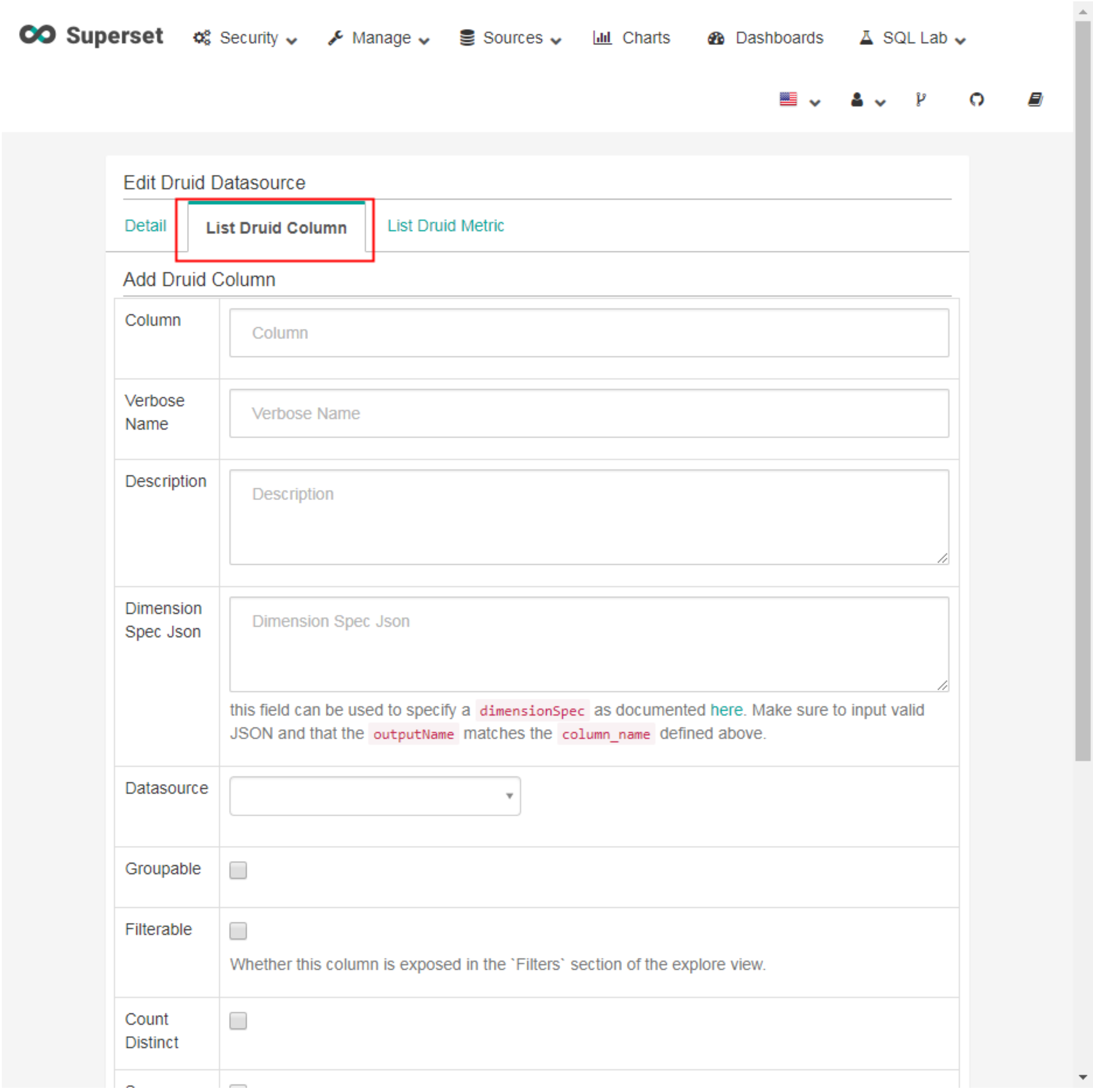
   You can also customize a new data source by clicking **Sources** > **Druid Datasources** on the interface. (The operation is equivalent to writing a JSON file for data source ingestion.)



You need to fill in necessary information for custom data source, and then save it.

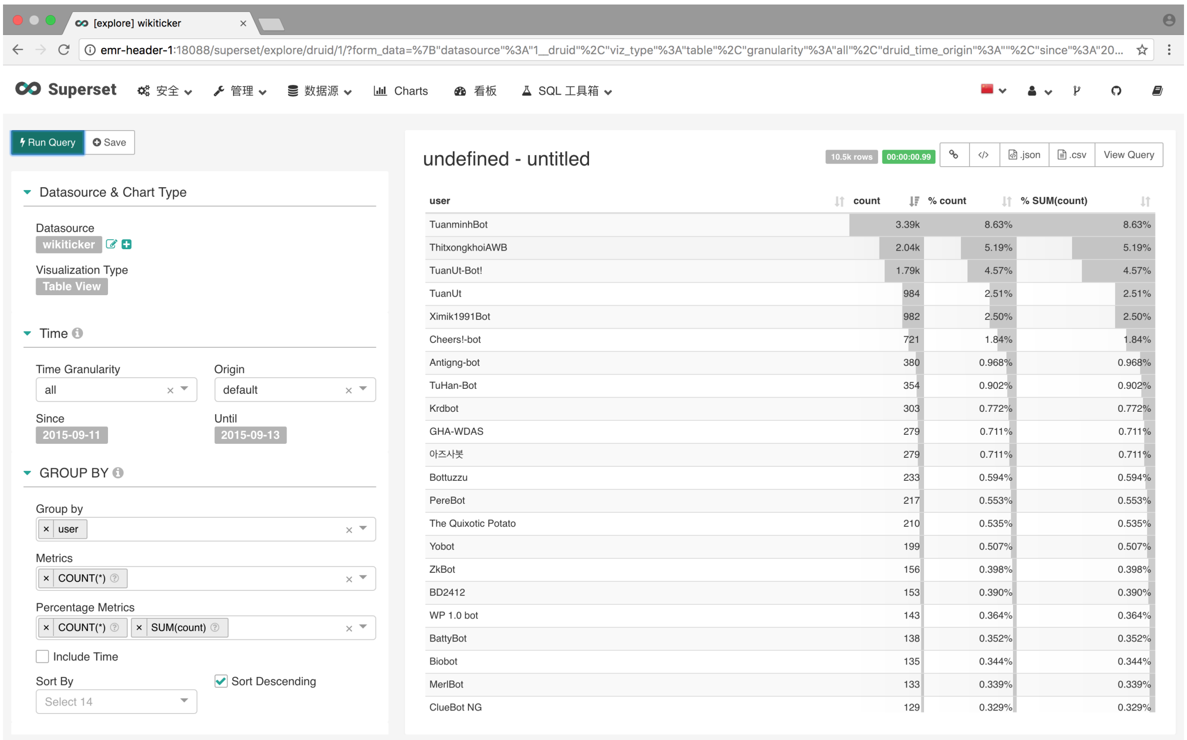


Click the second of the three small icons on the left side to edit the data source. Fill in the appropriate information, such as dimensions and metrics.



4. Query Druid.

After the data source has been added successfully, click the data source to go to the details page.

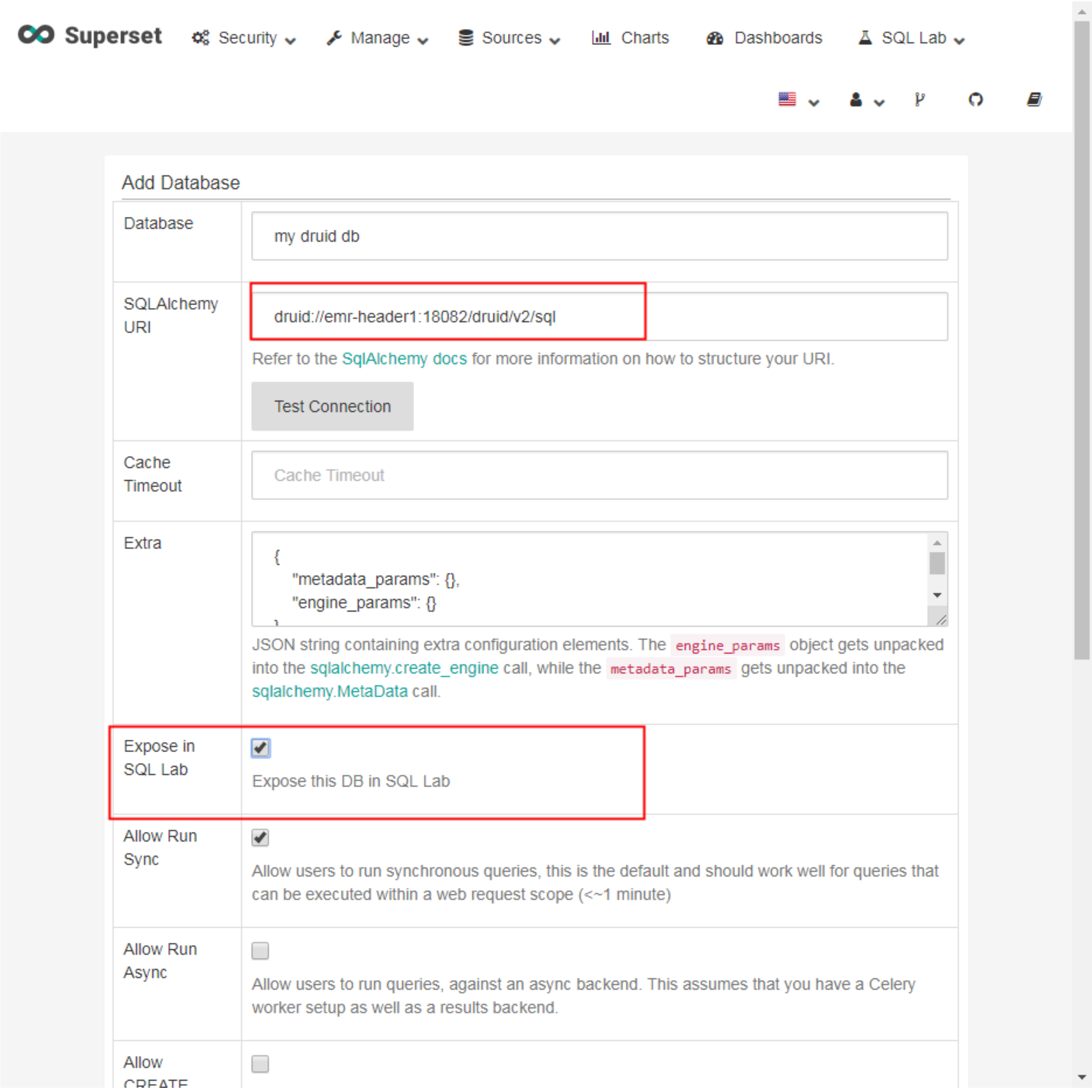


5. (Optional) Use Druid as a database.

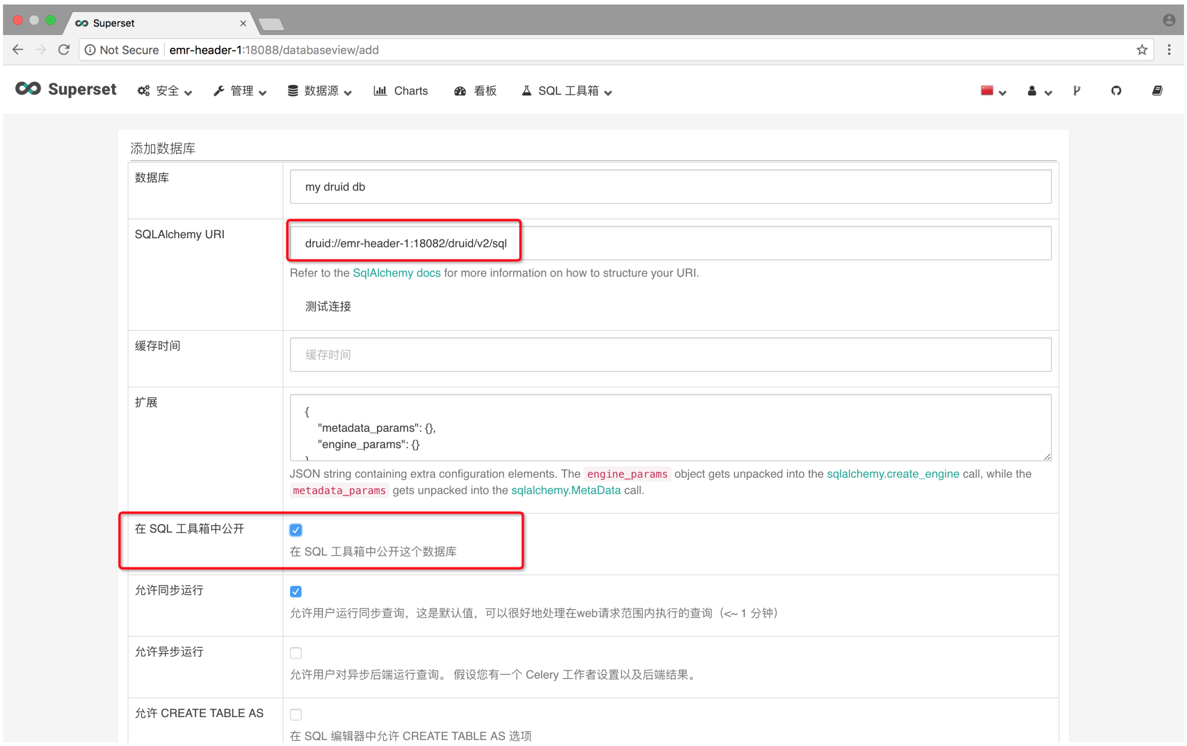
Superset provides SQLAlchemy to support a wide variety of databases with various dialects, as shown in the following figure.

database	pypi package	SQLAlchemy URI prefix
MySQL	`pip install mysqlclient`	`mysql://`
Postgres	`pip install psycopg2`	`postgresql+psycopg2://`
Presto	`pip install pyhive`	`presto://`
Oracle	`pip install cx_Oracle`	`oracle://`
sqlite		`sqlite://`
Redshift	`pip install sqlalchemy-redshift`	`redshift+psycopg2://`
MSSQL	`pip install pymssql`	`mssql://`
Impala	`pip install impyla`	`impala://`
SparkSQL	`pip install pyhive`	`jdbc+hive://`
Greenplum	`pip install psycopg2`	`postgresql+psycopg2://`
Athena	`pip install "PyAthenaJDBC>1.0.9"`	`awsathena+jdbc://`
Vertica	`pip install sqlalchemy-vertica-python`	`vertica+vertica_python://`
ClickHouse	`pip install sqlalchemy-clickhouse`	`clickhouse://`
Kylin	`pip install kylinpy`	`kylin://`

Superset also supports access to Druid in this way. The corresponding SQLAlchemy URI of Druid is “druid://emr-header-1:18082/druid/v2/sql”. When you add Druid as a database, check the Expose the database in the SQL toolkit check box.



Then you can use SQL to query in the SQL toolkit:



11.7.7 Druid common problems

This section describes Druid common problems you may meet

Analyze the indexing failure

When indexing fails, the following troubleshooting steps are typically followed:

- **For batch data index**

1. If curl returns an error directly, or no value returns, check the input file format. Or add a **-v** parameter to curl to observe the value returned from the REST API.
2. Observe the execution of the jobs on the Overlord page. If it fails, view the logs on the page.
3. In many cases, logs are not generated. If it is a Hadoop job, enter the Yarn page to see if there is an indexing job generated, and view the job execution log.
4. If no errors are found, you need to log on to the Druid cluster, and view the execution logs of Overlord (at *`/mnt/disk1/log/druid/overlord—emr-header-1.cluster-xxxx.log`*). If it is an HA cluster, check the Overlord that you submitted the job to.
5. If the job has been submitted to Middlemanager, but a failure is returned, you need to view the worker that the job is submitted to in Overlord, and log on to the worker node to view the Middlemanager logs in *`/mnt/disk1/log/druid/middleManager-emr-header-1.cluster-xxxx.log`*.

- For real-time Tranquility index

  Check the Tranquility logs to see if the message is received or dropped.

  The remaining troubleshooting steps are the same as 2-5 of batch data index.

  Most of the errors are cluster configuration issues and job problems. Cluster configuration errors are about memory parameters, cross-cluster connection, access to clusters in high-security mode, and principals. Job errors are about the format of the job description files, input data parsing, and other job-related configuration issues (such as ioConfig).

Obtain the FAQ list

- Service startup fails.

  Most of these problems are due to the configuration problems with the component JVM running parameters. For example, the machine may not have a large memory, but it is configured with a larger JVM memory or a larger number of threads.

  Solution: View the component logs and adjust the relevant parameters to resolve these issues. JVM memory involves heap memory and direct memory. For more information, see *http://druid.io/docs/latest/operations/performance-faq.html*.
- The Yarn task fails during the indexing process, and shows Jar package conflict error like this: `Error: class com.fasterxml.jackson.datatype.guava.deser.HostAndPortDeserializer overrides final method deserialize.( Lcom/fasterxml/jackson/core/JsonParser;Lcom/fasterxml/jackson/databind/DeserializationContext;)Ljava/lang/Object;`.

  Solution: Add the following content to the job configuration file of indexing:

```
"tuningConfig" : {
     ...
     "jobProperties" : {
         "mapreduce.job.classloader": "true"
         or
         "mapreduce.job.user.classpath.first": "true"
     }
     ...
 }
```

  The parameter **`mapreduce.job.classloader`** allows MapReduce job to use a standalone classloader, and the parameter **`mapreduce.job.user.classpath.first`** gives MapReduce the priority to use your jar packages. You can select one of these two configuration items. For details about this, see *http://druid.io/docs/0.9.2-rc1/operations/other-hadoop.html*.

- The logs of the index task report that the reduce task cannot create the segments directory.

  Solution:

  - Check the settings for deep storage, including type and directory. When the type is local , pay attention to the permission settings of directory. When the type is HDFS, directory should be written as the full HDFS path, such as hdfs://:9000/. For hdfs_master, IP is preferred. If you want to use a domain name, then use the full domain name, such as emr-header-1.cluster-xxxxxxxx rather than emr-header-1.
  - When you use Hadroop for batch index, you must set the deep storage of segments as "hdfs". The "local" type may cause the MR job to be in an unidentified state, because the remote Yarn cluster cannot create the segments directory in the reduce task.(This is for standalone Druid clusters.)
- Failed to create directory within 10000 attempts.

  This issue occurs typically because the path set by java.io.tmp in the JVM configuration file doesn't exist. Set the path and make sure that the Druid account has the permission to access it.
- com.twitter.finagle.NoBrokersAvailableException: No hosts are available for disco! firehose:druid:overlord

  This issue is typically due to ZooKeeper connection issues. Make sure that Druid and Tranquility have the same connection string for ZooKeeper. Because the default ZooKeeper path for Druid is /druid, make sure that zookeeper.connect in Tranquility settings includes /druid. (Two ZooKeeper settings exist in the Tranquility Kafka settings. One is zookeeper.connect used to connect the ZooKeeper of the Druid cluster, and the other is kafka.zookeeper.connect used to connect the ZooKeeper of the Kafka cluster. These two ZooKeepers may not belong to the same ZooKeeper cluster).
- The MiddleManager reports that the com.hadoop.compression.lzo.LzoCodec class cannot be found during the indexing process.

  This is because the Hadoop cluster of EMR is configured with lzo compression.

  Solution: Copy the jar package and the native file under the directory of EMR HADOOP_HOME/lib to druid.extensions.hadoopDependenciesDir (DRUID_HOME/hadoop-dependencies by default) of Druid.
- The following error is reported during the indexing process:

```
2018-02-01T09:00:32,647 ERROR [task-runner-0-priority-0] com.hadoop.
compression.lzo.GPLNativeCodeLoader - could not unpack the binaries
```

```
  java.io.IOException: No such file or directory
          at java.io.UnixFileSystem.createFileExclusively(Native
Method) ~[?:1.8.0_151]
          at java.io.File.createTempFile(File.java:2024) ~[?:1.8.
0_151]
          at java.io.File.createTempFile(File.java:2070) ~[?:1.8.
0_151]
          at com.hadoop.compression.lzo.GPLNativeCodeLoader.
unpackBinaries(GPLNativeCodeLoader.java:115) [hadoop-lzo-0.4.21-
SNAPSHOT.jar:?]
```

This issue occurs because the java.io.tmp path doesn't exist. Set the path and make sure that the Druid account has the permission to access it.

11.8 Presto

11.8.1 Connector

System connector

- Overview

  SQL can be used to query the basic information and measurements of the Presto cluster through the connector.

- Configuration

  All information can be obtained through a catalog known as system without configuration.

  Examples

```
--- List all supported data entries
SHOW SCHEMAS FROM system;
--- List all data entries in the project during runtime
SHOW TABLES FROM system.runtime;
--- Obtain node status
SELECT * FROM system.runtime.nodes;
     node_id |         http_uri         | node_version | coordinator
 | state
-------------+--------------------------+--------------
+-------------+--------
 3d7e8095-...| http://192.168.1.100:9090| 0.188        | false
 | active
 7868d742-...| http://192.168.1.101:9090| 0.188        | false
 | active
 7c51b0c1-...| http://192.168.1.102:9090| 0.188        | true
 | active
--- Force cancel a query
CALL system.runtime.kill_query('20151207_215727_00146_tx3nr');
```

- Data tables

  The connector provides the following data tables:

TABLE	SCHEMA	DESCRIPTION
catalogs	metadata	This table contains the list of all catalogs supported in the connector
schema_properties	metadata	This table contains the list of available properties that can be set when creating a Schema.
table_properties	metadata	This table contains the list of available properties that can be set when creating a table.
nodes	runtime	This table contains the list of all visible nodes and statuses thereof in the Presto cluster.
queries	runtime	This table contains information queries currently and recently initiated in the Presto cluster, including the original query texts (SQL), identities of the users who initiate the queries and information on query performances, for example, query queue and analysis time, etc.
tasks	runtime	This table contains information on the task involved in the queries in the Presto, including the locations and numbers of lines and bytes processed in each task.
transactions	runtime	This table contains the list of currently opened transactions and related metadata. The data includes information like creation time, idle time, initiation parameters, and access catalogs.

- Stored procedures

  The connector supports the following stored procedures:

  `runtime.kill_query(id)` Cancel query from specified ID.

JMX connector

- Overview

  JMX information for all nodes in the Presto cluster can be queried through the JMX connector. The connector is generally used for system monitoring and debugging. Regular dump of JMX information can be implemented through modifying the configuration of the connector.

- Configuration

Create a file *etc/catalog/jmx.properties*, add the following content, and enable JMX connector.

```
connector.name=jmx
```

If regular dump of JMX data is expected, the following content can be added in the configuration file:

```
connector.name=jmx
jmx.dump-tables=java.lang:type=Runtime,com.facebook.presto.execution
.scheduler:name=NodeScheduler
jmx.dump-period=10s
jmx.max-entries=86400
```

Where:

- **`dump-tables`** is a list of MBeans (Managed Beans) separated with commas. This configuration specifies which MBeans is sampled and stored in the memory for each sample period.
- **`dump-period`** is used for setting the sample period, which is 10s by default.
- **`max-entries`** is used for setting the max length of the history, which is 86400 by default.

If the name of a metric contains a comma, it must be escaped using `\,` as follows:

```
connector.name=jmx
jmx.dump-tables=com.facebook.presto.memory:type=memorypool\\,name=
general,\
   com.facebook.presto.memory:type=memorypool\\,name=system,\
   com.facebook.presto.memory:type=memorypool\\,name=reserved
```

• Data tables

JMX connector provides 2 schemas, **current** and **history**. Where:

current contains the current MBean in each node, the name of which is the table name in **current** (if the bean name contains non-standard characters, the table name must be in quotation marks for the query), which can be obtained through the following statement:

```
SHOW TABLES FROM jmx.current;
```

Examples

```
--- Obtain jvm information for each node
SELECT node, vmname, vmversion
FROM jmx.current."java.lang:type=runtime";
      node    |              vmname               | vmversion
--------------+-----------------------------------+-----------
 ddc4df17-xxx | Java HotSpot(TM) 64-Bit Server VM | 24.60-b09
```

```
(1 rows)
```

```
--- Obtain the metrics of max and min file descriptor counts for
each node
SELECT openfiledescriptorcount, maxfiledescriptorcount
FROM jmx.current."java.lang:type=operatingsystem";
 openfiledescriptorcount | maxfiledescriptorcount
-------------------------+------------------------
                     329 |                  10240
(1 rows)
```

history contains the data table corresponding to the metrics to be dumped in the configuration file. The following statement can be used to query:

```
SELECT "timestamp", "uptime" FROM jmx.history."java.lang:type=
runtime";
        timestamp        | uptime
-------------------------+--------
 2016-01-28 10:18:50.000 |  11420
 2016-01-28 10:19:00.000 |  21422
 2016-01-28 10:19:10.000 |  31412
(3 rows)
```

Kafka connector

- **Overview**

  The connector maps topic in Kafka to tables in Presto. Each record in Kafka is mapped to a message in Presto tables.

  Note:

  Since data in Kafka is dynamic, when Presto is used for multiple queries, something strange may sometimes occur. Currently, Presto is incapable of handling such cases.

- Configuration

  Create a file *etc/catalog/kafka.properties*, add the following content, and enable Kafka connector.

```
connector.name=kafka
kafka.table-names=table1,table2
kafka.nodes=host1:port,host2:port
```

  Note:

  Presto can connect to multiple Kafka cluster through adding a new properties file in the configuration catalog, and the file name is mapped to the Presto catalog. For example, when a configuration file *orders.properties* is added, Presto creates a catalog named orders.

```
## orders.properties
```

```
connector.name=kafka  # It denotes the connector type, which cannot
 be changed
kafka.table-names=tableA,tableB
kafka.nodes=host1:port,host2:port
```

Kafka connector provides the following properties:

- kafka.table-names

  Description: Required, it defines the list of tables supported in the connector.

  Details: The file name here can be modified using Schema name, with forms like *{schema_name}.{table_name}*. The file name also can be not modified using Schema name, and the table is mapped to the Schema defined in *kafka.default-schema* .
- kafka.default-schema

  Description: Optional，default Schema name, with the default value `default`.
- kafka.nodes

  Description: Required，the node list in the Kafka cluster.

  Details: the configuration form is like `hostname:port[,hostname:port…]`. You can configure only part of the Kafka nodes here, but Presto must be capable of connecting to all nodes in the Kafka cluster. Otherwise, a part of data may not be obtained.
- kafka.connect-timeout

  Description: Optional, timeout for the connector and the Kafka cluster, which is 10s by default.

  Details: If the pressure on the Kafka cluster is large, a long time may be taken for creating a connection, causing timeout when executing the query by Presto. At this time, adding the configured value is a better choice.
- kafka.buffer-size

  Description: Optional, read buffer size, which is 64 kb by default.

  Details: It is used to set the size of the buffer for internal data reads from Kafka. The data buffer must have a size larger than that of a message. A data buffer is distributed for each worker and data node.
- kafka.table-description-dir

  Description: [Optional]，the catalog of topic (table) description file, which is *etc/kafka* by default.

Details: Data table definition files in JSON format is stored in this directory (.json has to be used as a suffix).

- kafka.hide-internal-columns

  Description: Optional, the list of preset columns to be hidden, the value of which is `true` by default.

  Details: In addition to data columns defined in the table description file, the connector also maintains many extra columns for each table. The property is used to control whether these columns are shown in the execution result of the statement `DESCRIBE` and `SELECT *`. Regardless of the setting in the configuration, these columns are involved in the query process.

The Kafka connector provides internal columns as shown in the following table:

Column name	Type	Description
_partition_id	BIGINT	The ID of the Kafka partition where the record is located.
_partition_offset	BIGINT	The offset of the Kafka partition where the record is located.
_segment_start	BIGINT	The lowest offset containing this data segment. This offset is for each partition.
_segment_end	BIGINT	The largest offset containing this data segment (which is the start offset of the next segment). This offset is for each partition.
_segment_count	BIGINT	The serial number of the column in this segment. For an uncompressed topic, **`_segment_start`** + **`_segment_count`** = **`_partition_offset`**.
_message_corrupt	BOOLEAN	This field will be set to `TRUE` if a decoder cannot decode the record.
_message	VARCHAR	A string coded with UTF-8 from the message bytes. When the type of the topic message is text, the field will be useful.
_message_length	BIGINT	The byte length of the message.
_key_corrupt	BOOLEAN	This field will be set to `TRUE` if a key decoder cannot decode the record.

Column name	Type	Description
_key	VARCHAR	A string coded with UTF-8 from the key bytes. When the type of the topic message is text, the field will be useful.
_key_length	BIGINT	The byte length of the key.

Note:

For those tables without definition files, **`_key_corrupt`** and **`_message_corrupt`** remain FALSE.

- Table definition files

  Kafka is a Schema-Less message system, and the formats of the messages must defined by the producers and consumers. While Presto requires that data must be capable of being mapped into tables. Therefore, the users must provide corresponding table definition files according to the actual uses of the messages. For messages in JSON format, if a definition file is not provided, JSON functions in Presto can be used for resolution in the queries. While the method is flexible, it increases the difficulty of writing SQL statements.

  When JSON is used to define a table in a table definition file, the file name can be customized, while the extension must be *.json.

```
{
    "tableName": ...,
    "schemaName": ...,
    "topicName": ...,
    "key": {
        "dataFormat": ...,
        "fields": [
            ...
        ]
    },
    "message": {
        "dataFormat": ...,
        "fields": [
            ...
       ]
    }
}
```

Field	Optionality	Type	Description
tableName	required	string	Presto table name
schemaName	optional	string	the name of the Schema where the table is located

Field	Optionality	Type	Description
topicName	required	string	Kafka topic name
key	optional	JSON object	rules for mapping from message keys to columns
message	optional	JSON object	rules for mapping from messages to columns

In which, the mapping rules for keys and messages use the following fields for description.

Field	Optionality	Type	Description
dataFormat	required	string	A decoder for setting a group of columns
fields	required	JSON array	Column definition list

`fields` here is a JSON array, and each element is a JSON object as follows:

```
{
    "name": ...,
    "type": ...,
    "dataFormat": ...,
    "mapping": ...,
    "formatHint": ...,
    "hidden": ...,
    "comment": ...
}
```

Field	Optionality	Type	Description
name	required	string	column name
type	required	string	column data type
dataFormat	optional	string	column data decoder
mapping	optional	string	decoder parameters
formatHint	optional	string	hint set for the column, which can be used by the decoder
hiddent	optional	boolean	whether hidden or not
comment	optional	string	column description

- Decoder

  The function of the decoder is to map Kafka messages (key + message) to the columns in the data tables. Presto uses **dummy** decoder in the absence of table definition files.

Kafka connector provides the following decoders:

- raw: Original bytes are directly used without conversion.
- csv: Messages are processed as strings in CSV format.
- json: Messages are processed as strings in JSON format.

11.8.2 What is Presto

Presto is a distributed SQL-on-Hadoop analytics engine powered by Facebook. Presto is currently maintained by the open source community and Facebook engineers, and has derived multiple commercial versions.

Basic features

Presto is implemented in Java. It is easy-to-use, offers high-performance, strong expandability and other features include:

- Fully supports ANSI SQL.
- Supports rich data sources. Presto can access rich data sources as follows:
    - interaction with Hive data warehouse
    - Cassandra
    - Kafka
    - MongoDB
    - MySQL
    - PostgreSQL
    - SQL Server
    - Redis
    - Redshift
    - Local files
- Supports advanced data structures.
    - array and Map data
    - JSON data
    - GIS data
    - color data
- Strong expandability. Presto provides multiple expansion configurations.
    - Data connector expansion

    - Custom data types
    - Custom SQL functions

    Users can expand the corresponding modules according to their own service features to achieve efficient service processes.

- Based on the Pipeline process model, data is returned to users in real time during the process.
- Improved monitoring interfaces.
    - Friendly WebUI is provided to present the execution processes of the query tasks visually.
    - Supports JMX protocol.

Scenarios

Presto is a distributed SQL engine located in data warehouse and data analytics services and is well suited to the following scenarios:

- ETL
- Ad-Hoc query
- Massive structured and semi-structured data analysis
- Massive multi-dimensional data aggregation/reports

In particular, Presto is a data warehouse product, which is not designed to replace traditional RDBMS databases such as MySQL and PostgreSQL. It has limited support for transactions and is not suitable for online service scenarios.

Benefits

In addition to the advantages of open source, the EMR Presto product comes with the following advantages:

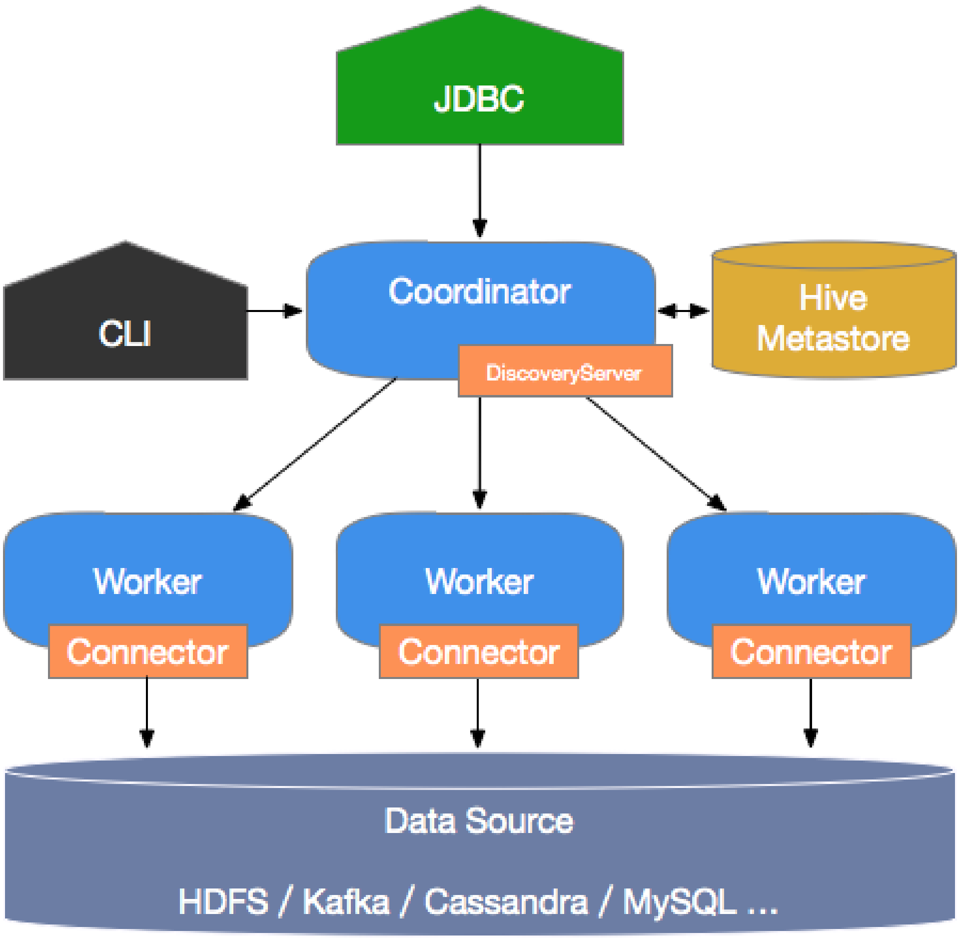
- You can purchase it for immediate use to build a Presto cluster with hundreds of nodes in minutes.
- It supports elastic resizing, you can complete up and down resizing of the cluster with simple operations.
- It works perfect in connection with the EMR software stacks, and supports processing of data stored in OSS.
- O&M free 24x7 all-in-one service.

11.8.3 Quick start with Presto

This article describes the basic usage and application development methods of the Presto database for developers to quickly start application development using Presto database.

System structure

Presto's system structure is shown in the following figure:



Presto is a typical M/S architecture system, comprising a Coordinator node and multiple Worker nodes. Coordinator is responsible for the following:

- Receiving and parsing users' query requests, generating execution plans, and sending the execution plans to the Worker nodes for execution.
- Monitoring the running status of the Worker nodes. Each Worker node maintains heartbeat connection with the Coordinator node, reporting the node statuses.
- Maintaining the MetaStore data

Worker nodes run the tasks assigned by the Coordinator node, read data from external storage systems through connectors, process the data, and send the results to the Coordinator node.

Basic concepts

This section describes the basic Presto concepts for a better understanding of the Presto work mechanism.

- Data model

  Data model indicates to the data organization form. Presto uses a three-level structure, namely Catalog, Schema, and Table, to manage data.

  - Catalog

    A Catalog contains multiple Schemas, and is physically directed to an external data source, which can be accessed through Connectors. When you run a SQL statement in Presto, you are running it against one or more Catalogs.

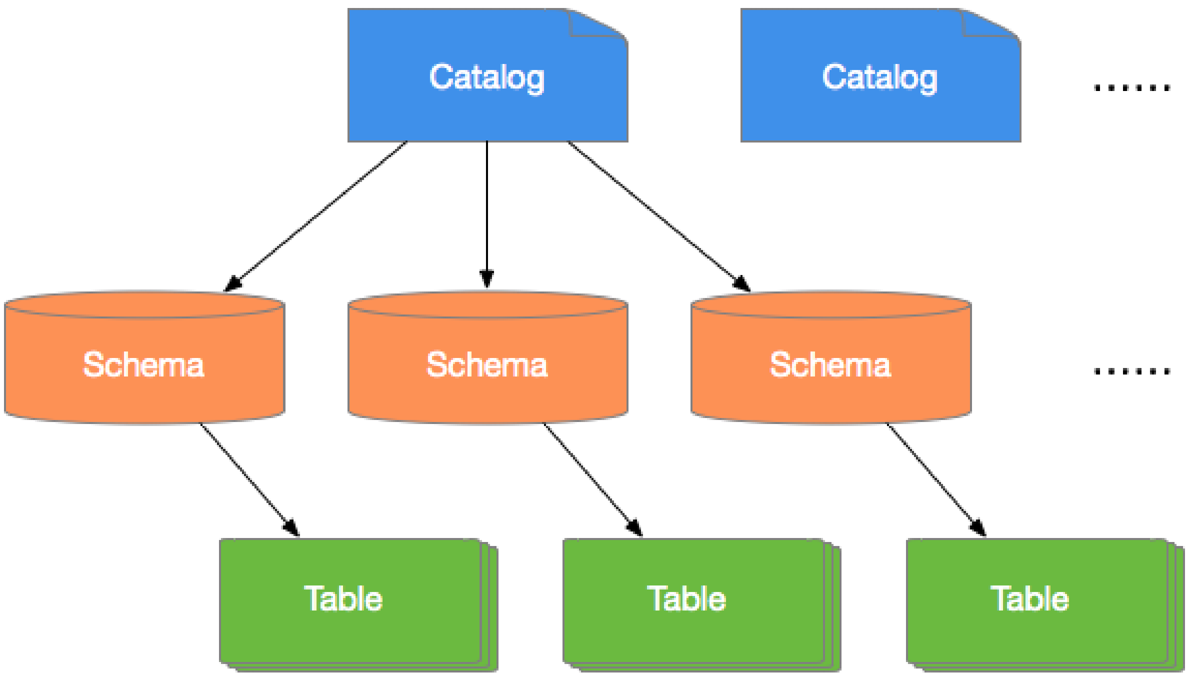
  - Schema

    You can take a Schema as a database instance, which contains multiple data tables.

  - Table

    Data table, which is the same as general database tables.

  Relations among Catalog, Schema, and Table are shown in the following figure.



- Connector

Presto uses Connector to connect to various external data sources. Presto provides a standard *SPI*, which allows users to develop their own Connectors using this standard API, to access customized data sources.

Generally, a Catalog is associated with a specific Connector (which can be configured in the Properties file of the Catalog). Presto contains multiple built-in Connectors. For more informatio n, see Connectors.

- Query-related concepts

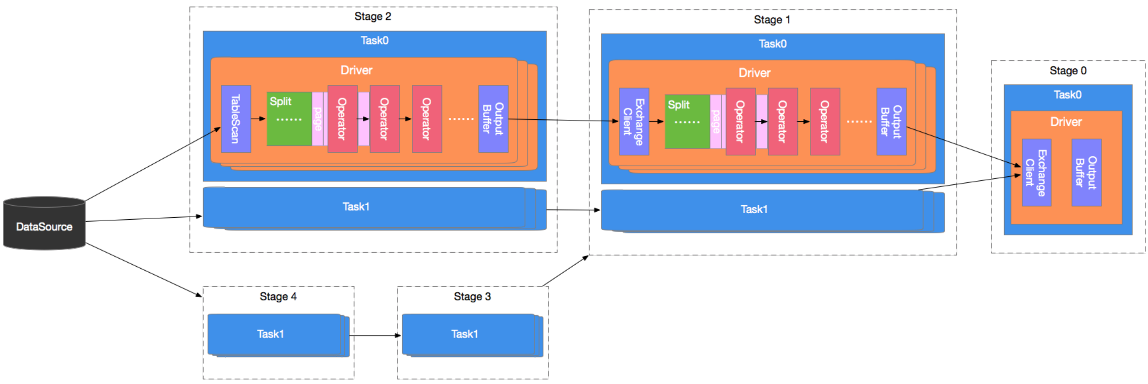
  This section mainly describes related concepts in the Presto query process, for users to understand better, the execution process of Presto statements and the performance optimizati on methods.

  - Statement

    Statement refers to an SQL statement entered by a user via JDBC or CLI.

  - Query

    Query refers to the execution process of a query. When Presto receives an SQL Statement, the Coordinator parses this statement, generates an execution plan, and sends this plan to a Worker for execution. A Query is logically made up by several components, namely Stage, Task, Driver, Split, Operator, and DataSource, which are shown in the following figure:



  - Stage

    A Presto query contains multiple Stages. Stage is a logical concept, which indicates a stage of the query process, comprising one or more execution tasks. Presto uses a tree structure to organize Stages, the root node of which is Single Stage. This Stage aggregates data output from the upstream Stages, and directly sends the results to Coordinator. The leaf node of this tree is Source Stage. The Source Stage receives data from Connector for processing.

- Task

  Task refers to a specific task to be executed, and it is the smallest Presto task scheduling unit. During the execution process, Presto task scheduler distributes these tasks to individual Workers for execution. Tasks in one Stage can be executed in parallel. Tasks in two different Stages transmits data via the Exchange module. `Task` is also a logical concept that contains the parameters and contents of the task, the actual task execution is done by the driver.
- Driver

  Driver is responsible for executing the specific tasks. A Task may contain multiple Driver instances, to achieve parallel processing within the same Task. Each Driver processes a Split. A Driver is made up by a set of Operators, and is responsible for specific data operations, such as conversion and filtering.
- Operator

  The Operator is the smallest execution unit, and is responsible for processing each Page of a Split, such as weighting and conversion. It is similar to logical operators in concept. Page is a column-based data structure, and is the smallest data unit that an Operator can process. A Page object constitutes of multiple Blocks, with each Block representing multiple data rows of a field. A Page can be of a maximum of 1 MB, and can contain data of up to 16 x 1024 rows.
- Exchange

  Two Stages exchange data through the Exchange module. The data transmission process is actually is completed between two Tasks. Generally, a downstream Task fetches data from the Output Buffer of an upstream Task using an Exchange Client. The fetched data is then transmitted to Driver in Splits for processing.

The command line tool

The command line tool uses *SSH to log on to an EMR cluster*, and executes the following command to enter the Presto console:

```
$ presto --server emr-header-1:9090 --catalog hive --schema default --
user hadoop
```

High-security clusters use the following command form:

```
$ presto  --server https://emr-header-1:7778  \
          --enable-authentication \
          --krb5-config-path /etc/krb5.conf \
```

```
          --krb5-keytab-path  /etc/ecm/presto-conf/presto.keytab \
          --krb5-remote-service-name presto \
          --keystore-path /etc/ecm/presto-conf/keystore \
          --keystore-password 81ba14ce6084 \
          --catalog hive --schema default \
          --krb5-principal  presto/emr-header-1.cluster-XXXX@EMR.XXXX.
COM
```

- *XXXX* are numbers as the ecm id of clusters that can be obtained through *cat /etc/hosts* .
- *81ba14ce6084* is the default password of */etc/ecm/presto-conf/keystore* . It is recommended that you use your own keystore after the deployment.

You can execute the following command from the console:

```
Presto: Default> show schemas;
    schema.
--------------------
default
Hive
information_schema
tpch_100gb_orc
tpch_10gb_orc
tpch_10tb_orc
tpch_1tb_orc
(7 rows)
```

We can execute the **presto --help** command to obtain help from the console. The parameters and definitions are as follows:

```
--server <server>                      # Specifies the URI of a
Coordinator
--user <user>                          # Sets the username
--catalog <catalog>                    # Specifies the default
Catalog
--schema <schema>                      # Specifies the default Schema
--execute <execute>                    # Executes a statement and
then exits
-f <file>, --file <file>               # Executes an SQL statement
and then exits
--debug                                # Shows debugging information
--client-request-timeout <timeout>     # Specifies the client timeout
 value, which is 2 minutes by default
--enable-authentication                # Enables client authentica
tion
--keystore-password <keystore password> # KeyStore password
--keystore-path <keystore path>        # KeyStore path
--krb5-config-path <krb5 config path>  # Kerberos configuration file
path (default: /etc/krb5.conf)
--krb5-credential-cache-path <path>    # Kerberos credential cache
path
--krb5-keytab-path <krb5 keytab path>  # Kerberos Key table path
--krb5-principal <krb5 principal>      # Kerberos principal to be
used
--krb5-remote-service-name <name>      # Remote Kerberos node name
--log-levels-file <log levels>         # Configuration file path for
debugging logs
```

```
--output-format <output-format>          # Bulk export data format,
which is CSV by default
--session <session>                      # Specifies the session
attribute, in the format key=value
--socks-proxy <socks-proxy>              # Sets the proxy server
--source <source>                        # Sets query source
--version                                # Shows version info
-h, --help                               # Shows help info
```

Uses JDBC

Java applications can access databases using the JDBC driver provided by Presto. The usage is basically the same as that of the general RDBMS databases.

- Introduction into Maven

  You can add the following configuration into the pom file to introduce Presto JDBC driver:

```
<dependency>
    <groupId>com.facebook.presto</groupId>
    <artifactId>presto-jdbc</artifactId>
    <version>0.187</version>
</dependency>
```

- Driver class name

  Presto JDBC driver class is `com.facebook.presto.jdbc.PrestoDriver`.

- Connection string

  The following connection string format is supported.

```
jdbc:presto://<COORDINATOR>:<PORT>/[CATALOG]/[SCHEMA]
```

  For example:

```
jdbc:presto://emr-header-1:9090               # Connects to data
base, using the default Catalog and Schema
jdbc:presto://emr-header-1:9090/hive          # Connects to data
base, using Catalog(hive) and the default Schema
jdbc:presto://emr-header-1:9090/hive/default  # Connects to data
base, using Catalog(hive) and Schema(default)
```

- Connection parameters

  Presto JDBC driver supports various parameters that may be set as URL parameters or as **`properties`** passed to DriverManager. Both of the following examples are equivalent:

  Example for passing to DriverManager as **`Properties`** :

```
String url = "jdbc:presto://emr-header-1:9090/hive/default";
Properties properties = new Properties();
properties.setProperty("user", "hadoop");
Connection connection = DriverManager.getConnection(url, properties
);
```

```
......
```

Example for passing to DriverManager as URL parameters:

```
String url = "jdbc:presto://emr-header-1:9090/hive/default? user=
hadoop";
Connection connection = DriverManager.getConnection(url);
......
```

The parameters are described as follows:

Parameter Name	Format	Description
user	STRING	User Name
password	STRING	Password
Socksproxy	\:\	SOCKS proxy server address and port. Example: localhost:1080
httpProxy	\:\	HTTP proxy server address and port. Example: localhost:8888
SSL	true\	Whether or not to use HTTPS for connections . Defaults to false.
SSLTrustStorePath	STRING	Java TrustStore file path
SSLTrustStorePassword	STRING	Java TrustStore password
KerberosRemoteServiceName	STRING	Kerberos service name
KerberosPrincipal	STRING	Kerberos principal
KerberosUseCanonicalHostname	true\	Whether or not to use the canonical hostname. Defaults to false.
KerberosConfigPath	STRING	Kerberos configuration file path
KerberosKeytabPath	STRING	Kerberos KeyTab file path
KerberosCredentialCachePath	STRING	Kerberos credential cache path

- Java example:

  The following is an example of using Presto JDBC driver with Java.

```
.....
// Loads the JDBC Driver class
try {
    Class.forName("com.facebook.presto.jdbc.PrestoDriver");
} catch(ClassNotFoundException e) {
    LOG.ERROR("Failed to load presto jdbc driver.", e);
    System.exit(-1);
```

```
}
Connection connection = null;
Statement stmt = null;
try {
    String url = "jdbc:presto://emr-header-1:9090/hive/default";
    Properties properties = new Properties();
    properties.setProperty("user", "hadoop");
    // Creates the connection object
    Connection = drivermanager. getconnection (URL, properties );
    // Creates the Statement object
    statement = connection.createStatement();
    Executes the query
    ResultSet rs = statement.executeQuery("select * from t1");
    Returns results
    int columnNum = rs.getMetaData().getColumnCount();
    int rowIndex = 0;
    while (rs.next()) {
        rowIndex++;
        for(int i = 1; i <= columnNum; i++) {
            System.out.println("Row " + rowIndex + ", Column " + i +
 ": " + rs.getInt(i));
        }
    }
} catch(SQLException e) {
    LOG.ERROR("Exception thrown.", e);
} finally {
  // Destroys Statement object
  If (statement! = null) {
      try {
        statement.close();
    } catch(Throwable t) {
        // No-ops
    }
  }
  Closes connection
  if (connection ! = null) {
      try {
        connection.close();
    } catch(Throwable t) {
        // No-ops
    }
  }
}
```

11.8.4 Data type

Presto supports multiple common data types by default, such as Boolean, Integer, Floating-Point, String, and Date and Time. You can also add customized data types using plugins. Additionally, the customized Presto connectors are not required to support all data types.

Data types

Presto has a set of built-in data types that are as follows:

- BOOLEAN

  Represents two option with a value of true or false.

- TINYINT

  An 8-bit signed *two's complement integer*.
- SMALLINT

  A 16-bit signed *two's complement integer*.
- INTEGER

  A 32-bit signed *two's complement integer*.
- BIGINT

  A 64-bit signed *two's complement integer*.
- REAL

  A real is a 32-bit inexact, variable-precision implementing the *IEEE Standard 754* for Binary Floating-Point Arithmetic.
- DOUBLE

  A 64-bit multi-precision *[IEEE-754]* binary floating-point numeric implementation.
- DECIMAL A fixed precision decimal number. Precision up to 38 digits is supported but performance is best up to 17 digits. It takes two literal parameters to define the DECIMAL type :
  - precision: total number of digits, excluding symbols
  - scale: number of digits in fractional part. Scale is optional and defaults to 0.

    Example: `DECIMAL '-10.7'` can be expressed with `DECIMAL(3,1)` type.

  The following table describes the bits and value range of the integer type

Value Type	Bits	Minimum Value	Maximum Value
TINYINT	8 bit	-2^7	2^7 - 1
SMALLINT	16 bit	2^15	2^15 - 1
INTEGER	32 bit	-2^31	-2^31 - 1
BIGINT	64 bit	-2^63	-2^63 - 1

String type

Presto supports the following built-in string types:

- VARCHAR

  Variable length character data with an optional maximum length.

Example: `VARCHAR`, and `VARCHAR(10)`

- CHAR

  Fixed length character data. A CHAR type without length specified has a default length of 1.

  Example: `CHAR`, and `CHAR(10)`

  Note:
  A string with the specified length always has the number of characters equal to this length. Where the string length is smaller than the specified length, leading and trailing spaces are included in comparisons of the string value. As a result, two character values of different lengths can never be equal.

- VARBINARY

  indicates variable length binary data.

Date and time

Presto supports the following built-in date and time types:

- DATE

  Refers to a calendar date (year, month, day) without time.

  Example: `DATE '1988-01-30'`

- TIME

  Refers to a time, including hour, minute, second, and millisecond. Values of this type can be rendered in the time zone.

  Example:

  - `TIME '18:01:02.345'`, does not have a time zone definition, and is thus parsed using the system time zone.
  - `TIME '18:01:02.345 Asia/Shanghai'`, has time zone definition, and is thus parsed using the defined time zone.

- TIMESTAMP

  Refers to an instant in time that includes the date and time of day. The value range is from `'1970-01-01 00:00:01' UTC` to `'2038-01-19 03:14:07' UTC`, which can be rendered in the time zone.

Example:`TIMESTAMP '1988-01-30 01:02:03.321'` , `TIMESTAMP '1988-01-30 01:02:03.321 Asia/Shanghai'`

- INTERVAL

  Mainly used in time calculated expressions to refer to a time span, the unit of which can be:

  - YEAR - Year
  - QUARTER - Quarter of a year
  - MONTH - Month
  - DAY - Day
  - HOUR - Hour
  - MINUTE - Minute
  - SECOND - Second
  - MILLISECOND - Millisecond

    Example: `DATE '2012-08-08' + INTERVAL '2' DAY`

Complex types

Presto supports multiple complex built-in data types, to support more complex business scenarios , and these data types include:

- JSON

  JSON value type, which can be a JSON object, a JSON array, a JSON number, a JSON string , as well as the boolean type true, false or null.

  Example:

  - `JSON '[1, null, 1988]'`
  - `JSON '{"K1": 1, "K2": "ABC "}'`
- ARRAY

  An array of the given component type. Types of elements in an array must be consistent.

  Example: `ARRAY[1, 2, 3]`
- MAP

  Represents a mapping relationship consisting of a key array and a value array.

  Example: `MAP(ARRAY['foo', 'bar'], ARRAY[1, 2])`
- ROW

A structure made up of named fields. The fields may be accessed with field reference operator `.` and the field names. Operator + the method of column names to access data columns.

Example: `CAST(ROW(1988, 1.0, 30) AS ROW(y BIGINT, m DOUBLE, d TINYINT ))`

- IPADDRESS

  An IP address that can represent either an IPv4 or IPv6 address. An IP address that can represent either an IPv4 or IPv6 address. Internally, the type is a pure IPv6 address. Support for IPv4 is handled using the *IPv4-mapped IPv6 address range*.

  Example:`IPADDRESS '0.0.0.0'` , `IPADDRESS '2001:db8::1'`

11.8.5 Common functions and operators

This article describes common Presto functions and operators.

Logical operators

Presto supports AND, OR, and NOT logical operators, and supports NULL in logical computation.

For example:

```
SELECT CAST(null as boolean) AND true; --- null
SELECT CAST(null AS boolean) AND false; -- false
SELECT CAST(null AS boolean) AND CAST(null AS boolean); -- null
SELECT NOT CAST(null AS boolean); -- null
```

A complete truth table is shown as follows:

a	b	a AND b	A or B
TRUE	TRUE	TRUE	TRUE
TRUE	FALSE	FALSE	TRUE
TRUE	NULL	NULL	TRUE
FALSE	TRUE	FALSE	TRUE
FALSE	FALSE	FALSE	FALSE
FALSE	NULL	FALSE	NULL
NULL	TRUE	NULL	TRUE
NULL	FALSE	FALSE	NULL
NULL	FALSE	NULL	NULL

Additionally, the result of NOT FALSE is TRUE, the result of NOT TRUE is FALSE, and the result of NOT NULL is NULL. For more information about the NOT operator, see *NOT operator*.

Comparison functions and operators

- Comparison operators:

  Comparison operations supported by Presto are as follows:

Operator	Description
<	Less than
>	Greater than
<=	Less than or equal to
>=	Greater than or equal to
=	Equal to
<>/**! =**	Not equal to
[NOT] BETWEEN	Value X is [not] between the min and the max values
IS [NOT] NULL	Tests whether a value is NULL
IS [NOT] DISTINCT FROM	Determines if two values are identical. Generally, NULL signifies an unknown value, so any comparison involving a NULL will produce NULL. However, the IS [NOT] DISTINCT FROM operator treats NULL as a known value, and returns a TRUE or FALSE result.

- Comparison functions

  Presto provides the following comparison related functions:

  - GREATEST

    Returns the largest of the provided values.

    Example:`GREATEST(1, 2)`
  - LEAST

    Returns the smallest of the provided values.

    Example: `LEAST(1, 2)`
- Quantified comparison predicates

Presto also provides several quantified comparison predicates to enhance the comparison expressions. The usage is as follows:

```
<EXPRESSION> <OPERATOR> <QUANTIFIER> (<SUBQUERY>)
```

For example:

```
SELECT 21 < ALL (VALUES 19, 20, 21); -- false
SELECT 42 >= SOME (SELECT 41 UNION ALL SELECT 42 UNION ALL SELECT 43
); -- true
```

ALL, ANY and SOME are quantified comparison predicates.

- `A = ALL (…)`: Evaluates to true when A is equal to all values. Example: `SELECT 21 = ALL (VALUES 20, 20, 20);` , return TRUE.
- `A <> ALL (…)`: Evaluates to true when A doesn't match any value. Example: `SELECT 21 <> ALL (VALUES 19, 20, 22);` , return TRUE.
- `A < ALL (…)`: Evaluates to true when A is smaller than the smallest value. Example: `SELECT 18 < ALL (VALUES 19, 20, 22);` , return TRUE.
- `A = ANY (…)`: Evaluates to true when A is equal to any of the values. This form is equivalent to `A IN (…)`. Example: `SELECT 'hello' = ANY (VALUES 'hello', 'world');` , return TRUE.
- `A <> ANY (…)`: Evaluates to true when A doesn't match one or more values. This form is equivalent to `A IN (…)`. Example: SELECT 21 <> ALL (VALUES 19, 20, 21);, return TRUE.
- `A < ANY (…)`: Evaluates to true when A is smaller than the biggest value. Example: `SELECT 21 < ALL (VALUES 19, 20, 22);`, return TRUE.

ANY and SOME have the same meaning and can be used interchangeably.

Conditional expressions

Conditional expressions are mainly used to express branch logic. Presto supports the following conditional expressions:

- CASE expression

  The standard SQL CASE expression has two different forms:

```
CASE expression
    WHEN <value|condition> THEN result
    [ WHEN ... ]
    [ ELSE result]
```

```
END
```

The *expression* statement compares the expression and the value/condition in *value|condition*. It returns a result if the same value is found or the condition is met.

Example:

```
--- Compare value
SELECT a,
       CASE a
           WHEN 1 THEN 'one'
           WHEN 2 THEN 'two'
           ELSE 'many'
       END
```

```
--- Compare conditional expression
SELECT a, b,
       CASE
           WHEN a = 1 THEN 'aaa'
           WHEN b = 2 THEN 'bbb'
           ELSE 'ccc'
       END
```

- IF function

  The IF function is a simple comparison function used to simplify the writing method for comparison logic of two values. Its expression forms are as follows:

  ```
  IF(condition, true_value, [false_value])
  ```

  Evaluates and returns true_value if *condition* is true, otherwise false_value is returned. false_value is optional. If it is not specified, NULL will be returned if condition is not true.

- COALESCE

  The COALESCE function returns the first non-null value in the argument list. Its expression forms are as follows:

  ```
  COALESCE(value1, value2[, ...])
  ```

- NULLIF

  The NULLIF function returns null if value1 equals value2, otherwise returns value1. Usage of the function is as follows:

  ```
  NULLIF(value1, value2)
  ```

- TRY

  The TRY function evaluates an expression and handle certain types of errors by returning NULL. The following errors are handled by TRY:

- Division by zero, e.g. x/0
- Invalid cast or function argument
- Numeric value out of range

Generally used in conjunction with COALESCE to return the default value in case of errors.

The usage is as follows:

```
TRY(expression)
```

Example:

```
--- When COALESCE and TRY are used in conjunction, if packages=0,
and a "division by zero" error is thrown, the default value (0) will
 be returned.
SELECT COALESCE(TRY(total_cost / packages), 0) AS per_package FROM
shipping;
per_package
-------------
           4
          14
           0
          19
(4 rows)
```

Conversion functions

Presto provides the following explicit conversion functions:

- CAST

  Explicitly casts a value as a type, and raises an error if the cast fails. The usage is as follows:

```
CAST(value AS type) -> value1:type
```

- TRY_CAST

  Like cast, but returns null if the cast fails. The usage is as follows:

```
TRY_CAST(value AS TYPE) -> value1:TYPE | NULL
```

- TYPEOF

  Returns the name of the type of the provided parameter or expression value. The usage is as follows:

```
TYPEOF(expression) -> type:VARCHAR
```

Example:

```
SELECT TYPEOF(123); -- integer
SELECT TYPEOF('cat'); -- varchar(3)
```

```
SELECT TYPEOF(cos(2) + 1.5); -- double
```

Mathematical functions and operators

- Mathematical operators

Operator	Description
+	Addition
-	Subtraction
*	Multiplication
/	Division (integer division performs truncation)
%	Modulus (remainder)

- Mathematical functions

  Presto provides a wealth of mathematical functions, as shown in the following table:

Function	Syntax	Description
abs	abs(x) →	Returns the absolute value of x.
cbrt	cbrt(x) → double	Returns the cube root of x.
ceil	ceil(x)	Returns x rounded up to the nearest integer. This is an alias for **ceiling**.
ceiling	ceiling(x)	Returns x rounded up to the nearest integer.
cosine_similarity	cosine_similarity(x, y) → double	Returns the cosine similarity between the sparse vectors x and y.
degrees	degress(x) -> double	Converts angle x in radians to degrees.
e	e()->double	Returns the constant Euler's number.
exp	exp(x)->double	Returns Euler's number raised to the power of x.
floor	floor(x)	Returns x rounded down to the nearest integer.
from_base	from_base(string, radix) → bigint	Returns the value of string interpreted as a base-radix number.
inverse_normal_cdf	inverse_normal_cdf(mean,sd, p)->double	Computes the inverse of the Normal cdf with given mean and standard deviation (sd) for the cumulative probability.
ln	ln(x)->double	Returns the natural logarithm of x.

Function	Syntax	Description
log2	log2(x)->double	Returns the base 2 logarithm of x.
log10	log10(x)->double	Returns the base 10 logarithm of x.
log	log(x,b) -> double	Returns the base b logarithm of x.
mod	mod(n,m)	Returns the modulus (remainder) of n divided by m.
pi	pi()->double	Returns the constant Pi.
pow	pow(x,p)->double	Returns x raised to the power of p. This is an alias for **power**.
power	power(x,p)->double	Returns x raised to the power of p.
radians	radians(x)->double	Converts angle x in degrees to radians.
rand	rand()->double	Returns a pseudo-random value in the range 0.0 <= x < 1.0. This is an alias for **random**.
random	random()->double	Returns a pseudo-random value in the range 0.0 <= x < 1.0.
random	random(n)	Returns a pseudo-random number between 0 and n (exclusive).
round	round(x)	Returns x rounded to the nearest integer.
round	round(x, d)	Returns x rounded to d decimal places.
sign	sign(x)	Returns the signum function of x, that is: 0 if the argument is 0; if the argument is greater than 0; -1 if the argument is less than 0. For double arguments, the function additionally returns: NaN if the argument is NaN; 1 if the argument is +Infinity; -1 if the argument is -Infinity.
sqrt	sqrt(x)->double	Returns the square root of x.
to_base	to_base(x, radix)->varchar	Returns the base-radix representation of x.
truncate	truncate(x) → double	Returns x rounded to integer by dropping digits after decimal point.
width_bucket	width_bucket(x, bound1, bound2, n) → bigint	Returns the bin number of x in an equi-width histogram with the specified bound1 and bound2 bounds and n number of buckets.
width_bucket	width_bucket(x, bins)	Returns the bin number of x according to the bins specified by the array bins.

Function	Syntax	Description
acos	acos(x)->double	Returns the arc cosine of x, which is a radian.
asin	asin(x)->double	Returns the arc sine of x, which is a radian.
atan	atan(x)->double	Returns the arc tangent of x, which is a radian .
atan2	atan2(y,x)->double	Returns the arc tangent of y / x, which is a radian.
cos	cos(x)->double	Returns the cosine of x, which is a radian.
cosh	cosh(x)->double	Returns the hyperbolic cosine of x, which is a radian.
sin	sin(x)->double	Returns the sine of x, which is a radian.
tan	tan(x)->double	Returns the tangent of x, which is a radian.
tanh	tanh(x)->double	Returns the hyperbolic tangent of x, which is a radian.
infinity	infinity() → double	Returns the constant representing positive infinity.
is_finite	is_finite(x) → boolean	Determines if x is finite.
is_infinite	is_infinite(x) → boolean	Determines if x is infinite.
is_nan	is_nan(x) → boolean	Determines if x is not-a-number.
nan	nan()	Returns the constant representing not-a-number.

Bitwise functions

Presto provides following bitwise functions:

Function	Syntax	Description
bit_count	bit_count(x, bits) → bigint	Returns the number of bits set in x at position 1 in 2’s complement representation.
bitwise_and	bitwise_and(x, y) → bigint	The bitwise AND function
bitwise_not	bitwise_not(x) → bigint	The bitwise NOT function
bitwise_or	bitwise_or(x, y) → bigint	The bitwise OR function
bitwise_xor	bitwise_xor(x, y) → bigint	The bitwise XOR function

Function	Syntax	Description
bitwise_and_agg	bitwise_and_agg(x) → bigint	Returns the bitwise AND of all input values in 2's complement representation, and x is an array.
bitwise_or_agg	bitwise_or_agg(x) → bigint	Returns the bitwise OR of all input values in 2's complement representation, and x is an array.

Examples

```
SELECT bit_count(9, 64); -- 2
SELECT bit_count(9, 8); -- 2
SELECT bit_count(-7, 64); -- 62
SELECT bit_count(-7, 8); -- 6
```

Decimal functions and operators

- Decimal literals

  Use the following syntax to define literal of DECIMAL type:

  ```
  DECIMAL 'xxxx.yyyyy'
  ```

  The *precision* of DECIMAL type for literal will be equal to number of digits in literal (including trailing and leading zeros). The *scale* will be equal to number of digits in fractional part (including trailing zeros). For example:

Example literal	Data type
DECIMAL '0'	DECIMAL(1)
DECIMAL '12345'	DECIMAL(5)
DECIMAL '0000012345.1234500000'	DECIMAL(20, 10)

- Operators

  Arithmetic operators

  Assuming x is of type DECIMAL(xp, xs) and y is of type DECIMAL(yp, ys),

  - x: DECIMAL(xp,xs)
  - y: DECIMAL(yp,ps)

  and they observe the following rules when used in arithmetic operation:

  - x + y or x - y

    - precision = min(38, 1 + min(xs, ys) + min(xp-xs, yp-ys))

- scale = max(xs, ys)

- x * y
  - precision = min(38, xp + yp)
  - scale = xs + ys
- x / y
  - precision = min(38, xp + ys + max(0, ys-xs))
  - scale = max(xs, ys)
- x % y
  - precision = min(xp - xs, yp - ys) + max(xs, bs)
  - scale = max(xs, ys)
- Comparison operators

  All standard comparison operators and BETWEEN operator work for DECIMAL type.
- Unary decimal operators

  The - operator performs negation for DECIMAL type.

String functions and operators

- Concatenation operator

  The `||` operator performs concatenation.
- String functions

  String functions supported by Presto are listed in the following table:

Function Name	Syntax	Description
chr	chr(n) → varchar	Returns the Unicode code point **n** as a single character string.
codepoint	codepoint(string) → integer	Returns the Unicode code point of the only character of **`string`**.
concat	concat(string1, …, stringN) → varchar	Returns the concatenation of string1, string2, …, stringN. This function provides the same functionality as the SQL-standard concatenat ion operator.
hamming_di stance	hamming_distance(string1, string2) → bigint	Returns the *Hamming distance* of string1 and string2, i.e. the number of positions at which

Function Name	Syntax	Description
		the corresponding characters are different. Note that the two strings must have the same length.
length	length(string) → bigint	Returns the length of string in characters.
levenshtein_distance	levenshtein_distance(string1, string2) → bigint	Returns the *Levenshtein edit distance* of string1 and string2.
lower	lower(string) → varchar	Converts string to lowercase.
upper	upper(string) → varchar	Converts string to uppercase.
replace	replace(string, search) → varchar	Removes all instances of **`search`** from **`string`**.
replace	replace(string, search, replace) → varchar	Replaces all instances of **`search`** with **`replace`** in **`string`**.
reverse	reverse(string) → varchar	Returns string with the characters in reverse order.
lpad	lpad(string, size, padstring) → varchar	Left pads string to size characters with **`padstring`**.If size is less than the length of **`string`**, the result is truncated to **`size`** characters. **`size`** must not be negative and **`padstring`** must be non-empty.
rpad	rpad(string, size, padstring) → varchar	Right pads string to size characters with **`padstring`**.If size is less than the length of **`string`**, the result is truncated to **`size`** characters. **`size`** must not be negative and **`padstring`** must be non-empty.
ltrim	ltrim(string) → varchar	Removes leading whitespace from string.
rtrim	rtrim(string) → varchar	Removes trailing whitespace from string.
split	split(string, delimiter) → array	Splits string on delimiter and returns an array.
split	split(string, delimiter, limit) → array	Splits string on delimiter and returns an array of size at the maximum of limit.
split_part	split_part(string, delimiter, index) → varchar	Splits string on delimiter and returns the field **`index`**. Field indexes start with 1.
split_to_map	split_to_map(string, entryDelimiter, keyValueDelimiter) → map	Splits string by entryDelimiter and keyValueDelimiter and returns a map.

Function Name	Syntax	Description
strpos	strpos(string, substring) → bigint	Returns the starting position of the first instance of substring in string. Positions start with 1. If not found, 0 is returned.
position	position(substring IN string) → bigint	Returns the starting position of the first instance of substring in string.
substr	substr(string, start, [length]) → varchar	Returns a substring from string of [length] length from the starting position **start**. Positions start with 1. The length parameter is optional.

- Unicode functions
  - normalize(string) → varchar

    Transforms string with *NFC normalization form*.
  - normalize(string, form) → varchar

    Transforms string with the specified normalization form. **form** must be one of the following keywords:
    - NFD Canonical Decomposition
    - NFC Canonical Decomposition, followed by Canonical Composition
    - NFKD Compatibility Decomposition
    - NFKC Compatibility Decomposition, followed by Canonical Composition
  - to_utf8(string) → varbinary

    Encodes string into a UTF-8 varbinary representation.
  - from_utf8(binary, [replace]) → varchar

    Decodes a UTF-8 encoded string from binary. Invalid UTF-8 sequences are replaced with **replace**, which is Unicode replacement character **U+FFFD** by default. Note that the replacement string **replace** must either be a single character or empty.

Regular expression functions

Presto supports all of the regular expression functions use the *Java Pattern* syntax, with a few notable exceptions:

- When using multi-line mode

- enabled via the `? m` flag.
- `\n` is recognized as a line terminator
- the `? d` flag is not supported

- Case-sensitive matching
  - enabled via the `?i` flag
  - the `?u` flag is not supported
  - context-sensitive matching is not supported
  - local-sensitive matching is not supported
- Surrogate pairs are not supported

  For example, `\uD800\uDC00` is not treated as `U+10000` and must be specified as `\x{10000}`.
- Boundaries `\b` are incorrectly handled for a non-spacing mark without a base character.
- `\Q` and `\E` are not supported in character classes (such as `[A-Z123]`) and are instead treated as literals.
- Unicode character classes (`\p{prop}`) are supported with the following differences:
  - All underscores in names must be removed. For example, use `OldItalic` instead of `Old_Italic`.
  - Scripts must be specified directly, without the `Is`, `script=` or `sc=` prefixes. Example:`\p{Hiragana}` instead of `\p{script=Hiragana}`.
  - Blocks must be specified with the `In` prefix. The `block=` and `blk=` prefixes are not supported. Example: `\p{InMongolia}`.
  - Categories must be specified directly, without the `Is`, `general_category=` or `gc=` prefixes. Example: `\p{L}`.
  - Binary properties must be specified directly, without the Is. Example: use `\p{NoncharacterCodePoint}` instead of `\p{IsNoncharacterCodePoint}`.

Regular expression functions provided by Presto are as follows:

- regexp_extract_all(string, pattern, [group]) → array

  Returns the substring(s) matched by the regular expression **`pattern`** in **`string`**. If the **`pattern`** expression uses the grouping function, then the **`group`** parameter can be set to specify the *capturing group*.

Examples

```
SELECT regexp_extract_all('1a 2b 14m', '\d+'); -- [1, 2, 14]
SELECT regexp_extract_all('1a 2b 14m', '(\d+)([a-z]+)', 2); -- ['a',
 'b', 'm']
```

- regexp_extract(string, pattern, [group]) → varchar

  The function and usage is similar to those of `regexp_extract_all`. The difference is that this function only returns the first substring matched by the regular expression.

  Examples

```
SELECT regexp_extract_all('1a 2b 14m', '\d+'); -- [1, 2, 14]
SELECT regexp_extract_all('1a 2b 14m', '(\d+)([a-z]+)', 2); -- ['a',
 'b', 'm']
```

- regexp_extract_all(string, pattern, [group]) → array

  Returns the substring(s) matched by the regular expression **`pattern`** in **`string`**: If the **`pattern`** expression uses the grouping function, then the **`group`** parameter can be set to specify the *capturing group* to be matched by the regular expression.

  Examples

```
SELECT regexp_extract('1a 2b 14m', '\d+'); -- 1
SELECT regexp_extract('1a 2b 14m', '(\d+)([a-z]+)', 2); -- 'a'
```

- regexp_like(string, pattern) → boolean

  Evaluates the regular expression **`pattern`** and determines if it is contained within **`string`**. It returns TRUE if yes, and False if otherwise. This function is similar to the LIKE operator, expect that the pattern only needs to be contained within string, rather than needing to match all of string.

  Examples

```
SELECT regexp_like('1a 2b 14m', '\d+b'); -- true
```

- regexp_replace(string, pattern, [replacement]) → varchar

  Replaces every instance of the substring matched by the regular expression **`pattern`** in **`string`** with **`replacement`**. **`replacement`** is optional, and will be replaced by **‘’**(deleting the matched substrings) if it is not specified.

  Capturing groups can be referenced in **`replacement`** using *$g* (g is the ordinal number, starting at one) for a numbered group or *`${name}`* for a named group. A dollar sign $ may be included in the **`replacement`** by escaping it with a backslash `\$`.

Examples

```
SELECT regexp_replace('1a 2b 14m', '\d+[ab] '); -- '14m'
SELECT regexp_replace('1a 2b 14m', '(\d+)([ab]) ', '3c$2 '); -- '3ca
 3cb 14m'
```

- regexp_split(string, pattern) → array

  Splits string using the regular expression **`pattern`** and returns an array. Trailing empty strings are preserved.

  Examples

```
SELECT regexp_split('1a 2b 14m', '\s*[a-z]+\s*'); -- ['1', '2', '14
', ''] 4 elements
                                                         -- The last one is
 an empty string
```

Binary functions and operators

- Concatenation operator

  The `||` operator performs binary concatenation.

- Binary functions

Function	Syntax	Description
length	length(binary) → bigint	Returns the length of binary in bytes.
concat	concat(binary1, …, binaryN) → varbinary	Returns the concatenation of binary1, binary2 , …, binaryN.
to_base64	to_base64(binary) → varchar	Encodes binary into a base64 string representation.
from_base64	from_base64(string) → varbinary	Decodes binary data from the base64 encoded string.
to_base64url	to_base64url(binary) → varchar	Encodes binary into a base64 string representation using the URL safe alphabet.
from_base64url	from_base64url(string) → varbinary	Decodes binary data from the base64 encoded string using the URL safe alphabet.
to_hex	to_hex(binary) → varchar	Encodes binary into a hex string representation.
from_hex	from_hex(string) → varbinary	Decodes binary data from the hex encoded string.
to_big_endian_64	to_big_endian_64(bigint) → varbinary	Encodes bigint in a 64-bit 2's complement big endian format.

Function	Syntax	Description
from_big_endian_64	from_big_endian_64(binary) → bigint	Decodes bigint value from a 64-bit 2's complement big endian binary.
to_ieee754_32	to_ieee754_32(real) → varbinary	Encodes real in a 32-bit big-endian binary according to *IEEE 754* single-precision floating-point format.
to_ieee754_64	to_ieee754_64(double) → varbinary	Encodes double in a 64-bit big-endian binary according to *IEEE 754* double-precision floating-point format.
crc32	crc32(binary) → bigint	Computes the CRC-32 of binary.
md5	md5(binary) → varbinary	Computes the md5 hash of binary.
sha1	sha1(binary) → varbinary	Computes the sha1 hash of binary.
sha256	sha256(binary) → varbinary	Computes the sha256 hash of binary.
sha512	sha512(binary) → varbinary	Computes the sha512 hash of binary.
xxhash64	xxhash64(binary) → varbinary	Computes the xxhash64 hash of binary.

Date and time functions and operators

- Date and time operators

  Presto supports two date and time operators: `+` and `-`.

  Examples

```
--- +
 date '2012-08-08' + interval '2' day                   --- 2012-08-10
 time '01:00' + interval '3' hour                       --- 04:00:00.
000
 timestamp '2012-08-08 01:00' + interval '29' hour     --- 2012-08-09
 06:00:00.000
 timestamp '2012-10-31 01:00' + interval '1' month     --- 2012-11-30
 01:00:00.000
 interval '2' day + interval '3' hour                   --- 2 03:00:00.
000
 interval '3' year + interval '5' month                  --- 3-5
 --- -
 date '2012-08-08' - interval '2' day                   --- 2012-08-06
 time '01:00' - interval '3' hour                       --- 22:00:00.
000
 timestamp '2012-08-08 01:00' - interval '29' hour     --- 2012-08-06
 20:00:00.000
 timestamp '2012-10-31 01:00' - interval '1' month     --- 2012-09-30
 01:00:00.000
 interval '2' day - interval '3' hour                   --- 1 21:00:00.
000
```

```
 interval '3' year - interval '5'                   --- month    2-7
```

- Time zone conversion

  The `AT TIME ZONE` operator sets the time zone of a timestamp.

  Examples

```
SELECT timestamp '2012-10-31 01:00 UTC';
 --- 2012-10-31 01:00:00.000 UTC
 SELECT timestamp '2012-10-31 01:00 UTC' AT TIME ZONE 'America/
Los_Angeles';
 --- 2012-10-30 18:00:00.000 America/Los_Angeles
```

- Date and time functions

  — Basic functions

Function	Syntax	Description
current_date	current_date -> date	Returns the current date as of the start of the query.
current_time	current_time -> time with time zone	Returns the current time as of the start of the query.
current_timestamp	current_timestamp -> timestamp with time zone	Returns the current timestamp as of the start of the query.
current_timezone	current_timezone() → varchar	Returns the current time zone.
date	date(x) → date	Parses a date literal into a date
from_iso8601_timestamp	from_iso8601_timestamp(string) → timestamp with time zone	Parses the ISO 8601 formatted string into a timestamp with time zone.
from_iso8601_date	from_iso8601_date(string) → date	Parses the ISO 8601 formatted string into a date.
from_unixtime	from_unixtime(unixtime, [timezone_str]) → timestamp	Returns the UNIX timestamp as a timestamp. Timestamp option is allowed.
from_unixtime	from_unixtime(unixtime, hours, minutes) → timestamp with time zone	Returns the UNIX timestamp as a timestamp with time zone using **`hours`** and **`minutes`** for the time zone offset.
localtime	localtime -> time	Returns the current time as of the start of the query.
localtimestamp	localtimestamp -> timestamp	Returns the current timestamp as of the start of the query.

Function	Syntax	Description
now	now() → timestamp with time zone	Returns the current time. This is an alias for **`current_time`**.
to_iso8601	to_iso8601(x) → varchar	Formats **x** as an ISO 8601 string. **x** can be `DATE`, or `TIMESTAMP [with time zone ]`.
to_milliseconds	to_milliseconds(interval) → bigint	Returns the day-to-second interval as milliseconds.
to_unixtime	to_unixtime(timestamp) → double	Returns timestamp as a UNIX timestamp.

Note:

The following SQL-standard functions do not use parenthesis:

- current_data
- current_time
- current_timestamp
- localtime
- localtimestamp

- Truncation function

  The truncation function truncates date and time value by the specified unit, and returns the date and time value of this unit. The usage is as follows:

  ```
  date_trunc(unit, x) -> [same as x]
  ```

  where **`unit`** is one of:

  - `second`: Seconds
  - `minute`: Minutes
  - `hour`: Hours
  - `day`: Days
  - `week`: Weeks
  - `month`: Months
  - `quarter`: Months
  - `year`: Years

- Interval functions

Presto provides two functions for interval calculation, which are:

- date_add(unit, value, timestamp) → [same as input]

  Adds an interval value of type unit to timestamp. Subtraction can be performed by using a negative value with a unit.
- date_diff(unit, timestamp1, timestamp2) → bigint

  Returns interval between two timestamps expressed in terms of unit.

  Where **`unit`** is one of:

  - `ns`: Nanoseconds
  - `us`: Microseconds
  - `ms`: Milliseconds
  - `s`: Seconds
  - `m`: Minutes
  - h: Hours
  - d: Days

— Date and time extraction functions

Presto provides a function `extract` to extract the specified fields from a date and time value, which is:

extract(field FROM x) → bigint

where, **`x`** is the date and time value, **`field`** is field to be extracted, which can be one of the following values:

- `YEAR`: Year
- `QUARTER`: Quarter of a year
- `MONTH`: Month
- `WEEK`: Week
- `DAY`: Day
- `DAY_OF_MONTH`: Day of a month
- `DAY_OF_WEEK`: Day of a week
- `DOW`: This is an alias for DAY_OF_WEEK
- `DAY_OF_YEAR`: Day of a year
- `DOY`: This is an alias for `DAY_OF_YEAR`

- `YEAR_OF_WEEK`: Year of an *ISO Week*
- `YOW`: This is an alias for `YEAR_OF_WEEK`
- `HOUR`: Hour
- `MINUTE`: Minute
- `SECOND`: Second
- `TIMEZONE_HOUR`: Hour with timezone
- `TIMEZONE_MINUTE`: Minute with timezone

For the sake of convenience, Presto provides the following helper functions:

Function	Syntax	Description
day	day(x) → bigint	Returns the day of the month from x.
day_of_month	day_of_month(x) → bigint	This is an alias for `day`.
dayofweek	day_of_week(x) → bigint	Returns the ISO day of the week from x.
day_of_year	day_of_year(x) → bigint	Returns the day of the year from x.
dow	dow(x) → bigint	This is an alias for `day_of_week`.
doy	doy(x) → bigint	This is an alias for `day_of_year`.
hour	hour(x) → bigint	Returns the hour of the day from x. The value ranges from 0 to 23.
minute	minute(x) → bigint	Returns the minute from x. The value ranges from 0 to 59.
month	month(x) → bigint	Returns the month of the year from x. The value ranges from 1 to 12.
quarter	quarter(x) → bigint	Returns the quarter of the year from x.
second	second(x) → bigint	Returns the second from x. The value ranges from 0 to 59.
timezone_hour	timezone_hour(timestamp) → bigint	Returns the hour of the time zone offset from timestamp.
timezone_minute	timezone_minute(timestamp) → bigint	Returns the minute of the time zone offset from timestamp.
week	week(x) → bigint	Returns the ISO week of the year from x. The value ranges from 1 to 53.
week_of_year	week_of_year(x) → bigint	This is an alias for `week`.

Function	Syntax	Description
year	year(x) → bigint	Returns the year from x.
year_of_week	year_of_week(x) → bigint	Returns the year of a week from **x**(*ISO Week*).
yow	yow(x) → bigint	This is an alias for `year_of_week`.

- MySQL date functions

Presto uses a format string that is compatible with MySQL `date_parse` and `str_to_date` functions, which are:

- date_format(timestamp, format) → varchar

  Formats **`timestamp`** as a string using **`format`**.
- date_parse(string, format) → timestamp

  Parses string into a timestamp using **`format`**.

MySQL format specifiers supported by Presto are shown in the following table:

Specifier	Description
%a	Abbreviated weekday name (Sun .. Sat).
%b	Abbreviated month name (Jan .. Dec).
%c	Month, numeric (1 .. 12), cannot be zero
%d	Day of the month, numeric (01 .. 31), cannot be zero
%e	Day of the month, numeric (1 .. 31), cannot be zero
%f	Fraction of second (6 digits for printing: 000000 .. 999000; 1 - 9 digits for parsing: 0 .. 999999999).
%H	Hour (00 .. 23).
%h	Hour (01 .. 12).
%I	Hour (01 .. 12).
%i	Minutes, numeric (00 .. 59).
%j	Day of year (001 .. 366).
%k	Hour (0 .. 23).
%l	Hour (1 .. 12).
%M	Month name (January .. December).
%m	Month, numeric (01 .. 12) [4].

Specifier	Description
%p	AM / PM
%r	Time, 12-hour (hh:mm:ss AM/PM)
%S	Seconds (00 .. 59).
%s	Seconds (00 .. 59).
%T	Time, 24-hour (hh:mm:ss)
%v	Week (01 .. 53), where Monday is the first day of the week; used with %X
%W	Weekday name (Sunday .. Saturday)
%x	Year for the week, where Monday is the first day of the week, numeric, four digits
%Y	Year, numeric, four digits
%y	Year, numeric (two digits). When parsing, two-digit year format assumes range [1970 .. 2069]
%%	A literal **'%'** character

Note:

The following specifiers are not currently supported: %D %U %u %V %w %X

- Java date functions

  The functions in this section use a format string that is compatible with *JodaTime's DateTimeFormat pattern* format.

  - format_datetime(timestamp, format) → varchar: Formats timestamp
  - parse_datetime(string, format) → timestamp with time zone: Parses string into a timestamp

Aggregate functions

Aggregate functions have the following features:

- Input a data set
- Output a single computation result.

Almost all of these aggregate functions ignore `null` values and return `null` for no input rows or when all values are `null`, with a few notable exceptions:

- count

- count_if
- max_by
- min_by
- approx_distinct
- Basic aggregate functions

Function	Syntax	Description
arbitrary	arbitrary(x) → [same as input]	Returns an arbitrary non-null value of x.
array_agg	array_agg(x) → array<[same as input]>	Returns an array created from the input x elements.
avg	avg(x) → double	Returns the average (arithmetic mean) of all input values.
avg	avg(time interval type) → time interval type	Returns the average interval length of all input values.
bool_and	bool_and(boolean) → boolean	Returns TRUE if every input value is TRUE, otherwise FALSE.
bool_or	bool_or(boolean) → boolean	Returns TRUE if any input value is TRUE, otherwise FALSE.
checksum	checksum(x) → varbinary	Returns an order-insensitive checksum of the given values.
count	count(*) → bigint	Returns the number of input rows.
count	count(x) → bigint	Returns the number of non-null input values.
count_if	count_if(x) → bigint	Returns the number of TRUE input values. This function is equivalent to `count(CASE WHEN x THEN 1 END)`.
every	every(boolean) → boolean	This is an alias for **bool_and**.
geometric_mean	geometric_mean(x) → double	Returns the geometric mean of all input values.
max_by	max_by(x, y) → [same as x]	Returns the value of x associated with the maximum value of y over all input values.
max_by	max_by(x, y, n) → array<[same as x]>	Returns n values of x associated with the n largest of all input values of y in descending order of y.
min_by	min_by(x, y) → [same as x]	Returns the value of x associated with the minimum value of y over all input values.

Function	Syntax	Description
min_by	min_by(x, y, n) → array<[same as x]>	Returns n values of x associated with the n smallest of all input values of y in ascending order of y.
max	max(x) → [same as input]	Returns the maximum value of all input values.
max	max(x, n) → array<[same as x]>	Returns n largest values of all input values of x.
min	min(x) → [same as input]	Returns the minimum value of all input values.
min	min(x, n) → array<[same as x]>	Returns n smallest values of all input values of x.
sum	sum(x) → [same as input]	Returns the sum of all input values.

- Bitwise aggregate functions

  For bitwise aggregate functions, refer to`bitwise_and_agg` and `bitwise_or_agg` functions as described in *General aggregate functions*.
- Map aggregate functions

Function	Syntax	Description
histogram	histogram(x) → map	Returns a map containing the count of the number of times each input value occurs.
map_agg	map_agg(key, value) → map	Returns a MAP created from the input key/value pairs.
map_union	map_union(x) → map	Returns the union of all the input maps. If a key is found in multiple input maps, that key’s value in the resulting map comes from an arbitrary input map.
multimap_agg	multimap_agg(key, value) → map>	Returns a multimap created from the input key/value pairs.

- Close aggregate function

Function	Syntax	Description
approx_distinct	approx_distinct(x, [e]) → bigint	Returns the approximate number of distinct input values. This function provides an approximation of `count(DISTINCT x)`. Zero is returned if all input values are null.

Function	Syntax	Description
		This function should produce a standard error of no more than **e**, which is the standard deviation of the (approximately normal) error distribution over all possible sets. It is optional, and is 2.3% by default. The current implementation of this function requires that **e** be in the range of [0.01150, 0.26000]. It does not guarantee an upper bound on the error for any specific input set.
approx_percentile	approx_percentile(x, percentage) → [same as x]	Returns the approximate percentile for all input values of x at the given percentage.
approx_percentile	approx_percentile(x, percentages) → array<[same as x]>	Similar to the preceding function, percentages is an array, and returns constant values for all input rows.
approx_percentile	approx_percentile(x, w, percentage) → [same as x]	Similar to the preceding function, w is the weighted value of x.
approx_percentile	approx_percentile(x, w, percentage, accuracy) → [same as x]	Similar to the preceding function, **accuracy** is the upper bound of the estimation accuracy, and the value must be in the range of [0, 1].
approx_percentile	approx_percentile(x, w, percentages) → array<[same as x]>	Similar to the preceding function, percentages is an array, and returns constant values for all input rows.
numeric_histogram	numeric_histogram(buckets, value, [weight]) → map	Computes an approximate histogram with up to a given number of buckets. **buckets** must be a BIGINT. **value** and **weight** must be numeric. **weight** is optional, and is 1 by default.

- Statistical aggregate functions

Function	Syntax	Description
corr	corr(y, x) → double	Returns correlation coefficient of input values.
covar_pop	covar_pop(y, x) → double	Returns the population covariance of input values.
covar_samp	covar_samp(y, x) → double	Returns the sample covariance of input values.

Function	Syntax	Description
kurtosis	kurtosis(x) → double	Returns the excess kurtosis of all input values . Unbiased estimate using the following expression: kurtosis(x) = n(n+1)/((n-1)(n-2)(n-3))sum[(x_i-mean)^4]/sttdev(x)^4-3(n-1)^2/((n-2)(n-3))
regr_intercept	regr_intercept(y, x) → double	Returns linear regression intercept of input values. *y* is the dependent value. *x* is the independent value.
regr_slope	regr_slope(y, x) → double	Returns linear regression slope of input values. *y* is the dependent value. *x* is the independent value.
skewness	skewness(x) → double	Returns the skewness of all input values.
sttdev_pop	sttdev_pop(x) → double	Returns the population standard deviation of all input values.
sttdev_samp	sttdev_samp(x) → double	Returns the sample standard deviation of all input values.
sttdev	sttdev(x) → double	This is an alias for `sttdev_samp`.
var_pop	var_pop(x) → double	Returns the population variance of all input values.
var_samp	var_samp(x) → double	Returns the sample variance of all input values.
variance	variance(x) → double	This is an alias for `var_samp`.

11.8.6 SQL statement

SQL statement

ALTER SCHEMA

- Synopsis

```
ALTER SCHEMA name RENAME TO new_name
```

- Description

  Renames SCHEMA.

- Examples

```
ALTER SCHEMA web RENAME TO traffic -- Renames Schema 'web' as '
traffic'
```

ALTER TABLE

- Synopsis

```
ALTER TABLE name RENAME TO new_name
ALTER TABLE name ADD COLUMN column_name data_type
ALTER TABLE name DROP COLUMN column_name
ALTER TABLE name RENAME COLUMN column_name TO new_column_name
```

- Description

  Changes the definition of an existing table

- Examples

```
ALTER TABLE users RENAME TO people; --- Rename
ALTER TABLE users ADD COLUMN zip varchar; --- Add column
ALTER TABLE users DROP COLUMN zip; --- Drop column
ALTER TABLE users RENAME COLUMN id TO user_id; --- Rename column
```

CALL

- Synopsis

```
CALL procedure_name ( [ name => ] expression [, ...] )
```

- Description

  Calls a stored procedure. Stored procedures can be provided by connectors to perform data manipulation or administrative tasks. Some connectors such as the PostgreSQL Connector, are for systems that have their own stored procedures. These systems must use the stored procedures provided by the connectors to access their own stored procedures, which are not directly callable via **CALL**.

- Examples

```
CALL test(123, 'apple'); --- Call a stored procedure using
positional arguments
CALL test(name => 'apple', id => 123); --- Call a stored procedure
using named arguments
```

```
CALL catalog.schema.test(); --- Call a stored procedure using a
fully qualified name
```

COMMIT

- Synopsis

```
COMMIT [WORK]
```

- Description

Commits the current transaction.

- Examples

```
COMMIT;
COMMIT WORK;
```

CREATE SCHEMA

- Synopsis

```
CREATE SCHEMA [ IF NOT EXISTS ] schema_name
[ WITH ( property_name = expression [, ...] ) ]
```

- Description

Creates a new SCHEMA. Schema is a container that holds tables, views, and other database objects.

  - The optional `IF NOT EXISTS` clause causes the error to be suppressed if the schema already exists;
  - The optional `WITH` clause can be used to set properties on the newly created schema. To list all available schema properties, run the following query:

```
SELECT * FROM system.metadata.schema_properties;
```

- Examples

```
CREATE SCHEMA web;
CREATE SCHEMA hive.sales;
CREATE SCHEMA IF NOT EXISTS traffic;
```

CREATE TABLE

- Synopsis

```
CREATE TABLE [ IF NOT EXISTS ]
table_name (
  { column_name data_type [ COMMENT comment ]
  | LIKE existing_table_name [ { INCLUDING | EXCLUDING } PROPERTIES
 ] }
```

```
  [, ...]
)
[ COMMENT table_comment ]
[ WITH ( property_name = expression [, ...] ) ]
```

- Description

  Creates an empty table. Use the `CREATE TABLE AS` to create a table from an existing data set.

  - The optional `IF NOT EXISTS` clause causes the error to be suppressed if the table already exists.
  - The optional `WITH` clause can be used to set properties on the newly created table. To list all available table properties, run the following query:

    ```
    SELECT * FROM system.metadata.table_properties;
    ```

  - The `LIKE` clause can be used to include all the column definitions from an existing table in the new table. Multiple `LIKE` clauses may be specified.
  - If `INCLUDING PROPERTIES` is specified, all of the table properties are copied to a new table. If the `WITH` clause specifies the same property name as one of the copied properties using `INCLUDING PROPERTIES`, the value from the `WITH` clause is used. The default behavior is `EXCLUDING PROPERTIES`.
- Examples

```
--- Create a new table orders:
CREATE TABLE orders (
  orderkey bigint,
  orderstatus varchar,
  totalprice double,
  orderdate date
)
WITH (format = 'ORC')
--- Create the table orders if it does not already exist, adding a
table comment and a column comment:
CREATE TABLE IF NOT EXISTS orders (
  orderkey bigint,
  orderstatus varchar,
  totalprice double COMMENT 'Price in cents.',
  orderdate date
)
COMMENT 'A table to keep track of orders.'
Create the table bigger_orders, using some column definitions from
orders:
CREATE TABLE bigger_orders (
  another_orderkey bigint,
  LIKE orders,
  another_orderdate date
```

```
)
```

CREATE TABLE AS

- Synopsis

```
CREATE TABLE [ IF NOT EXISTS ] table_name [ ( column_alias, ... ) ]
[ COMMENT table_comment ]
[ WITH ( property_name = expression [, ...] ) ]
AS query
[ WITH [ NO ] DATA ]
```

- Description

  Creates a new table containing the result of a `SELECT` query.

  - The optional `IF NOT EXISTS` clause causes the error to be suppressed if the table already exists.
  - The optional `WITH` clause can be used to set properties on the newly created table. To list all available table properties, run the following query:

    ```
    SELECT * FROM system.metadata.table_properties;
    ```

- Examples

```
--- Select two columns from orders to create a new table
CREATE TABLE orders_column_aliased (order_date, total_price)
AS
SELECT orderdate, totalprice
FROM orders
--- Create a new table using the aggregate function
CREATE TABLE orders_by_date
COMMENT 'Summary of orders by date'
WITH (format = 'ORC')
AS
SELECT orderdate, sum(totalprice) AS price
FROM orders
GROUP BY orderdate
--- Create a new table, using the **IF NOT EXISTS** clause
CREATE TABLE IF NOT EXISTS orders_by_date AS
SELECT orderdate, sum(totalprice) AS price
FROM orders
GROUP BY orderdate
--- Create a new table with the same schema as nation and no data
Create Table maid
SELECT *
FROM nation
```

```
WITH NO DATA
```

CREATE VIEW

- Synopsis

```
CREATE [ OR REPLACE ] VIEW view_name AS query
```

- Description

  Creates a view. The view is a logic table that does not contain any data. It can be referenced by future queries. The query stored by the view is run every time the view is referenced by another query.

  The optional `OR REPLAE` clause causes the view to be replaced if it already exists rather than raising an error.

- Examples

```
--- Create a simple view
CREATE VIEW test AS
SELECT orderkey, orderstatus, totalprice / 2 AS half
FROM orders
--- Create view using the aggregate function
CREATE VIEW orders_by_date AS
SELECT orderdate, sum(totalprice) AS price
FROM orders
GROUP BY orderdate
--- Create a view that replaces an existing view
CREATE OR REPLACE VIEW test AS
SELECT orderkey, orderstatus, totalprice / 4 AS quarter
FROM orders
```

DEALLOCATE PREPARE

- Synopsis

```
DEALLOCATE PREPARE statement_name
```

- Synopsis

  Removes a statement with the name statement_name from the list of prepared statements in a session.

- Examples

```
--- Deallocate a statement named my_query
```

```
DEALLOCATE PREPARE my_query;
```

DELETE

- Synopsis

```
DELETE FROM table_name [ WHERE condition ]
```

- Description

If the `WHERE` clause is specified, delete the matching rows from the table. If the `WHERE` is not specified, all rows from the table are deleted.

- Examples

```
--- Delete the matching row
DELETE FROM lineitem WHERE shipmode = 'AIR';
--- Delete the matching row
DELETE FROM lineitem
WHERE orderkey IN (SELECT orderkey FROM orders WHERE priority = 'LOW
');
--- Clear the table
DELETE FROM orders;
```

- **Limitations**

Some connectors have limits or no support for `DELETE`.

DESCRIBE

- Synopsis

```
DESCRIBE table_name
```

- Description

Retrieves the table definitions, and is an alias for *SHOW COLUMNS*.

- Examples

```
DESCRIBE orders;
```

DESCRIBE INPUT

- Synopsis

```
DESCRIBE INPUT statement_name
```

- Description

Lists the input parameters of a prepared statement along with the position and type of each parameter.

- Examples

```
--- Create a pre-compiled query 'my_ select1'
PREPARE my_select1 FROM
SELECT ? From nation where regionkey =? AND name < ? ;
--- Get the descriptive information of this prepared statement
DESCRIBE INPUT my_select1;
```

DESCRIBE INPUT my_select1;

```
Position | Type
--------------------
        0 | unknown
        1 | bigint
        2 | varchar
(3 rows)
```

DESCRIBE OUTPUT

- Synopsis

```
DESCRIBE OUTPUT statement_name
```

- Description

Lists the output columns of a prepared statement, including the column name (or alias), catalog , schema, table name, type, type size in bytes, and a boolean indicating if the column is aliased .

- Examples
  - Example one

    Prepare a prepared statement:

```
PREPARE my_select1 FROM
SELECT * FROM nation;
```

    Execute `DESCRIBE OUTPUT`, which outputs:

```
DESCRIBE OUTPUT my_select1;
 Column Name | Catalog | Schema | Table  |  Type   | Type Size |
Aliased
-------------+---------+--------+--------+---------+-----------
+---------
 nationkey   | tpch    | sf1    | nation | bigint  |         8 |
false
 name        | tpch    | sf1    | nation | varchar |         0 |
false
 regionkey   | tpch    | sf1    | nation | bigint  |         8 |
false
 comment     | tpch    | sf1    | nation | varchar |         0 |
false
```

```
(4 rows)
```

- Example two

```
PREPARE my_select2 FROM
SELECT count(*) as my_count, 1+2 FROM nation
```

Execute `DESCRIBE OUTPUT`, which outputs:

```
DESCRIBE OUTPUT my_select2;
 Column Name | Catalog | Schema | Table |  Type  | Type Size |
Aliased
-------------+---------+--------+-------+--------+-----------
+---------
 my_count    |         |        |       | bigint |         8 |
true
 _col1       |         |        |       | bigint |         8 |
false
(2 rows)
```

- Example three:

```
PREPARE my_create FROM
CREATE TABLE foo AS SELECT * FROM nation;
```

Execute `DESCRIBE OUTPUT`, which outputs:

```
DESCRIBE OUTPUT my_create;
 Column Name | Catalog | Schema | Table |  Type  | Type Size |
Aliased
-------------+---------+--------+-------+--------+-----------
+---------
 rows        |         |        |       | bigint |         8 |
false
(1 row)
```

DROP SCHEMA

- Synopsis

```
DROP SCHEMA [ IF EXISTS ] schema_name
```

- Description

  Drops an existing Schema.

  - The schema must be empty.
  - The optional `IF EXISTS` clause causes the error to be suppressed if the schema does not exist.
- Examples

```
DROP SCHEMA web;
```

```
DROP TABLE IF EXISTS sales;
```

DROP TABLE

- Synopsis

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

- Description

  Drops an existing table. The optional **IF EXISTS** clause causes the error to be suppressed if the table does not exist.

- Examples

```
DROP TABLE orders_by_date;
DROP TABLE IF EXISTS orders_by_date;
```

DROP VIEW

- Synopsis

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

- Description

  Drops an existing view. The optional **IF EXISTS** clause causes the error to be suppressed if the view does not exist.

- Examples

```
DROP VIEW orders_by_date;
DROP VIEW IF EXISTS orders_by_date;
```

EXECUTE

- Synopsis

```
EXECUTE statement_name [ USING parameter1 [ , parameter2, ... ] ]
```

- Description

  Executes a prepared statement. Parameter values are defined in the **USING** clause.

- Examples

  - Example one

```
PREPARE my_select1 FROM
SELECT name FROM nation;
--- Execute a prepared statement
```

```
EXECUTE my_select1;
```

- Example two

```
PREPARE my_select2 FROM
SELECT name FROM nation WHERE regionkey = ? and nationkey < ? ;
--- Execute a prepared statement
EXECUTE my_select2 USING 1, 3;
--- The preceding statement is equivalent to executing the
following statement:
SELECT name FROM nation WHERE regionkey = 1 AND nationkey < 3;
```

EXPLAIN

- Synopsis

```
EXPLAIN [ ( option [, ...] ) ] statement
where option can be one of:
    FORMAT { TEXT | GRAPHVIZ }
    TYPE { LOGICAL | DISTRIBUTED | VALIDATE }
```

- Description

  Achieves one of the following functions based on the option used:

  - Shows the logical plan of a query statement
  - Shows the distributed execution plan of a query statement
  - Validates a query statement

  Use `TYPE DISTRIBUTED` option to display fragmented plan. Each plan fragment is executed by a single or multiple Presto nodes. Fragments separation represent the data exchange between Presto nodes. Fragment type specifies how the fragment is executed by Presto nodes and how the data is distributed between fragments. Fragment types are as follows:

  - `SINGLE`: Fragment is executed on a single node.
  - `HASH`: Fragment is executed on a fixed number of nodes with the input data distributed using a hash function.
  - `ROUND_ROBIN`: Fragment is executed on a fixed number of nodes with the input data distributed in a `ROUND-ROBIN` fashion.
  - `BROADCAST`: Fragment is executed on a fixed number of nodes with the input data broadcasted to all nodes.
  - `SOURCE`: Fragment is executed on nodes where input splits are accessed.

- Examples

  - Example one

Logical plan:

```
presto:tiny> EXPLAIN SELECT regionkey, count(*) FROM nation GROUP
BY 1;
                                                 Query Plan
----------------------------------------------------------------------------------------------
 - Output[regionkey, _col1] => [regionkey:bigint, count:bigint]
         _ Col1: = count?
     - RemoteExchange[GATHER] => regionkey:bigint, count:bigint
         - Aggregate(FINAL)[regionkey] => [regionkey:bigint, count
:bigint]
                count := "count"("count_8")
             - LocalExchange[HASH][$hashvalue] ("regionkey") =>
regionkey:bigint, count_8:bigint, $hashvalue:bigint
                 - RemoteExchange[REPARTITION][$hashvalue_9] =>
regionkey:bigint, count_8:bigint, $hashvalue_9:bigint
                     - Project[] => [regionkey:bigint, count_8:
bigint, $hashvalue_10:bigint]
                             $hashvalue_10 := "combine_hash"(
BIGINT '0', COALESCE("$operator$hash_code"("regionkey"), 0))
                         - Aggregate(PARTIAL)[regionkey] => [
regionkey:bigint, count_8:bigint]
                                 count_8 := "count"(*)
                             - TableScan[tpch:tpch:nation:sf0.1,
originalConstraint = true] => [regionkey:bigint]
                                     regionkey := tpch:regionkey
```

- Example two

Distributed plan:

```
presto:tiny> EXPLAIN (TYPE DISTRIBUTED) SELECT regionkey, count
(*) FROM nation GROUP BY 1;
                                           Query Plan
----------------------------------------------------------------------------------------------
 Fragment 0 [SINGLE]
     Output layout: [regionkey, count]
     Output partitioning: SINGLE []
     - Output[regionkey, _col1] => [regionkey:bigint, count:bigint
]
             _col1 := count
         - RemoteSource[1] => [regionkey:bigint, count:bigint]
 Fragment 1 [HASH]
     Output layout: [regionkey, count]
     Output partitioning: SINGLE []
     - Aggregate(FINAL)[regionkey] => [regionkey:bigint, count:
bigint]
             count := "count"("count_8")
         - LocalExchange[HASH][$hashvalue] ("regionkey") =>
regionkey:bigint, count_8:bigint, $hashvalue:bigint
             - RemoteSource[2] => [regionkey:bigint, count_8:
bigint, $hashvalue_9:bigint]
 Fragment 2 [SOURCE]
     Output layout: [regionkey, count_8, $hashvalue_10]
     Output partitioning: HASH [regionkey][$hashvalue_10]
     - Project[] => [regionkey:bigint, count_8:bigint, $hashvalue_
10:bigint]
             $hashvalue_10 := "combine_hash"(BIGINT '0', COALESCE
("$operator$hash_code"("regionkey"), 0))
```

```
          - Aggregate(PARTIAL)[regionkey] => [regionkey:bigint,
count_8:bigint]
                 count_8 := "count"(*)
              - TableScan[tpch:tpch:nation:sf0.1, originalCo
nstraint = true] => [regionkey:bigint]
                     regionkey := tpch:regionkey
```

- Example three:

  Validation:

```
presto:tiny> EXPLAIN (TYPE VALIDATE) SELECT regionkey, count(*)
FROM nation GROUP BY 1;
 Valid
-------
 true
```

EXPLAIN ANALYZE

- Synopsis

```
EXPLAIN ANALYZE [VERBOSE] statement
```

- Description

  Executes the statement and shows the distributed execution plan of the statement along with the cost of each operation. The `VERBOSE` option gives more detailed information and low-level statistics.

- Examples

  In the following example, you can see the CPU time spent in each stage, as well as the relative cost of each plan node in the stage. Note that the relative cost of the plan nodes is based on wall time, which may or may not be correlated to CPU time. For each plan node you can see some additional statistics, which are useful if you want to detect data anomalies for a query (skewness, abnormal hash collisions).

```
presto:sf1> EXPLAIN ANALYZE SELECT count(*), clerk FROM orders WHERE
 orderdate > date '1995-01-01' GROUP BY clerk;
                                          Query Plan
--------------------------------------------------------------------------------
Fragment 1 [HASH]
    Cost: CPU 88.57ms, Input: 4000 rows (148.44kB), Output: 1000
rows (28.32kB)
    Output layout: [count, clerk]
    Output partitioning: SINGLE []
    - Project[] => [count:bigint, clerk:varchar(15)]
            Cost: 26.24%, Input: 1000 rows (37.11kB), Output: 1000
rows (28.32kB), Filtered: 0.00%
            Input avg.: 62.50 lines, Input std.dev.: 14.77%
        - Aggregate(FINAL)[clerk][$hashvalue] => [clerk:varchar(15),
 $hashvalue:bigint, count:bigint]
                Cost: 16.83%, Output: 1000 rows (37.11kB)
                Input avg.: 250.00 lines, Input std.dev.: 14.77%
```

```
                count := "count"("count_8")
            - LocalExchange[HASH][$hashvalue] ("clerk") => clerk:
varchar(15), count_8:bigint, $hashvalue:bigint
                    Cost: 47.28%, Output: 4000 rows (148.44kB)
                    Input avg.: 4000.00 lines, Input std.dev.: 0.00%
                - RemoteSource[2] => [clerk:varchar(15), count_8:
bigint, $hashvalue_9:bigint]
                        Cost: 9.65%, Output: 4000 rows (148.44kB)
                        Input avg.: 4000.00 lines, Input std.dev.: 0
.00%
Fragment 2 [tpch:orders:1500000]
    Cost: CPU 14.00s, Input: 818058 rows (22.62MB), Output: 4000
rows (148.44kB)
    Output layout: [clerk, count_8, $hashvalue_10]
    Output partitioning: HASH [clerk][$hashvalue_10]
    - Aggregate(PARTIAL)[clerk][$hashvalue_10] => [clerk:varchar(15
), $hashvalue_10:bigint, count_8:bigint]
            Cost: 4.47%, Output: 4000 rows (148.44kB)
            Input avg.: 204514.50 lines, Input std.dev.: 0.05%
            Collisions avg.: 5701.28 (17569.93% est.), Collisions
std.dev.: 1.12%
            count_8 := "count"(*)
        - ScanFilterProject[table = tpch:tpch:orders:sf1.0,
originalConstraint = ("orderdate" > "$literal$date"(BIGINT '9131
')), filterPredicate = ("orderdate" > "$literal$date"(BIGINT '9131
'))] => [cler
                Cost: 95.53%, Input: 1500000 rows (0B), Output:
818058 rows (22.62MB), Filtered: 45.46%
                Input avg.: 375000.00 lines, Input std.dev.: 0.00%
                $hashvalue_10 := "combine_hash"(BIGINT '0', COALESCE
("$operator$hash_code"("clerk"), 0))
                orderdate := tpch:orderdate
                clerk := tpch:clerk
```

When the `VERBOSE` option is used, some operators may report additional information.

```
EXPLAIN ANALYZE VERBOSE SELECT count(clerk) OVER() FROM orders WHERE
 orderdate > date '1995-01-01';
                                          Query Plan
------------------------------------------------------------------------------------
  ...
         - Window[] => [clerk:varchar(15), count:bigint]
                 Cost: {rows: ?, bytes: ?}
                 CPU fraction: 75.93%, Output: 8130 rows (230.24kB)
                 Input avg.: 8130.00 lines, Input std.dev.: 0.00%
                 Active Drivers: [ 1 / 1 ]
                 Index size: std.dev.: 0.00 bytes , 0.00 rows
                 Index count per driver: std.dev.: 0.00
                 Rows per driver: STD. Dev.: 0.00
                 Size of partition: std.dev.: 0.00
                 count := count("clerk")
 ...
```

GRANT

- **Synopsis**

```
GRANT ( privilege [, ...] | ( ALL PRIVILEGES ) )
ON [ TABLE ] table_name TO ( grantee | PUBLIC )
```

```
[ WITH GRANT OPTION ]
```

- Description

  Grants the specified privileges to the specified grantee.

  - Specifying `ALL PRIVILEGES` grants DELETE, INSERT and SELECT privileges.
  - Specifying `PUBLIC` grants privileges to the PUBLIC role and hence to all users.
  - The optional `WITH GRANT OPTION` clause allows the grantee to grant these same privileges to others.
- Examples

```
GRANT INSERT, SELECT ON orders TO alice; --- Grant privileges to
user alice
GRANT SELECT ON nation TO alice WITH GRANT OPTION; --- Grant SELECT
 privilege to user alice, additionally allowing alice to grant **
SELECT** privilege to others
GRANT SELECT ON orders TO PUBLIC; --- Grant **SELECT** privilege on
the table order to everyone
```

- Limitations

  Some connectors have no support for `GRANT`.

INSERT

- Synopsis

```
INSERT INTO table_name [ ( column [, ... ] ) ] query
```

- Description

  Inserts new rows into a table. If the list of column names is specified, they must exactly match the list of columns produced by the `query`. Each column in the table not present in the column list is filled with a `null` value.
- Examples

```
INSERT INTO orders SELECT * FROM new_orders; --- Insert the SELECT
results into the orders table.
INSERT INTO cities VALUES (1, 'San Francisco'); --- Insert a single
row
INSERT INTO cities VALUES (2, 'San Jose'), (3, 'Oakland'); ---
Insert multiple rows
INSERT INTO nation (nationkey, name, regionkey, comment) VALUES (26,
 'POLAND', 3, 'no comment'); --- Insert a single row
```

```
INSERT INTO nation (nationkey, name, regionkey) VALUES (26, 'POLAND
', 3); --- Inserts a single row (only includes some columns)
```

PREPARE

- Synopsis

```
PREPARE statement_name FROM statement
```

- Description

Prepares a statement for execution at a later time. Prepared statements are queries saved in a session with a given name. The statement can include parameters in place of literals to be replaced at execution time. Parameters are represented by ?.

- Examples

```
--- Prepare a query that does not include parameters
PREPARE my_select1 FROM
SELECT * FROM nation;
--- Prepare a query that includes parameters
PREPARE my_select2 FROM
SELECT name FROM nation WHERE regionkey = ? AND nationkey < ? ;
--- Prepare an insert statement that does not include parameters
PREPARE my_insert FROM
INSERT INTO cities VALUES (1, 'San Francisco');
```

RESET SESSION

- Synopsis

```
RESET SESSION name
RESET SESSION catalog.name
```

- Description

Reset a session property value to the default value.

- Examples

```
RESET SESSION optimize_hash_generation;
RESET SESSION hive.optimized_reader_enabled;
```

REVOKE

- Synopsis

```
REVOKE [ GRANT OPTION FOR ]
(Privilege [,...] | ALL PRIVILEGES )
ON [ TABLE ] table_name FROM ( grantee | PUBLIC )
```

- Description

Revokes the specified privileges from the specified grantee.

    - Specifying `ALL PRIVILEGE` revokes `SELECT`, `INSERT` and `DELETE` privileges.
    - Specifying `PUBLIC` revokes privileges from the `PUBLIC` role. Users will retain privileges assigned to them directly or via other roles.
    - The optional `GRANT OPTION FOR` clause also revokes the privileges to `GRANT` the specified privileges.
    - Usage of the term `grantee` denotes both users and roles.
- Examples

```
--- Revoke INSERT and SELECT privileges on the table orders from
user alice
REVOKE INSERT, SELECT ON orders FROM alice;
--- Revoke SELECT privilege on the table nation from everyone,
--- additionally revoking the privilege to grant SELECT privilege to
 others
REVOKE GRANT OPTION FOR SELECT ON nation FROM PUBLIC;
--- Revoke all privileges on the table test from user alice
REVOKE ALL PRIVILEGES ON test FROM alice;
```

- Limitations

  Some connectors have no support for `REVOKE`.

ROLLBACK

- Synopsis

```
ROLLBACK [ WORK ]
```

- Description

  Rollback the current transaction.

- Examples

```
ROLLBACK;
ROLLBACK WORK;
```

SELECT

- Synopsis

```
[ WITH with_query [, ...] ]
SELECT [ ALL | DISTINCT ] select_expr [, ...]
[ FROM from_item [, ...] ]
[ WHERE condition ]
[ GROUP BY [ ALL | DISTINCT ] grouping_element [, ...] ]
[ HAVING condition]
[ { UNION | INTERSECT | EXCEPT } [ ALL | DISTINCT ] select ]
[ ORDER BY expression [ ASC | DESC ] [, ...] ]
```

```
[ LIMIT [ count | ALL ] ]
```

where `from_item` is one of:

```
Table_name [[as] alias [(column_alias [,...] ) ] ]
```

```
From_item join_type from_item [ON join_condition | using (join_colum
n [,...] ) ]
```

and `join_type` is one of:

- [INNER] JOIN
- LEFT [OUTER] JOIN
- RIGHT [OUTER] JOIN
- FULL [OUTER] JOIN
- CROSS JOIN

and `grouping_element` is one of:

- ()
- expression
- GROUPING SETS ((column [, …]) [, …])
- CUBE (column [, …])
- ROLLUP (column [, …])

- **Description**

  Retrieve rows from zero or more tables to get data sets.

- **WITH clause**

  - Basic functions

    The WITH clause defines named relations for use within a query. It allows flattening nested queries or simplifying subqueries. For example, the following queries are equivalent:

    ```
    --- The WITH clause is not used
    SELECT a, b
    FROM (
      SELECT a, MAX(b) AS b FROM t GROUP BY a
    ) AS x;
    --- The WITH clause is used, and the query statement looks to be
    much clearer
    WITH x AS (SELECT a, MAX(b) AS b FROM t GROUP BY a)
    SELECT a, b FROM x;
    ```

  - Define multiple subqueries

The WITH clause can be used to define multiple subqueries:

```
WITH
  t1 AS (SELECT a, MAX(b) AS b FROM x GROUP BY a),
  t2 AS (SELECT a, AVG(d) AS d FROM y GROUP BY a)
SELECT t1.*, t2. *
FROM t1
JOIN t2 ON t1.a = t2.a;
```

- Form a chain structure

Additionally, the relations within a WITH clause can chain:

```
WITH
  x AS (SELECT a FROM t),
  y AS (SELECT a AS b FROM x),
  z AS (SELECT b AS c FROM y)
SELECT c FROM z;
```

- GROUP BY clause

- Basic functions

The `GROUP BY` clause divides the output of a `SELECT` statement into groups of rows containing matching values. A simple `GROUP BY` clause may contain any expression composed of input columns or it may be an ordinal number selecting an output column by position (starting at one).

The following queries are equivalent (position for the `nationkey` column is two).

```
--- Using the ordinal number
SELECT count(*), nationkey FROM customer GROUP BY 2;
--- Using the input column name
SELECT count(*), nationkey FROM customer GROUP BY nationkey;
```

`GROUP BY` clauses can group output by input column names not appearing in the output of a select statement, for example:

```
--- The mktsegment column has not been specified in the SELECT
list.
--- The result set does not contain content of the mktsegment
column.
SELECT count(*) FROM customer GROUP BY mktsegment;
 _col0
-------
 29968
 30142
 30189
 29949
 29752
```

```
(5 rows)
```

Note:

When a `GROUP BY` BY clause is used in a `SELECT` statement, all output expressions must be either aggregate functions or columns present in the `GROUP BY` BY clause.

- Complex grouping operations

Presto supports the following three complex aggregation syntaxes, which allows users to perform analysis that requires aggregation on multiple sets of columns in a single query:

- GROUPING SETS

  `CUBE` `ROLLUP`

  The shipping table is a data table with five columns, which are shown as follows:

```
SELECT * FROM shipping;
 origin_state | origin_zip | destination_state | destinatio
n_zip | package_weight
--------------+------------+-------------------
+------------------+----------------
 California   |      94131 | New Jersey        |
8648 |            13
 California   |      94131 | New Jersey        |
8540 |            42
 New Jersey   |       7081 | Connecticut       |
6708 |           225
 California   |      90210 | Connecticut       |
6927 |          1337
 California   |      94131 | Colorado          |
80302 |            5
 New York     |      10002 | New Jersey        |
8540 |             3
(6 rows)
```

  Now we want to retrieve the following grouping results using a single query statement:

  - Group by origin_state, and get the total package_weight.
  - Group by origin_state and origin_zip, and get the total package_weight.
  - Group by destination_state, and get the total package_weight.

  `GROUPING SETS` allows users to retrieve the result set of the above three groups with a single query statement, as shown below:

```
SELECT origin_state, origin_zip, destination_state, sum(
package_weight)
FROM shipping
GROUP BY GROUPING SETS (
    (origin_state),
    (origin_state, origin_zip),
    (destination_state));
```

```
 origin_state | origin_zip | destination_state | _col0
--------------+------------+-------------------+-------
 New Jersey   | NULL       | NULL              |   225
 California   | NULL       | NULL              |  1397
 New York     | NULL       | NULL              |     3
 California   |      90210 | NULL              |  1337
 California   |      94131 | NULL              |    60
 New Jersey   |       7081 | NULL              |   225
 New York     |      10002 | NULL              |     3
 NULL         | NULL       | Colorado          |     5
 NULL         | NULL       | New Jersey        |    58
 NULL         | NULL       | Connecticut       |  1562
(10 rows)
```

The preceding query may be considered logically equivalent to a `UNION ALL` of multiple `GROUP BY` queries:

```
SELECT origin_state, NULL, NULL, sum(package_weight)
FROM shipping GROUP BY origin_state
UNION ALL
SELECT origin_state, origin_zip, NULL, sum(package_weight)
FROM shipping GROUP BY origin_state, origin_zip
UNION ALL
SELECT NULL, NULL, destination_state, sum(package_weight)
FROM shipping GROUP BY destination_state;
```

However, the query with the complex grouping syntax (such as `GROUPING SETS`) only reads from the underlying data source once, while the query with the `UNION ALL` reads the underlying data three times. This is why queries with a `UNION ALL` may produce inconsistent results when the data source is not deterministic.

- CUBE

  The **CUBE** operator generates all possible grouping sets for a given set of columns. For example, the query:

```
SELECT origin_state, destination_state, sum(package_weight)
FROM shipping
Group by cube (glas_state, destiny _ State );
 origin_state | destination_state | _col0
--------------+-------------------+-------
 California   | New Jersey        |    55
 California   | Colorado          |     5
 New York     | New Jersey        |     3
 New Jersey   | Connecticut       |   225
 California   | Connecticut       |  1337
 California   | NULL              |  1397
 New York     | NULL              |     3
 New Jersey   | NULL              |   225
 NULL         | New Jersey        |    58
 NULL         | Connecticut       |  1562
 NULL         | Colorado          |     5
 NULL         | NULL              |  1625
```

```
(12 rows)
```

is equivalent to:

```
SELECT origin_state, destination_state, sum(package_weight)
FROM shipping
GROUP BY GROUPING SETS (
    (origin_state, destination_state),
    (origin_state),
    (destination_state),
    ());
```

- ROLLUP

  The **ROLLUP** operator generates all possible subtotals for a given set of columns. For example, the query:

```
SELECT origin_state, origin_zip, sum(package_weight)
FROM shipping
GROUP BY ROLLUP (origin_state, origin_zip);
 origin_state | origin_zip | _col2
--------------+------------+-------
 California   |      94131 |    60
 California   |      90210 |  1337
 New Jersey   |       7081 |   225
 New York     |      10002 |     3
 California   | NULL       |  1397
 New York     | NULL       |     3
 New Jersey   | NULL       |   225
 NULL         | NULL       |  1625
(8 rows)
```

  is equivalent to:

```
SELECT origin_state, origin_zip, sum(package_weight)
FROM shipping
GROUP BY GROUPING SETS ((origin_state, origin_zip), (origin_sta
te), ());
```

- Combining multiple grouping expressions

  The following three statements are equivalent:

```
SELECT origin_state, destination_state, origin_zip, sum(
package_weight)
FROM shipping
GROUP BY
    GROUPING SETS ((origin_state, destination_state)),
    ROLLUP (origin_zip);
```

```
SELECT origin_state, destination_state, origin_zip, sum(
package_weight)
FROM shipping
GROUP BY
    GROUPING SETS ((origin_state, destination_state)),
```

```
    GROUPING SETS ((origin_zip), ());
```

```
SELECT origin_state, destination_state, origin_zip, sum(
package_weight)
FROM shipping
GROUP BY GROUPING SETS (
    (origin_state, destination_state, origin_zip),
    (origin_state, destination_state));
```

Output results are as follows:

```
origin_state | destination_state | origin_zip | _col3
--------------+-------------------+------------+-------
 New York     | New Jersey        |      10002 |     3
 California   | New Jersey        |      94131 |    55
 New Jersey   | Connecticut       |       7081 |   225
 California   | Connecticut       |      90210 |  1337
 California   | Colorado          |      94131 |     5
 New York     | New Jersey        | NULL       |     3
 New Jersey   | Connecticut       | NULL       |   225
 California   | Colorado          | NULL       |     5
 California   | Connecticut       | NULL       |  1337
 California   | New Jersey        | NULL       |    55
(10 rows)
```

In a `GROUP BY` clause, the `ALL` and `DISTINCT` quantifiers determine whether duplicate grouping sets each produce distinct output rows. For example, the query:

```
SELECT origin_state, destination_state, origin_zip, sum(
package_weight)
FROM shipping
GROUP BY ALL
    CUBE (origin_state, destination_state),
    ROLLUP (origin_state, origin_zip);
```

is equivalent to

```
SELECT origin_state, destination_state, origin_zip, sum(
package_weight)
FROM shipping
GROUP BY GROUPING SETS (
    (origin_state, destination_state, origin_zip),
    (origin_state, origin_zip),
    (origin_state, destination_state, origin_zip),
    (origin_state, origin_zip),
    (origin_state, destination_state),
    (origin_state),
    (origin_state, destination_state),
    (origin_state),
    (origin_state, destination_state),
    (origin_state),
    (destination_state),
```

```
    ());
```

Multiple duplicate grouping sets are available. However, if the query uses the `DISTINCT` quantifier, only unique grouping sets are generated.

```
SELECT origin_state, destination_state, origin_zip, sum(
package_weight)
FROM shipping
GROUP BY DISTINCT
    CUBE (origin_state, destination_state),
    ROLLUP (origin_state, origin_zip);
```

is equivalent to

```
SELECT origin_state, destination_state, origin_zip, sum(
package_weight)
FROM shipping
GROUP BY GROUPING SETS (
    (origin_state, destination_state, origin_zip),
    (origin_state, origin_zip),
    (origin_state, destination_state),
    (origin_state),
    (destination_state),
    ());
```

Note:

The default set quantifier for `GROUP BY` BY is `ALL`.

- GROUPING operation

  Presto provides a `grouping` operation that returns a bit set converted to decimal, indicating which columns are present in a grouping. The semantics is demonstrated as follows:

```
grouping(col1, ..., colN) -> bigint
```

`grouping` is used in conjunction with `GROUPING SETS`, `ROLLUP`, `CUBE`, or `GROUP BY`. `grouping` columns must match exactly the columns referenced in the corresponding `GROUPING SETS`, `ROLLUP`, `CUBE`, or `GROUP BY` clause.

```
SELECT origin_state, origin_zip, destination_state, sum(package_we
ight),
       grouping(origin_state, origin_zip, destination_state)
FROM shipping
GROUP BY GROUPING SETS (
        (origin_state),
        (origin_state, origin_zip),
        (destination_state));
origin_state | origin_zip | destination_state | _col3 | _col4
--------------+------------+-------------------+-------+-------
California   | NULL       | NULL              |  1397 |     3
 --- 011
New Jersey   | NULL       | NULL              |   225 |     3
 --- 011
```

```
New York     | NULL       | NULL              |     3 |      3
 --- 011
California   |      94131 | NULL              |    60 |      1
 --- 001
New Jersey   |       7081 | NULL              |   225 |      1
 --- 001
California   |      90210 | NULL              |  1337 |      1
 --- 001
New York     |      10002 | NULL              |     3 |      1
 --- 001
NULL         | NULL       | New Jersey        |    58 |      6
 --- 100
NULL         | NULL       | Connecticut       |  1562 |      6
 --- 100
NULL         | NULL       | Colorado          |     5 |      6
 --- 100
(10 rows)
```

As shown in the preceding table, bits are assigned to the argument columns with the rightmost column being the least significant bit. For a given `grouping`, a bit is set to 0 if the corresponding column is included in the grouping and to 1 otherwise.

- HAVING clause

  The `HAVING` clause is used in conjunction with aggregate functions and the `GROUP BY` clause to control which groups are selected. A `HAVING` clause will be executed after completion of grouping and aggregation, to eliminate groups that do not satisfy the given conditions.

  The following example selects user groups with an account balance greater than 5700000:

```
SELECT count(*), mktsegment, nationkey,
       CAST(sum(acctbal) AS bigint) AS totalbal
FROM customer
GROUP BY mktsegment, nationkey
HAVING sum(acctbal) > 5700000
ORDER BY totalbal DESC;
```

  The output is as follows:

```
_col0 | mktsegment | nationkey | totalbal
-------+------------+-----------+----------
  1272 | AUTOMOBILE |        19 |  5856939
  1253 | FURNITURE  |        14 |  5794887
  1248 | FURNITURE  |         9 |  5784628
  1243 | FURNITURE  |        12 |  5757371
  1231 | HOUSEHOLD  |         3 |  5753216
  1251 | MACHINERY  |         2 |  5719140
  1247 | FURNITURE  |         8 |  5701952
(7 rows)
```

- Set operations

Presto supports three set operations, namely `UNION`, `INTERSECT`, and `EXCEPT`. These clauses are used to combine the results of more than one query statement into a single result set. The usage is as follows:

```
query UNION [ALL | DISTINCT] query
query INTERSECT [DISTINCT] query
query EXCEPT [DISTINCT] query
```

The argument **`ALL`** or **`DISTINCT`** controls which rows are included in the final result set, and the default is **`DISTINCT`**.

- **`ALL`**: may return duplicated rows;
- parmnamepar **`DISTINCT`**parmname : eliminates duplicated rows.

The **`ALL`** argument is not supported for `INTERSECT` or `EXCEPT`.

The above three set operations are processed left to right, and `INTERSECT` has the highest priority. That means `A UNION B INTERSECT C EXCEPT D` is the same as `A UNION (B INTERSECT C) EXCEPT D`.

- UNION

  `UNION` combines two query result sets, and uses the **`ALL`** and **`DISTINCT`** arguments to control whether or not to remove duplicates.

  - Example one

```
SELECT 13
UNION
Select 42;
 _col0
-------
    13
    42
(2 rows)
```

  - Example two

```
SELECT 13
UNION
SELECT * FROM (VALUES 42, 13);
 _col0
-------
    13
    42
(2 rows)
```

  - Example three:

```
SELECT 13
UNION ALL
```

```
SELECT * FROM (VALUES 42, 13);
 _col0
-------
    13
    42
    13
(3 rows)
```

- INTERSECT

  `INTERSECT` returns only the rows that are in both query result sets.

  Examples

```
SELECT * FROM (VALUES 13, 42)
INTERSECT
SELECT 13;
 _col0
-------
   13
(1 row)
```

- EXCEPT

  `EXCEPT` returns the rows that are in the result set of the first query, but not the second.

```
SELECT * FROM (VALUES 13, 42)
EXCEPT
SELECT 13;
 _col0
-------
   42
(1 row)
```

- ORDER BY clause

  The `ORDER BY` clause is used to sort a result set. The semantics is demonstrated as follows:

```
ORDER BY expression [ ASC | DESC ] [ NULLS { FIRST | LAST } ]
 [, ...]
```

  Where:

  - Each **`expression`** may be composed of output columns or it may be an ordinal number selecting an output column by position (starting at one).
  - The `ORDER BY` clause is the last step of a query after any `GROUP BY` or `HAVING` clause;
  - **`NULLS { FIRST | LAST }`** is used to control the sorting method of the **`NULL`** value (regardless of `ASC` or `DESC`), and the default null ordering is `LAST`.

- LIMIT clause

  The `LIMIT` clause restricts the number of rows in the result set. `LIMIT ALL` is the same as omitting the `LIMIT` clause.

Examples

```
In this example, because the query lacks an ORDER BY, exactly which
rows are returned is arbitrary.
SELECT orderdate FROM orders LIMIT 5;
 orderdate
-------------
 1996-04-14
 1992-01-15
 1995-02-01
 1995-11-12
 1992-04-26
(5 rows)
```

- TABLESAMPLE

Presto provides two sampling methods, namely `BERNOULLI` and `SYSTEM`. However, neither of the two methods allow deterministic bounds on the number of rows returned.

- `BERNOULLI`:

  Each row is selected to be in the table sample with a probability of the sample percentage . When a table is sampled using the Bernoulli method, all physical blocks of the table are scanned and certain rows are skipped based on a comparison between the sample percentage and a random value calculated at runtime.

  The probability of a row being included in the result is independent from any other row. This does not reduce the time required to read the sampled table from disk. It may have an impact on the total query time if the sampled output is processed further.

- `SYSTEM`

  This sampling method divides the table into logical segments of data and samples the table at this granularity. This sampling method either selects all the rows from a particular segment of data or skips it (based on a comparison between the sample percentage and a random value calculated at runtime).

  The rows selected in a system sampling is dependent on which connector is used. For example, when used with Hive, it is dependent on how the data is laid out on HDFS. This method does not guarantee independent sampling probabilities.

Examples

```
--- Using BERNOULLI sampling
SELECT *
FROM users TABLESAMPLE BERNOULLI (50);
--- Using system sampling
SELECT *
FROM users TABLESAMPLE SYSTEM (75);
```

```
Using sampling with joins:
--- Using sampling with JOIN
SELECT o.*, i. *
FROM orders o TABLESAMPLE SYSTEM (10)
JOIN lineitem i TABLESAMPLE BERNOULLI (40)
  ON o.orderkey = i.orderkey;
```

- UNNEST

`UNNEST` can be used to expand an ARRAY or MAP into a relation. Arrays are expanded into a single column, and maps are expanded into two columns (key, value). `UNNEST` can also be used with multiple arrays and maps, in which case they are expanded into multiple columns, with as many rows as the highest cardinality argument (the other columns are padded with nulls). `UNNEST` can optionally have a `WITH ORDINALITY`clause, in which case an additional ordinal column is added to the end. `UNNEST` is normally used with a `JOIN` and can reference columns from relations on the left side of the join.

- Example one

```
--- Using a single column
SELECT student, score
FROM tests
CROSS JOIN UNNEST(scores) AS t (score);
```

- Example two

```
--- Using multiple columns
SELECT numbers, animals, n, a
FROM (
  VALUES
    (ARRAY[2, 5], ARRAY['dog', 'cat', 'bird']),
    (ARRAY[7, 8, 9], ARRAY['cow', 'pig'])
) AS x (numbers, animals)
CROSS JOIN UNNEST(numbers, animals) AS t (n, a);
  numbers  |     animals      |  n   |  a
-----------+------------------+------+------
 [2, 5]    | [dog, cat, bird] |    2 | dog
 [2, 5]    | [dog, cat, bird] |    5 | cat
 [2, 5]    | [dog, cat, bird] | NULL | bird
 [7, 8, 9] | [cow, pig]       |    7 | cow
 [7, 8, 9] | [cow, pig]       |    8 | pig
 [7, 8, 9] | [cow, pig]       |    9 | NULL
(6 rows)
```

- Example three:

```
--- Using a WITH ORDINALITY clause
SELECT numbers, n, a
FROM (
  VALUES
    (ARRAY[2, 5]),
    (ARRAY[7, 8, 9])
) AS x (numbers)
CROSS JOIN UNNEST(numbers) WITH ORDINALITY AS t (n, a);
  numbers  | n | a
```

```
-----------+---+---
 [2, 5]    | 2 | 1
 [2, 5]    | 5 | 2
 [7, 8, 9] | 7 | 1
 [7, 8, 9] | 8 | 2
 [7, 8, 9] | 9 | 3
(5 rows)
```

- Joins

Joins allow you to combine data from multiple relations. A `CROSS JOIN` returns the *Cartesian product* of two relations (all combinations). `CROSS JOIN` can either be specified using

- the explicit `CROSS JOIN` syntax, or
- by specifying multiple relations in the `FROM` clause.

Both of the following queries are equivalent:

```
--- using the explicit **CROSS JOIN** syntax
SELECT *
FROM nation
CROSS JOIN region;
--- specifying multiple relations in the **FROM** clause
VALUES
FROM nation, region;
```

Examples: The nation table contains 25 rows and the region table contains 5 rows, so a cross join between the two tables produces 125 rows:

```
SELECT n.name AS nation, r.name AS region
FROM nation AS n
CROSS JOIN region AS r
ORDER BY 1, 2;
     nation     |   region
----------------+-------------
 ALGERIA        | AFRICA
 ALGERIA        | AMERICA
 ALGERIA        | ASIA
 ALGERIA        | EUROPE
 ALGERIA        | MIDDLE EAST
 ARGENTINA      | AFRICA
 ARGENTINA      | AMERICA
...
(125 rows)
```

When two relations in a join have columns with the same name, the column references must be qualified using the relation name (or alias).

```
--- Correct
SELECT nation.name, region.name
FROM nation
CROSS JOIN region;
--- Correct
SELECT n.name, r.name
```

```
FROM nation AS n
CROSS JOIN region AS r;
--- Correct
SELECT n.name, r.name
FROM nation n
CROSS JOIN region r;
--- Wrong, it will raise the "Column 'name' is ambiguous" error
SELECT name
FROM nation
CROSS JOIN region;
```

- Subquery

A subquery is an expression which is composed of a query. The subquery is correlated when it refers to columns outside of the subquery. Presto has limited support for correlated subqueries.

  - EXISTS

    The `EXISTS` predicate determines if a subquery returns any rows. If subquery returns any rows, the WHERE expression is TRUE, and FALSE if otherwise.

    Examples

```
SELECT name
FROM nation
WHERE EXISTS (SELECT * FROM region WHERE region.regionkey =
nation.regionkey);
```

  - IN

    The IN predicate determines if any columns specified by `WHERE` are included in the result set produced by the subquery. If yes, it returns results, and does not return results if otherwise. The subquery must produce exactly one column.

    Examples

```
SELECT name
FROM nation
WHERE regionkey IN (SELECT regionkey FROM region);
```

  - Scalar subquery

    A scalar subquery is a non-correlated subquery that returns zero or one row. The subquery cannot produce more than one row. The returned value is NULL if the subquery produces no rows.

    Examples

```
SELECT name
FROM nation
```

```
WH ERregionkey = (SELECT max(regionkey) FROM regio;);
```

SET SESSION

- Synopsis

```
SET SESSION name = expression
SET SESSION catalog.name = expression
```

- Description

  Sets a session property value.

- Examples

```
SET SESSION optimize_hash_generation = true;
SET SESSION hive.optimized_reader_enabled = true;
```

SHOW CATALOGS

- Synopsis

```
SHOW CATALOGS [ LIKE pattern ]
```

- Description

  Lists the available catalogs. The `LIKE` clause can be used to filter the catalog names.

- Examples

```
SHOW CATALOGS;
```

SHOW COLUMNS

- Synopsis

```
SHOW COLUMNS FROM table
```

- Description

  Lists the columns in a given table along with their data type and other attributes.

- Examples

```
SHOW COLUMNS FROM orders;
```

SHOW CREATE TABLE

- Synopsis

```
SHOW CREATE TABLE table_name
```

- Description

Shows the SQL statement that creates the specified table.

- Examples

```
SHOW CREATE TABLE sf1.orders;
-----------------------------------------
 CREATE TABLE tpch.sf1.orders (
    orderkey bigint,
    orderstatus varchar,
    totalprice double,
    orderdate varchar
 )
 WITH (
    format = 'ORC',
    partitioned_by = ARRAY['orderdate']
 )
(1 row)
```

SHOW CREATE VIEW

- Synopsis

```
SHOW CREATE VIEW view_name
```

- Description

Shows the SQL statement that creates the specified view.

- Examples

```
SHOW CREATE VIEW view1;
```

SHOW FUNCTIONS

- Synopsis

```
SHOW FUNCTIONS
```

- Description

List all the functions available for use in queries.

- Examples

```
SHOW FUNCTIONS
```

SHOW GRANTS

- Synopsis

```
SHOW GRANTS [ ON [ TABLE ] table_name ]
```

- Description

Lists the grants for the current user on the specified table in the current catalog.

- Examples

```
--- List the grants for the current user on table orders
SHOW GRANTS ON TABLE orders;
--- List the grants for the current user on all the tables in all
schemas of the current catalog
SHOW GRANTS;
```

- Limitations

Some connectors have no support for `SHOW GRANTS`.

SHOW SCHEMAS

- Synopsis

```
SHOW SCHEMAS [ FROM catalog ] [ LIKE pattern ]
```

- Description

Lists all schemas in the specified catalog, or in the current catalog if no catalog has been specified. The `LIKE` clause can be used to filter the schema names.

- Examples

```
SHOW SCHEMAS;
```

SHOW SESSION

- Synopsis

```
SHOW SESSION
```

- Description

Lists the current session properties.

- Examples

```
SHOW SESSION
```

SHOW TABLES;

- Synopsis

```
SHOW TABLES [ FROM schema ] [ LIKE pattern ]
```

- Description

Lists all tables in the specified schema, or in the current schema if no schema has been specified. The `LIKE` clause can be used to filter the table name.

- Examples

```
SHOW TABLES;
```

START TRANSACTION

- Synopsis

```
START TRANSACTION [ mode [, ...] ]
where **mode** is one of:
ISOLATION LEVEL { READ UNCOMMITTED | READ COMMITTED | REPEATABLE
READ | SERIALIZABLE }
READ { ONLY | WRITE }
```

- Description

Starts a new transaction for the current session.

- Examples

```
START TRANSACTION;
START TRANSACTION ISOLATION LEVEL REPEATABLE READ;
START TRANSACTION READ WRITE;
START TRANSACTION ISOLATION LEVEL READ COMMITTED, READ ONLY;
START TRANSACTION READ WRITE, ISOLATION LEVEL SERIALIZABLE;
```

USE

- Synopsis

```
USE catalog.schema
USE schema
```

- Description

Updates the session to use the specified catalog and schema. If a catalog is not specified, the schema is resolved relative to the current catalog.

- Examples

```
USE hive.finance;
USE information_schema;
```

VALUES

- Synopsis

```
VALUES row [, ...]
where **row** is a single expression or
```

```
( column_expression [, ...] )
```

- Description

  Defines a literal inline table.

  - `VALUE` can be used anywhere a query can be used. For example, behind the `FROM` clause of a `SELECT`, in an `INSERT`, or even at the top level.
  - `VALUE` creates an anonymous table without column names by default. The table and columns can be named using an `AS` clause.
- Examples

```
--- Return a table with one column and three rows
VALUES 1, 2, 3
--- Return a table with two columns and three rows
VALUES
    (1, 'a'),
    (2, 'b'),
    (3, 'c')
--- Using in a query statement:
SELECT * FROM (
    VALUES
        (1, 'a'),
        (2, 'b'),
        (3, 'c')
) AS t (id, name)
--- Create a table
CREATE TABLE example AS
SELECT * FROM (
    VALUES
        (1, 'a'),
        (2, 'b'),
        (3, 'c')
) AS t (id, name)
```

11.8.7 Technical support

Technical support

For any questions, contact technical support:

- *Open a ticket*

11.9 TensorFlow instructions

TensorFlow is supported by E-MapReduce 3.13.0 and later versions. Users can add the TensorFlow component from available services in software configurations. When using

TensorFlow in E-MapReduce to perform high-performance computing, you can allocate CPU and GPU resources through YARN.

Preparations

- On the software side, an E-MapReduce cluster installs TensorFlow and a TensorFlow on Yarn (TOY) toolkit.
- On the hardware side, E-MapReduce supports computing using both CPU and GPU resources. If you need to use GPU computing, you can choose ECS instances from compute optimized type families with GPU, such as gn5 and gn6, for the core nodes and task nodes in the cluster. Compute optimized type families with GPU support heterogeneous computing. After determining the instance type, choose the CUDA toolkit and cuDNN versions as required.

Submit TensorFlow jobs

Users can log on to the master node in the E-MapReduce cluster to submit TensorFlow jobs using the command line. For example:

```
el_submit [-h] [-t APP_TYPE] [-a APP_NAME] [-m MODE] [-m_arg MODE_ARG]
[-interact INTERACT] [-x EXIT]
[-enable_tensorboard ENABLE_TENSORBOARD]
[-log_tensorboard LOG_TENSORBOARD] [-conf CONF] [-f FILES]
[-pn PS_NUM] [-pc PS_CPU] [-pm PS_MEMORY] [-wn WORKER_NUM]
[-wc WORKER_CPU] [-wg WORKER_GPU] [-wm WORKER_MEMORY]
[-wnpg WNPG] [-ppn PPN] [-c COMMAND [COMMAND ...]]
```

Description of basic parameters:

- The -t APP_TYPE parameter specifies the type of task to be submitted. The supported types are tensorflow-ps, tensorflow-mpi, and standalone. They are used in conjunction with the following –m MODE parameter.
  - tensorflow-ps: Uses a parameter server for the communication of data, which is the PS mode of native TensorFlow.
  - tensorflow-mpi: Uses Horovod, an open source framework from UBER, which relies on message passing interface (MPI) primitives, for the communication of data.
  - standalone: Users assign the tasks to one instance in the YARN cluster for execution. It is similar to a standalone execution.

- The –a APP_NAME parameter specifies the name of the submitted TensorFlow job. Users can name jobs as needed.
- The –m MODE parameter specifies the runtime environment for submitted TensorFlow jobs. E-MapReduce supports the following environments: local, virtual-env, and docker.
  - local: Uses Python runtime environments set up in the EMR worker nodes. If you want to use third-party Python packages, you need to install the packages on all the nodes manually.
  - docker: Uses the Docker containers installed on the EMR worker nodes. Tensorflow runs in Docker containers.
  - virtual-env: Uses isolated Python environments created by users. You can install Python libraries in Python environments. These libraries can be different from those installed in the environments that are set up in the worker nodes.
- -m_arg MODE_ARG: Specifies the supplemental parameter for the –m MODE. If the runtime environment is docker, set the value to the Docker image name. If the runtime environment is virtual-env, set the value to the name of Python environment tar.gz file.
- –x Exit: Users need to exit the parameter servers manually for some APIs of distributed TensorFlow. To exit parameter servers automatically when worker servers finish training their models, specify the -x option.
- The -enable_tensorboard parameter specifies whether to enable TensorBoard when TensorFlow starts training models.
- The -log_tensorboard parameter specifies the location of TensorBoard logs on HDFS. If TensorBoard is enabled when TensorFlow starts training models, then this parameter is required.
- The -conf CONF parameter specifies the location of the Hadoop configuration. It is optional to set the value. The default EMR configuration is used.
- The –f FILES parameter specifies all dependent files and folders for TensorFlow to run, including executable scripts. If virtual-env files that are executed in a virtual environment are specified, users can put all dependencies in one folder, the script automatically uploads the folders into HDFS according to the folder hierarchy.
- The -pn TensorFlow parameter specifies the number of parameter servers to start.
- The -pc parameter specifies the number of CPU cores that each parameter server requests.
- The -pm parameter specifies the memory size that each parameter server requests.
- The -wn parameter specifies the number of worker nodes started by TensorFlow.

- The -wc parameter specifies the number of CPU cores that each worker requests.
- The -wg parameter specifies the number of GPU cores that each worker requests.
- The -wm parameter specifies the memory usage that each worker requests.
- The -c COMMAND parameter specifies the command to run. For example, pythoncensus.py.

Advanced options. Users need to carefully use advanced options, which may cause failure of running jobs.

- The -wnpg parameter specifies the number of workers that use a GPU simultaneously (for tensorflow-ps).
- The -ppn parameter specifies the number of workers that use a GPU simultaneously (for horovod). The preceding options refer to multitasking on a single GPU. Thresholds should be set to avoid GPU running out of memory.

11.10 Knox guide

Currently E-MapReduce supports *Apache Knox*. If you select the Knox-supported image to create a cluster, you can directly access the Web UI from the public network to use services such as YARN, HDFS, and SparkHistory after completing the following preparations.

Preparations

- Enable Knox access using a public IP address

  1. The service port of Knox on E-MapReduce is 8443. In the cluster details, find the ECS security group in which the cluster is located.
  2. Change the corresponding security group in the ECS console and add a rule in **Internet inbound** to enable Port 8443.

  Note:

  - For security, the authorization object must be your limited IP address range. 0.0.0.0/0 is forbidden.
  - After Port 8443 of the security group is enabled, all nodes (including non-E-MapReduce ECS nodes) in the security group enable Port 8443 at the ingress of the public network.

- Set a Knox user

  Accessing Knox requires the username and password for authentication. The authentication is based on LDAP. You can use your own LDAP service or the LDAP service of Apache Directory Server in the cluster.

- Use the LDAP service in the cluster

  Method one(recommended):

  In the *User Management* page, add Knox account directly.

  Method Two

  1. Log on to the cluster over SSH. See *SSH Logon to Clusters* for detailed steps.
  2. Prepare your user data, for example, user Tom. In the file, replace all **`emr-guest`** with `Tom`, and **`cn:EMR GUEST`** with `cn:Tom`, and set **`userPassword`** to your password.

```
su knox
cd /usr/lib/knox-current/templates
vi users.ldif
```

Note:

For security, before you export your user data to LDAP, change the password of users.ldif by setting **`userPassword`** to your password.

  3. Export to LDAP.

```
su knox
cd /usr/lib/knox-current/templates
sh ldap-sample-users.sh
```

- Use your LDAP service

  1. In the cluster configuration management, find the Knox configuration management. In the cluster-topo configuration, set **`main.ldapRealm.userDnTemplate`** to your user DN template and **`main.ldapRealm.contextFactory.url`** to your LDAP server domain name and port. Then, save the settings and restart Knox.

  2. Generally, your LDAP service is not running in the cluster. You must enable the Knox port for accessing the LDAP service in the public network, for example, Port 10389. For more information, see the preceding steps for enabling Port 8443. Select **Internet outbound**.

Note:
For security, the authorization object must be the public IP address of your Knox cluster. 0.0.0.0/0** is forbidden.

Access Knox

- Access using the shortcut link of E-MapReduce
  1. Log on to the *E-MapReduce console*.
  2. Click the ID link of the target cluster.
  3. In the left-side navigation pane, click **Clusters and Services**.
  4. Click the relevant services on the EMR Service console page, such as HDFS and YARN.
  5. In the upper-right corner, click **Quick Link**.
- Access using the public IP address of the cluster
  1. Check the public IP address in cluster details.
  2. Access the URLs of relevant services in the browser.
     - HDFS UI: *https://{cluster_access_ip}:8443/gateway/cluster-topo/hdfs/*
     - Yarn UI: *https://{cluster_access_ip}:8443/gateway/cluster-topo/yarn/*
     - SparkHistory UI : *https://{cluster_access_ip}:8443/gateway/cluster-topo/sparkhistory/*
     - Ganglia UI: *https://{cluster_access_ip}:8443/gateway/cluster-topo/ganglia/*
     - Storm UI: *https://{cluster_access_ip}:8443/gateway/cluster-topo/storm/*
     - Oozie UI: *https://{cluster_access_ip}:8443/gateway/cluster-topo/oozie/*
  3. The browser shows **website is not security** because the Knox service uses the self-signed certificate. Confirm that the accessed IP address is the same as that of your cluster and the port is 8443. Click **advance** > **continue**.
  4. Enter the username and password set in LDAP in the logon dialog box.

Access control lists (ACLs)

Knox provides service-level permission management to limit service access to specific users, user groups, or IP addresses. See *Apache Knox Authorization*.

- Example:
  - Scenario: YARN UI only allows the access by user Tom.

- Steps: In the cluster configuration management, find the Knox configuration management and the cluster-topo configuration, and add ACL code between `<gateway>...</gateway>` labels in the cluster-topo configuration.

```
<provider>
      <role>authorization</role>
      <name>AclsAuthz</name>
      <enabled>true</enabled>
      <param>
          <name>YARNUI.acl</name>
          <value>Tom;*;*</value>
      </param>
</provider>
```

- Notes:

  Knox provides REST APIs for operating a range of services, for example, adding or deleting HDFS files. For security, make sure the authorization object is your limited IP address range when you enable Knox Port 8443 of the security group in the ECS console. 0.0.0.0/0 is forbidden. Do not use the LDAP username and password in the Knox installation directory to access Knox.

12 OSS ACL

Procedure

E-MapReduce supports using RAM to isolate the data of different sub-accounts. The procedures are shown as follows:

1. Log on to the *Alibaba Cloud RAM console*.
2. Create the sub-account in RAM with the process in *How to create a sub-account in RAM*.
3. In the left-side navigation pane, click **policies** to enter the page of policy management.
4. Click **Custom Policy**.
5. In the upper-right corner, click **Create Authorization Policy** enter the authorization policy creation page. Create the policy according to the prompted steps. You can create as many policies as the sets of authorization control you need.

   It is assumed that you need the following two sets of data control policies:

   - Testing environment, bucketname: test-bucket. The corresponding complete policy is as follows.

     ```
     {
     "Version": "1",
     "Statement": [
     {
     "Effect": "Allow",
     "Action": [
       "oss:ListBuckets"
     ],
     "Resource": [
       "acs:oss:*:*:*"
     ]
     },
     {
     "Effect": "Allow",
     "Action": [
       "oss:Listobjects",
       "oss:GetObject",
       "oss:PutObject",
       "oss:DeleteObject"
     ],
     "Resource": [
       "acs:oss:*:*:test-bucket",
       "acs:oss:*:*:test-bucket/*"
     ]
     }
     ]
     ```

```
}
```

- Production environment, bucketname: prod-bucket. The corresponding complete policy is as follows:

```
{
"Version": "1",
"Statement": [
{
"Effect": "Allow",
"Action": [
  "oss:ListBuckets"
],
"Resource": [
  "acs:oss:*:*:*"
]
},
{
"Effect": "Allow",
"Action": [
  "oss:Listobjects",
  "oss:GetObject",
  "oss:PutObject"
],
"Resource": [
  "acs:oss:*:*:prod-bucket",
  "acs:oss:*:*:prod-bucket/*"
]
}
]
}
```

6. Click **Users**.
7. Find out the sub-account item which the policy is given to and click the **Manage** button.
8. In the left-side navigation pane, click **User Authorization Policy**.
9. In the upper-right corner, click **Edit Authorization Policy**.
10. Select and add authorization policies.
11. Click **OK** to complete the policy authorization of the sub-account.
12. In the upper-right corner, click **User Details** to enter the user details page of the sub-account.
13. Click **Start Console Logon** in the Web console logon management bar to start up the authorization of the sub-account logon console.

Complete and use

After completing all preceding steps, use the corresponding sub-account to log on to E-MapReduce with following limits:

- All buckets can be seen in the OSS selection interface for cluster, operation, and plan execution creations, but the authorized bucket can only be entered.
- The content under authorized bucket can only be seen, rather than those under other buckets.

- The authorized bucket can only be read and written. Otherwise, an error is reported.

13 Connect to clusters using SSH

If the existing jobs and execution plans cannot meet your more complex application requirements, log on to the master node of the E-MapReduce cluster. Here, navigate to the cluster details page where the public network IP address of the cluster master exists. You can log on to the master node through SSH to view various settings and states.

The function of logining clusters

Relevant environment variables have been set on the machine, including the following common ones:

- JAVA_HOME
- HADOOP_HOME
- HADOOP_CONF_DIR
- HADOOP_LOG_DIR
- YARN_LOG_DIR
- HIVE_HOME
- HIVE_CONF_DIR
- PIG_HOME
- PIG_CONF_DIR

You can quote these variables in the script, however, we recommend that you do not change them to avoid unexpected E-MapReduce errors.

Connect to the Master

1. SSH logs on to the master with the following commands. Obtain the public network IP of the cluster master in the hardware information column on the *Cluster details*.

```
ssh root@ip.of.master
```

2. Enter the password set during creation.

Connect to a cluster using SSH without a password

You must connect to the cluster for management and operation. To connect to the cluster master, you can break through the SSH password-less logon from the master machine (by default, the cluster master opens up the public network IP). The procedure is as follows:

1. Connect to the master with the root and password mode as mentioned previously.
2. Change to Hadoop or hdfs user.

SSH mode of Linux

1. Copy the private key to the local machine.

```
sz ~/.ssh/id_rsa
```

2. Return to your local machine and attempt to connect to the master again.

```
ssh -i private_key_path/id_rsa hadoop@server_ip_address
```

If only one private key exits, you can put it in your `~/.ssh/` and use it by default without designation of `-i`.

Connect to the Master Node using SSH on Windows

You can connect to the master through SSH without input password with multiple methods under Windows.

- Method I: PuTTY

1. Click *Download PuTTY*.
2. Download PuTTYgen from the same location.
3. Open PuTTYgen and load your private key.

> **Note:**
> Keep the private key safe. In case of accidental disclosure, generate a new private key immediately for replacement.

4. Use default configuration and save the private key. Obtain a secret PuTTY key file with a suffix of ppk.
5. Operate PuTTY and select Session on the configuration page.
6. Enter the public network IP address of the target machine you will connect to and add the user name (for example, hadoop@MasterNodeIP).
7. Select **Connetion** > **SSH** > **Auth** on the configuration page.
8. Select the generated ppk file.
9. Click **Open** to log on to the master node automatically.

- Method II: Cygwin | MinGW

It is a convenient tool to simulate Linux env in Windows.

For this method, see the preceding SSH method of Linux.

MinGW method is recommended for use because it is the most compact. If the official website cannot be opened, download a Git client. The default Git Bash can be used.

View webui of Hadoop, Spark, Ganglia, and other systems

Note:

Confirm you have finished the preceding *SSH logon without password* process before this step.

For safety, the webui monitoring system ports of Hadoop, Spark, Ganglia, and other systems in the E-MapReduce cluster are not opened to the outside world. If you want to visit these webUIs, a SSH tunnel needs to be built to forward through a port. The following two methods are available:

Note:

The following operations are completed in your local machine, instead of the machine in the cluster.

- Method I: Port dynamic forwarding

  Create a SSH tunnel that can connect certain dynamic port connections between the local machine and the master machine in E-MapReduce cluster.

  ```
  ssh -i /path/id_xxx -ND 8157 hadoop@masterNodeIP
  ```

  8157 is any port not used in the local machine and can be customized by you.

  After dynamic forwarding, you can view the following:

  - Recommended methods

    We recommend that you use the Chrome browser. Visit Web UI in the following methods:

    ```
    chrome --proxy-server="socks5://localhost:8157" --host-resolver-
    rules="MAP * 0.0.0.0 , EXCLUDE localhost" --user-data-dir=/tmp/
    ```

    For Windows system, the`tmppath` can be written into similar `d:/tmppath`. For Linux or OSX, `/tmp/` can be written directly.

    The Chrome location varies with operating systems. See the following table.

Operating System	Chrome Location
Mac OS X	/Applications/Google Chrome.app/Contents/MacOS/Google Chrome
Linux	/usr/bin/google-chrome

Operating System	Chrome Location
Windows	C:\Program Files (x86)\Google\Chrome\Application\chrome.exe

- Plug-in method

  SSH tunnel between local machine and master machine in the E-MapReduce cluster has been broken through. You need to configure a local agent in order to view webUI of Hadoop, Spark and Ganglia in the browser. The procedure is as follows:

  1. For Chrome or Firefox browser, please click *[Download FoxyProxy Standard agent software]*.
  2. After installation and restart of browser, open a text editor and edit the following content:

```
<?<!--?--> xml version="1.0" encoding="UTF-8"? >
<foxyproxy>
<proxies>
<proxy name="aliyun-emr-socks-proxy" id="2322596116" notes
="" fromSubscription="false" enabled="true" mode="manual"
selectedTabIndex="2" lastresort="false" animatedIcons="true
" includeInCycle="true" color="#0055E5" proxyDNS="true"
noInternalIPs="false" autoconfMode="pac" clearCacheBeforeUse
="false" disableCache="false" clearCookiesBeforeUse="false"
rejectCookies="false">
<matches>
<match enabled="true" name="120.*" pattern="http://120.*"
isRegEx="false" isBlackList="false" isMultiLine="false"
caseSensitive="false" fromSubscription="false" ></match>
</matches>
<manualconf host="localhost" port="8157" socksversion="5"
isSocks="true" username="" password="" domain="" ></manualconf>
</proxy>
</proxies>
</foxyproxy>
```

     Specifically:

     - `Port 8157` is a port which your local machine uses to build SSH connection with cluster master machine. It will match with the port used in SSH command executed in the terminal.
     - `120.*` is used to match with IP address in the master machine. Please confirm it based on master IP address.
  3. In a browser, click the **Foxyproxy** button and then select **Options**.
  4. Select **Import/Export**.
  5. Select the xml file you edited just now and click **Open**。
  6. In the **Import FoxyProxy Setting** dialogue box, click **Add**.

7. In a browser, click the **Foxyproxy** button and select **Use Proxy aliyun-emr-socks-proxy for all URLs**.
8. nter localhost:8088 in the browser to open the Hadoop interface at the far end.

- Method II: Local port forwarding

Note:

A local port forwarding disadvantage is that only the interface in the outermost layer can be seen. The viewing of detailed job information results in an error.

```
ssh -i /path/id_rsa -N -L 8157:masterNodeIP:8088 hadoop@masterNodeIP
```

Parameter description:

- **`path`**: Private key storage path.
- **`masterNodeIP`**: IP address of the master node to be connected.
- **`8088`**: Access port number of ResourceManager on the master node.

14 Create your gateway

Gateway is an ECS server in the same intranet as the E-MapReduce cluster. You can use Gateway to achieve load balancing and security isolation, or submit jobs to the E-MapReduce cluster.

You can create Gateway in the following two ways:

- (Recommended) Create in *E-MapReduce*.
- Set up a Gateway manually.

Create a gateway on the E-MapReduce Console

E-MapReduce gateways only support Hadoop clusters. You must create a Hadoop cluster before creating an E-MapReduce gateway. To create an E-MapReduce gateway, follow these steps.

1. Log on to the *E-MapReduce console* .
2. Click **Create Gateway**.
3. Configure in the **Create Gateway** page.
    - **Billing Method**:
        - **Subscription**: Subscription billing method pays for a period one time, the price is relatively cheap compared to Pay-As-You-Go method, especially when you pay for three years one time, the discount is larger.
        - **Pay-As-You-Go**: Pay-As-You-Go method is based on the actual number of hours that you used the product to calculate the order, and it charges by hour.
    - **Cluster**: Create a gateway for the cluster, that is, the created gateway can submit jobs to which cluster. Gateway will automatically configure the Hadoop environment that is consistent with the cluster.
    - **Configuration**: The available ECS instance specifications in the zone.
    - **System Disk Type**: The system disk type of the gateway node. There are two types of system disk: SSD cloud disk and efficient cloud disk. The displayed type of system disk varies according to different server models and different regions. The system disk is released with the release of the cluster by default.
    - **System Disk Size**: The minimum is 40GB and the maximum is 500GB. The default is 300 GB.
    - **Data Disk Type**: The data disk type of the gateway node. There are two types of data disk: SSD Disk and efficient cloud disk. The displayed type of data disk varies according to

different server models and different regions. The data disk is released with the release of the cluster by default.

- **Data Disk Size**: The minimum is 200GB and the maximum is 4000GB. The default value is 300GB.
- **Quantity**: The number of data disks. The minimum is 1 and the maximum is 10.
- **Cluster Name**: The name of a gateway. The length can be 1~64 characters. It only allows Chinese character, letter, number, hyphen (-), and underscore (_).
- **Password/Key Pair**:
  - **Password Mode**: Enter the password for gateway login in the text box.
  - **Key Pair Mode**: Select the key pair name for Gateway login in the drop-down menu. If no key pair has been created yet, click **Create Key Pair** on the right to go to the ECS console to create. Do not disclose the private key file with .pem format corresponding to the key pair. After Gateway is created successfully, the public key of the key pair will be bound to the ECS in which Gateway is located automatically. When you log on to Gateway via SSH, enter the private key in the private key file.

4. Click **Create** to save the configurations.

   The newly created gateway will be displayed in the cluster list, and the status in the **Status** column becomes **Idle** when the creation is successful.

Set up a gateway manually

- **Network environment**

  Make sure that the Gateway machine is in the security group of the corresponding EMR cluster, so that the Gateway nodes can smoothly access the EMR cluster. For setting the security group of the machine, see the *Create a security*.

- **Software environment**
  - System environment: CentOS 7.2+ is recommended.
  - Java environment: JDK 1.7 or later version must be installed and OpenJDK 1.8.0 is recommended.

- **Procedure**
  - **EMR 2.7 or later version, 3.2 or later version**

    To create Gateway in these versions, we recommend that you use the EMR console.

If you want to set up a Gateway manually, copy the following script to the gateway host and run it. The command is **`sh deploy.sh <masteri_ip> master_password_file`**.

- *`deploy.sh`* is the script name, and the content is as follows.
- *`masteri_ip`* is the IP address of the master node in the cluster, which needs to be accessible.
- *`master_password_file`* is the file for storing password of the master node, which is directly written in the file.

```
#! /usr/bin/bash
If [$ #! = 2]
then
   echo "Usage: $0 master_ip master_password_file"
   exit 1;
fi
masterip=$1
masterpwdfile=$2
if ! type sshpass >/dev/null 2>&1; then
   yum install -y sshpass
fi
if ! type java >/dev/null 2>&1; then
   yum install -y java-1.8.0-openjdk
fi
mkdir -p /opt/apps
mkdir -p /etc/ecm
echo "Start to copy package from $masterip to local gateway(/opt/
apps)"
echo " -copying hadoop-2.7.2"
sshpass -f $masterpwdfile scp -r -o 'StrictHostKeyChecking no'
root@$masterip:/usr/lib/hadoop-current /opt/apps/
echo " -copying hive-2.0.1"
sshpass -f $masterpwdfile scp -r root@$masterip:/usr/lib/hive-
current /opt/apps/
echo " -copying spark-2.1.1"
sshpass -f $masterpwdfile scp -r root@$masterip:/usr/lib/spark-
current /opt/apps/
echo "Start to link /usr/lib/\${app}-current to /opt/apps/\${app}"
if [ -L /usr/lib/hadoop-current ]
then
   unlink /usr/lib/hadoop-current
fi
ln -s /opt/apps/hadoop-current  /usr/lib/hadoop-current
if [ -L /usr/lib/hive-current ]
then
   unlink /usr/lib/hive-current
fi
ln -s /opt/apps/hive-current  /usr/lib/hive-current
if [ -L /usr/lib/spark-current ]
then
   unlink /usr/lib/spark-current
fi
ln -s /opt/apps/spark-current /usr/lib/spark-current
echo "Start to copy conf from $masterip to local gateway(/etc/ecm
)"
sshpass -f $masterpwdfile scp -r root@$masterip:/etc/ecm/hadoop-
conf  /etc/ecm/hadoop-conf
```

```
sshpass -f $masterpwdfile scp -r root@$masterip:/etc/ecm/hive-conf
 /etc/ecm/hive-conf
sshpass -f $masterpwdfile scp -r root@$masterip:/etc/ecm/spark-
conf /etc/ecm/spark-conf
echo "Start to copy environment from $masterip to local gateway(/
etc/profile.d)"
sshpass -f $masterpwdfile scp root@$masterip:/etc/profile.d/hdfs.
sh /etc/profile.d/
sshpass -f $masterpwdfile scp root@$masterip:/etc/profile.d/yarn.
sh /etc/profile.d/
sshpass -f $masterpwdfile scp root@$masterip:/etc/profile.d/hive.
sh /etc/profile.d/
sshpass -f $masterpwdfile scp root@$masterip:/etc/profile.d/spark.
sh /etc/profile.d/
if [ -L /usr/lib/jvm/java ]
then
   unlink /usr/lib/jvm/java
fi
echo "" >>/etc/profile.d/hdfs.sh
echo export JAVA_HOME=/usr/lib/jvm/jre-1.8.0 >>/etc/profile.d/hdfs
.sh
echo "Start to copy host info from $masterip to local gateway(/etc
/hosts)"
sshpass -f $masterpwdfile scp root@$masterip:/etc/hosts /etc/
hosts_bak
cat /etc/hosts_bak | grep emr | grep cluster >>/etc/hosts
if ! id hadoop >& /dev/null
then
   useradd hadoop
fi
```

- **EMR 2.7 earlier version, 3.2 earlier version**

Copy the following script to the Gateway host and run it. The command is **sh deploy.sh <masteri_ip> master_password_file**.

- *`deploy.sh`* is the script name, and the content is as follows.
- *`masteri_ip`* is the IP address of the master node in the cluster, which needs to be accessible.
- *`master_password_file`* is the file for storing password of the master node, which is directly written in the file.

```
! /usr/bin/bash
if [ $# ! = 2 ]
then
   echo "Usage: $0 master_ip master_password_file"
   exit 1;
fi
masterip=$1
masterpwdfile=$2
if ! type sshpass >/dev/null 2>&1; then
   yum install -y sshpass
fi
if ! type java >/dev/null 2>&1; then
   yum install -y java-1.8.0-openjdk
fi
mkdir -p /opt/apps
```

```
mkdir -p /etc/emr
echo "Start to copy package from $masterip to local gateway(/opt/
apps)"
echo " -copying hadoop-2.7.2"
sshpass -f $masterpwdfile scp -r -o 'StrictHostKeyChecking no'
root@$masterip:/usr/lib/hadoop-current /opt/apps/
echo " -copying hive-2.0.1"
sshpass -f $masterpwdfile scp -r root@$masterip:/usr/lib/hive-
current /opt/apps/
echo " -copying spark-2.1.1"
sshpass -f $masterpwdfile scp -r root@$masterip:/usr/lib/spark-
current /opt/apps/
echo "Start to link /usr/lib/\${app}-current to /opt/apps/\${app}"
if [ -L /usr/lib/hadoop-current ]
then
   Unlink/usr/lib/hadoop-Current
fi
ln -s /opt/apps/hadoop-current  /usr/lib/hadoop-current
if [ -L /usr/lib/hive-current ]
then
   unlink /usr/lib/hive-current
fi
ln -s /opt/apps/hive-current  /usr/lib/hive-current
if [ -L /usr/lib/spark-current ]
then
   unlink /usr/lib/spark-current
fi
Ln-S/opt/apps/spark-current/usr/lib/spark-Current
echo "Start to copy conf from $masterip to local gateway(/etc/emr
)"
sshpass -f $masterpwdfile scp -r root@$masterip:/etc/emr/hadoop-
conf  /etc/emr/hadoop-conf
sshpass -f $masterpwdfile scp -r root@$masterip:/etc/emr/hive-conf
 /etc/emr/hive-conf
sshpass -f $masterpwdfile scp -r root@$masterip:/etc/emr/spark-
conf /etc/emr/spark-conf
Echo "start to copy environment from $ masterip to local Gateway
 (/etc/profile. d )"
sshpass -f $masterpwdfile scp root@$masterip:/etc/profile.d/hadoop
.sh /etc/profile.d/
if [ -L /usr/lib/jvm/java ]
then
   unlink /usr/lib/jvm/java
fi
ln -s /usr/lib/jvm/java-1.8.0-openjdk-1.8.0.131-3.b12.el7_3.x86_64
/jre /usr/lib/jvm/java
echo "Start to copy host info from $masterip to local gateway(/etc
/hosts)"
sshpass -f $masterpwdfile scp root@$masterip:/etc/hosts /etc/
hosts_bak
cat /etc/hosts_bak | grep emr | grep cluster >>/etc/hosts
if ! id hadoop >& /dev/null
then
   useradd hadoop
fi
```

- **Test**
  - Hive

```
[hadoop@iZ23bc05hrvZ ~]$ hive
```

```
hive> show databases;
OK
default
Time taken: 1.124 seconds, Fetched: 1 row(s)
hive> create database school;
OK
Time taken: 0.362 seconds
hive>
```

- Run the Hadoop job

```
[hadoop@iZ23bc05hrvZ ~]$ hadoop  jar /usr/lib/hadoop-current/share
/hadoop/mapreduce/hadoop-mapreduce-examples-2.6.0.jar pi 10 10
Number of Maps  = 10
Samples per Map = 10
Wrote input for Map #0
Wrote input for Map #1
Wrote input for Map #2
Wrote input for Map #3
Wrote input for Map #4
Wrote input for Map #5
Wrote input for Map #6
Wrote input for Map #7
Wrote input for Map #8
Wrote input for Map #9
  File Input Format Counters
      Bytes Read=1180
  File Output Format Counters
      Bytes Written=97
Job Finished in 29.798 seconds
Estimated value of Pi is 3.20000000000000000000
```

15 MetaService

MetaService is provided under the E-MapReduce environment. MetaService allows you to access Alibaba Cloud resources in the E-MapReduce cluster without using AK.

Default roles

By default, you must authorize an application role (AliyunEmrEcsDefaultRole) to E-MapReduce when creating a cluster. After authorization, you can perform operations on E-MapReduce to access Alibaba Cloud resources without the need to explicitly input AK. By default, the following permission policies are granted to AliyunEmrEcsDefaultRole:

```
{
  "Version": "1",
  "Statement": [
    {
      "Action": [
        "oss:GetObject",
        "oss:ListObjects",
        "oss:PutObject",
        "oss:DeleteObject",
        "oss:ListBuckets",
        "oss:AbortMultipartUpload"
      ],
      "Resource": "*",
      "Effect": "Allow"
    }
  ]
}
```

By default, your operations based on MetaService can Access OSS Data Only. If you want to access other Alibaba Cloud resources, such as LogService by using MetaService, you must grant permissions to AliyunEmrEcsDefaultRole. You can perform the preceding operations by using the *RAM console*.

Note:

MetaService only supports AK-free operations on the OSS, LogService, and MNS data. You must edit and delete the default role with caution. Otherwise, your cluster creation or operations may fail.

Custom application roles

In most cases, you only need to use a default role or modify the default role. E-MapReduce also allows you to create your own application role. When creating a cluster, you can use a default role or create your own application role. For more information about how to create and authorize a role to E-MapReduce, see *RAM documentations*.

Access to MetaService

MetaService is an HTTP service which can be accessed directly to obtain metadata information. For example, you can obtain the region where the current cluster is located using the **`curl http://localhost:10011/cluster-region`** command.

MetaService supports the following types of information:

- Region: /cluster-region
- Role name: /cluster-role-name
- AccessKeyId: /role-access-key-id
- AccessKeySecret: /role-access-key-secret
- SecurityToken: /role-security-token
- Network type: /cluster-network-type

Use MetaService

You can use MetaSerivce to access Alibaba Cloud resources without the need to use AK, which can:

- Reduce the risk of an AK leak. The RAM-based usage can minimize security risk. The permissions are minimized by only granting the required permissions to the role.
- Improve user experience. This is intended especially when you interactively access the OSS resources by using MetaService. You do not need to write a long string of OSS path.

Several usage methods are introduced as follows:

```
I. Using the Hadoop command line to display OSS data
    Previously, we used: hadoop fs -ls oss://ZaH******As1s:Ba23N
*************sdaBj2@bucket.oss-cn-hangzhou-internal.aliyuncs.com/a/b/
c
    Now, we use: hadoop fs -ls oss://bucket/a/b/c
II. Using Hive to create a table
    Previously, we used:
        CREATE EXTERNAL TABLE test_table(id INT, name string)
        ROW FORMAT DELIMITED
        FIELDS TERMINATED BY '/t'
        LOCATION 'oss://ZaH******As1s:Ba23N*************sdaBj2@bucket
.oss-cn-hangzhou-internal.aliyuncs.com/a/b/c';
    Now, we use:
        CREATE EXTERNAL TABLE test_table(id INT, name string)
        ROW FORMAT DELIMITED
        FIELDS TERMINATED BY '/t'
        LOCATION 'oss://bucket/a/b/c';
III. Spark
    Previously, we used: val data = sc.textFile("oss://ZaH******As1s:
Ba23N*************sdaBj2@bucket.oss-cn-hangzhou-internal.aliyuncs.com
/a/b/c")
    Now, we use: val data = sc.textFile("oss://bucket/a/b/c")
```

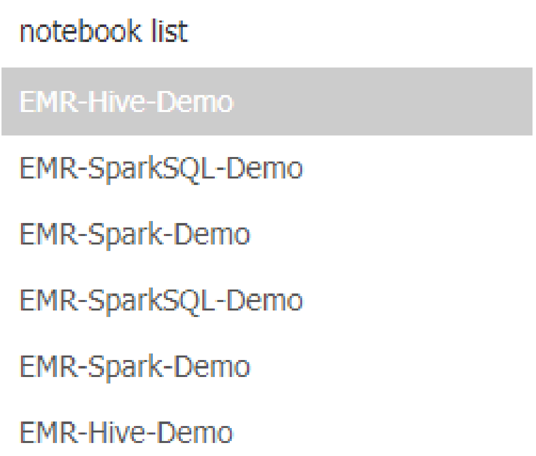
16 Notebook

16.1 Introduction

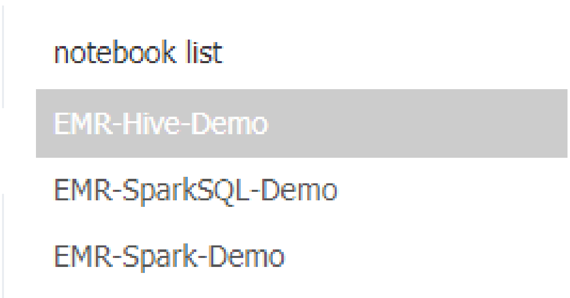
Notebook allows you to compile and run Spark, Spark SQL, and Hive SQL tasks directly on the E-MapReduce console. You can view the running results directly on Notebook. Notebook is ideal for processing debugging tasks that require shorter runtime and whose data results need to be viewed directly. For tasks with longer runtime and requiring regular execution, the job and execution plan function must be used. This section describes how to create and run a demo task. For other examples and operation instructions, refer to the subsequent chapters.

Create a demo task

1. Log on to the *Alibaba Cloud E-MapReduce console*.
2. At the top of the navigation bar, click **Old EMR Scheduling**.
3. In the left-side navigation bar, click **Notebook**.
4. Click **New notebook demo**.



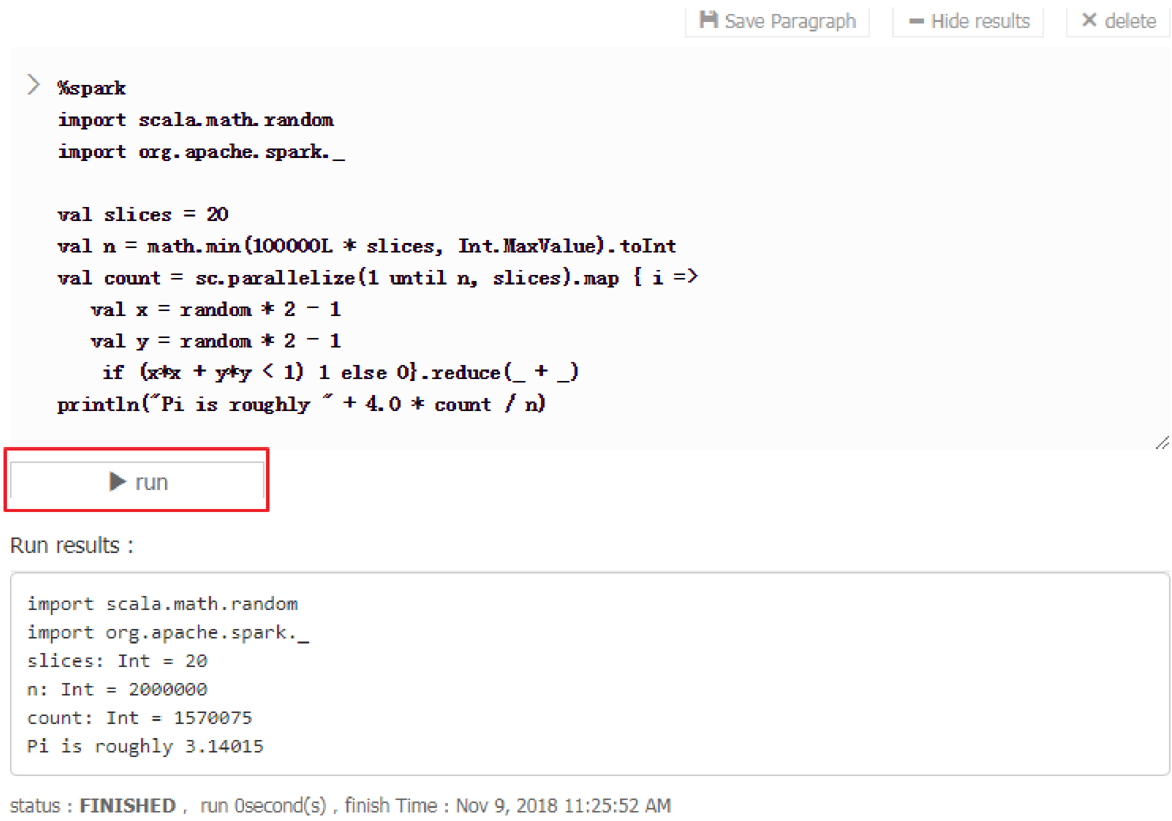
5. A confirmation box is displayed, indicating the required cluster environment. Click **OK** to create demo tasks. Three examples of interactive tasks will be created.



Run a Spark demo task

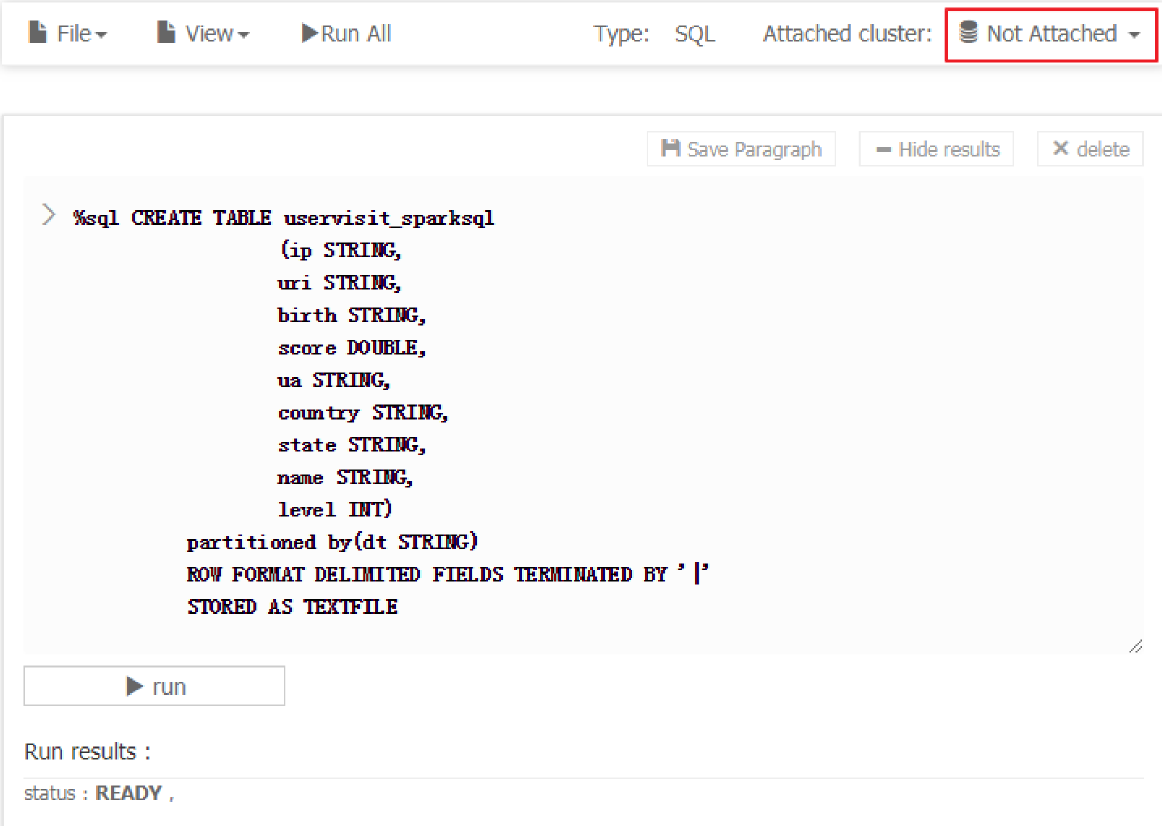
1. Click **EMR-Spark-Demo** to display the example of a Spark notebook. Before running the notebook, you need to associate the task to a created cluster. Select a created cluster in the list of available clusters. Note that the associated cluster must be EMR-2.3 or later and has no less than three nodes, each with at least 4 cores and 8 GB of memory.

2. After a cluster is associated, click **Run**. When the associated cluster executes the Spark or Spark SQL notebook for the first time, it takes about one minute to build the Spark context and running environment. It does not need to be built in subsequent executions. The running result is displayed below the Run button.



Run a SparkSQL demo task

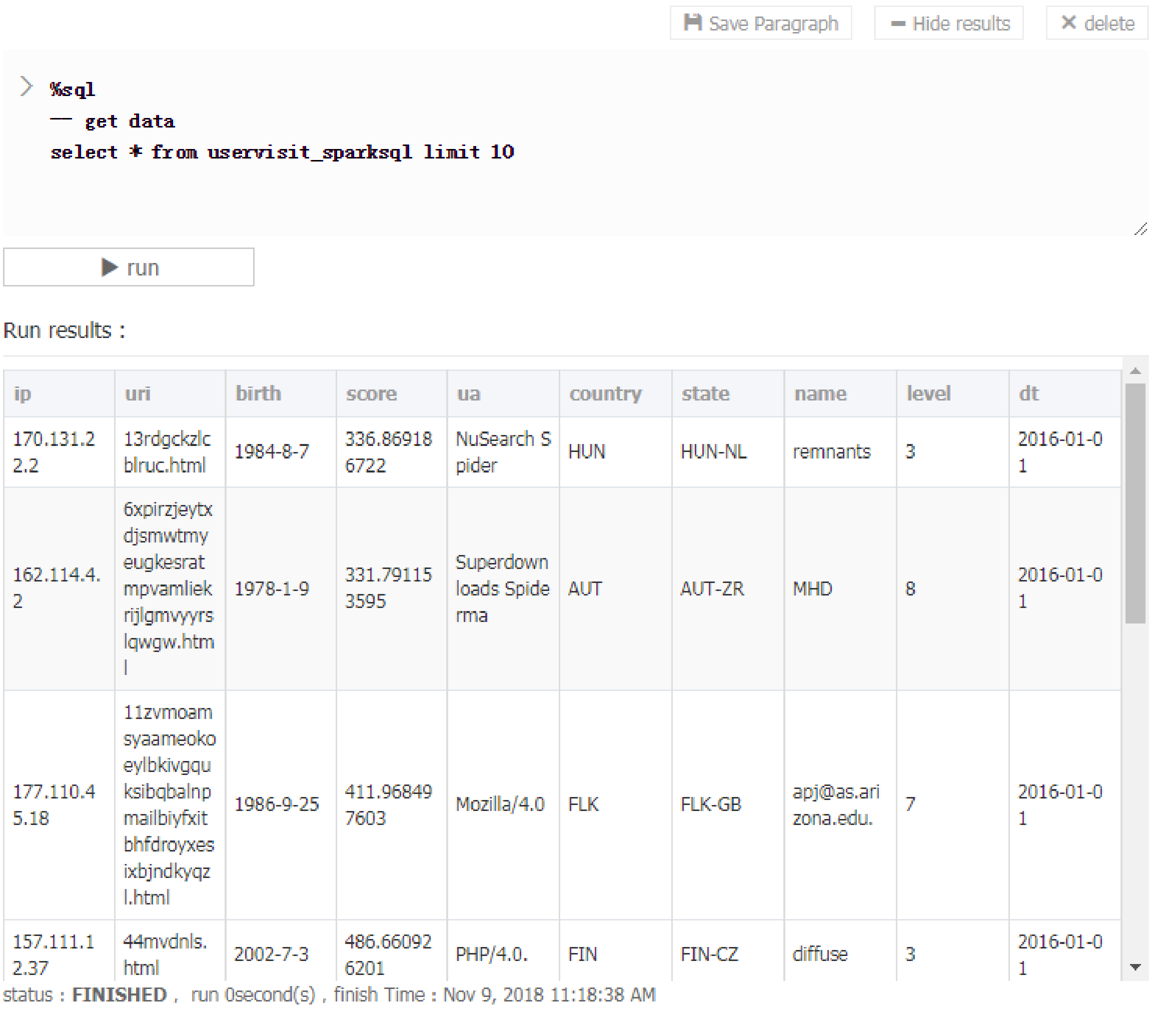
1. Click **EMR-Spark-Demo** to display the SparkSQL notebook example. Before running the notebook, you need to associate the notebook to a created cluster. Click the upper right corner and select a created cluster in the list of available clusters.



2. The SparkSQL demo contains several demo sections which can be run individually or all together by clicking **Run All**. After the running, you can see all returned data results of each section.

Note:

If the section for creating a table is run multiple times, an error will be reported indicating that the table already exists.




```
%sql
-- get data
select * from uservisit_sparksql limit 10
```

run

Run results :

ip	uri	birth	score	ua	country	state	name	level	dt
170.131.22.2	13rdgckzlcblruc.html	1984-8-7	336.869186722	NuSearch Spider	HUN	HUN-NL	remnants	3	2016-01-01
162.114.4.2	6xpirzjeytxdjsmwtmyeugkesratmpvamliekrijlgmvyyrslqwgw.html	1978-1-9	331.791153595	Superdownloads Spiderma	AUT	AUT-ZR	MHD	8	2016-01-01
177.110.45.18	11zvmoamsyaameokoeylbkivgqquksibqbalnpmailbiyfxitbhfdroyxesixbjndkyqzl.html	1986-9-25	411.968497603	Mozilla/4.0	FLK	FLK-GB	apj@as.arizona.edu.	7	2016-01-01
157.111.12.37	44mvdnls.html	2002-7-3	486.660926201	PHP/4.0.	FIN	FIN-CZ	diffuse	3	2016-01-01

status : **FINISHED** , run 0second(s) , finish Time : Nov 9, 2018 11:18:38 AM

Run a Hive demo task

1. Click **EMR-Hive-Demo** to display the Hive notebook example. Before running the notebook, you need to associate the notebook to a created cluster. Click the upper right corner and select a created cluster in the list of available clusters.
2. The Hive demo task contains several demo sections, which can be run individually, or all together by clicking **Run All**. After running, you can see all returned data results of each section.

> **Note:**
>
> - When the associated cluster executes the Hive notebook for the first time, it takes a few seconds to build the Hive client running environment. It will no longer need to be built in subsequent execution.

- If the section for creating a table is run multiple times, an error will be reported indicating that the table already exists.

Save Paragraph | Hide results | ✕ delete

```
%hive
-- get data
select * from uservisit_hive limit 10
```

▶ run

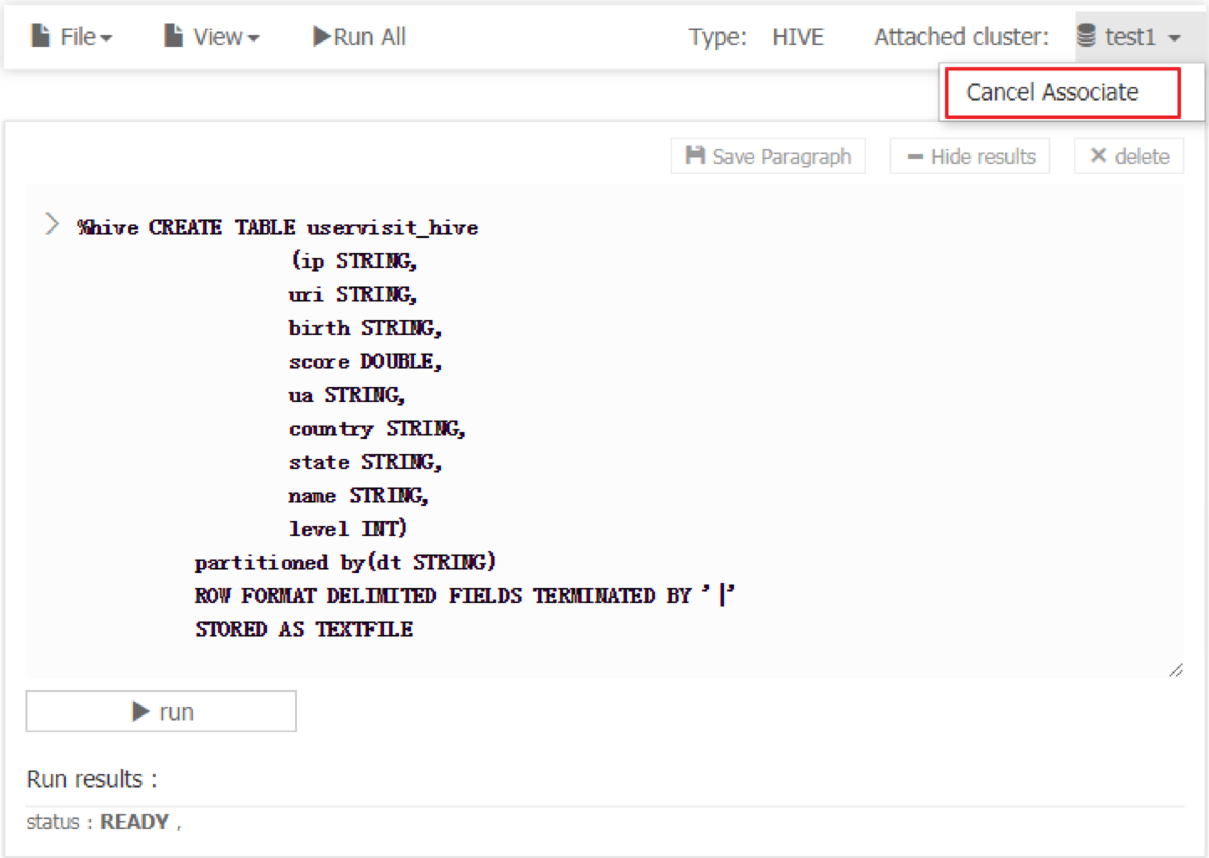
Run results :

uservisit_hive.ip	uservisit_hive.uri	uservisit_hive.birth	uservisit_hive.score	uservisit_hive.ua	uservisit_hive.country	uservisit_hive.state	uservisit_hive.name	uservisit_hive.level	uservisit_hive.dt
170.131.22.2	13rdgckzlcblruc.html	1984-8-7	336.869186722	NuSearch Spider	HUN	HUN-NL	remnants	3	2016-01-01
162.114.4.2	6xpirzjeytxdjsmwtmyeugkesratmpvamliekrijlgmvyyrslqwgw.html	1978-1-9	331.791153595	Superdownloads Spiderma	AUT	AUT-ZR	MHD	8	2016-01-01
177.110.45.18	11zvmoamsyaameokoeylbkivgquksibqbalnpmailbiyfxitbhfdroyxesixbjndkyqzl.html	1986-9-25	411.968497603	Mozilla/4.0	FLK	FLK-GB	apj@as.arizona.edu.	7	2016-01-01

status : **FINISHED** , run 0second(s) , finish Time : Nov 9, 2018 11:21:08 AM

Cancel the association with clusters

After a notebook is run in a cluster, the cluster creates a process for catching some context running environments in order to ensure quick response upon re-execution. If you do not need to execute other notebooks, and you want to release the cluster resources occupied by caching, you can disassociate all interactive tasks that have been run from the associated clusters. In this way, you can release the memory resources occupied on the original associated clusters.



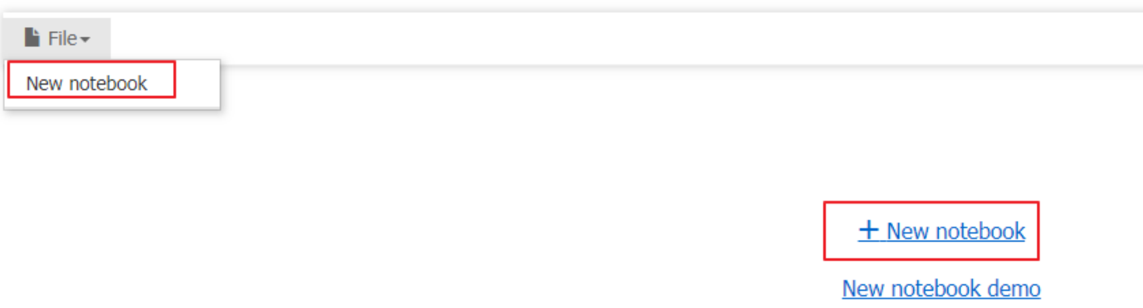
16.2 Manual

This article shows you how to create a new notebook task on the EMR console and guide you through the task creation and operation.

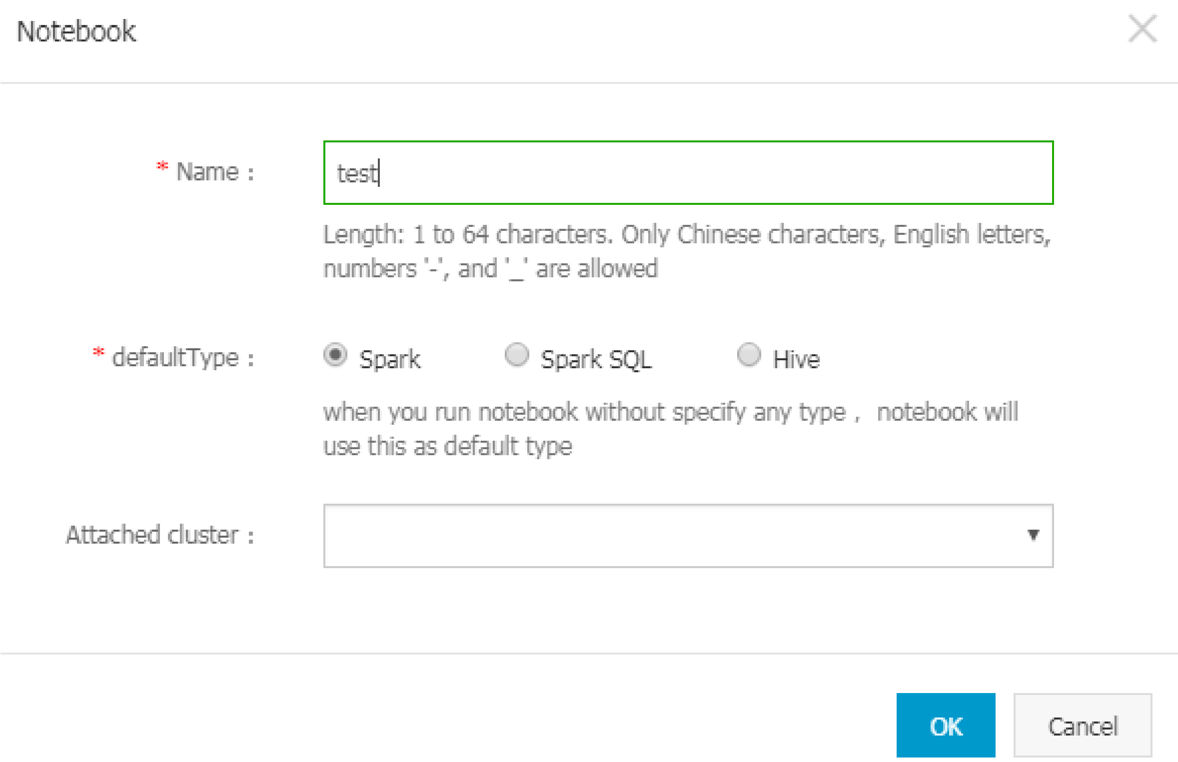
Create a new notebook task

> **Note:**
> The cluster on which an interactive task is run must be EMR-2.3 or later, and has no less than three nodes, each with at least 4 cores and 8 GB of memory.

1. Log on to the *Alibaba Cloud E-MapReduce console*.
2. At the top of the navigation bar, click **Old EMR Scheduling**.
3. In the left-side navigation bar, click **Notebook**.
4. Click **New notebook** or **File** > **-New notebook.**



5. Input the name and select the default type. The associated cluster is optional. Click **OK** to create a notebook.



Three types are supported for a notebook task. Spark can be used to write scala spark codes. Spark SQL can be used to write SQL statements supported by Spark. Hive can be used to write SQL statements supported by Hive.

6. An associated cluster must be a created cluster of EMR-2.3 or later, and has no less than three nodes, each with at least 4 cores and 8 GB of memory. You can also associate the cluster before running the task.

Up to 20 interactive tasks can be created in one account.

Enter and save a section

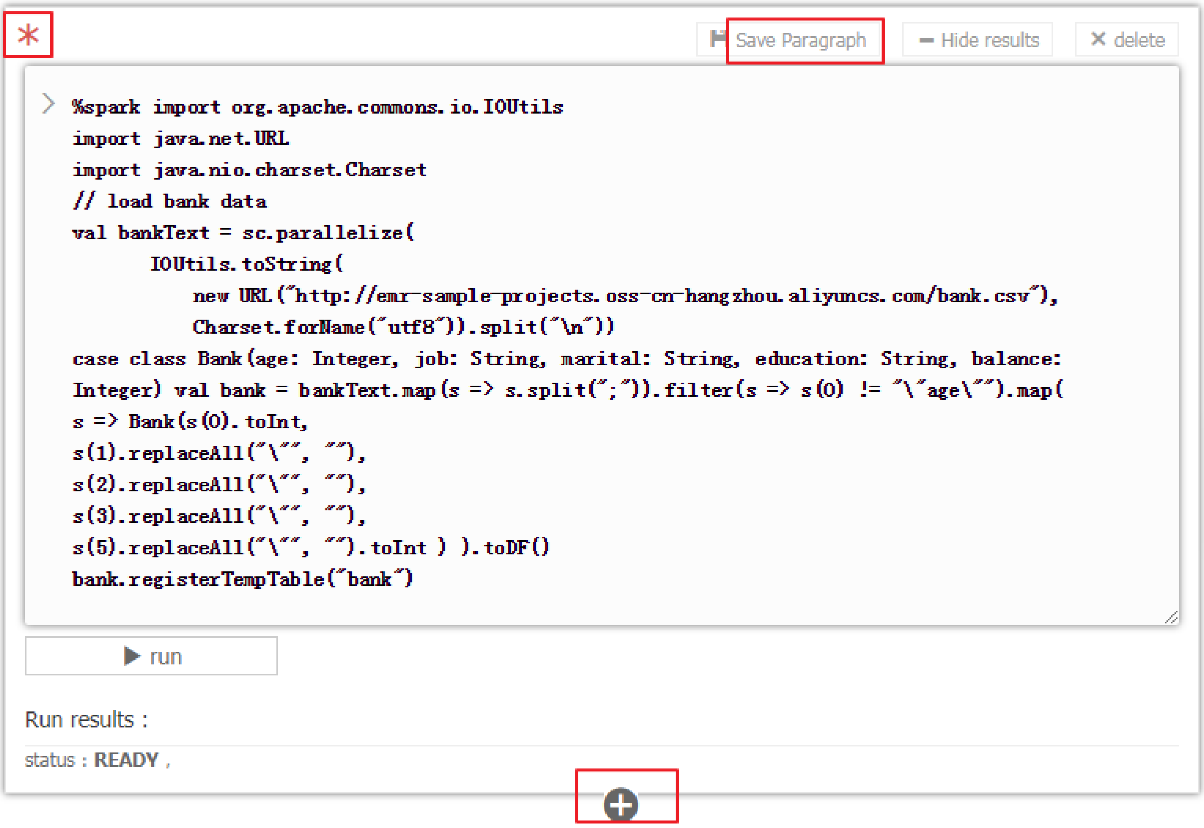
A paragraph is the smallest unit for running a notebook. For a notebook, you can fill in multiple paragraphs. Each paragraph can start with `%spark`, `%sql`, and `%hive` indicating that this paragraph is a scala spark code paragraph, spark SQL paragraph, or Hive SQL paragraph. The type prefix is segregated by a blank space or by line feed and actual content. If the type prefix is not specified, the default type of the interactive task will be used as the run type of this paragraph.

The following is an example showing how to create a temporary Spark table:

Paste the following code in the section and a red * symbol is displayed, indicating that this notebook has been changed. You can click the **Save Paragraph** button or **run** button to save the modifications to the paragraph. Click **+** below the paragraph to create a new paragraph. Up to 30 paragraphs can be created in one notebook.

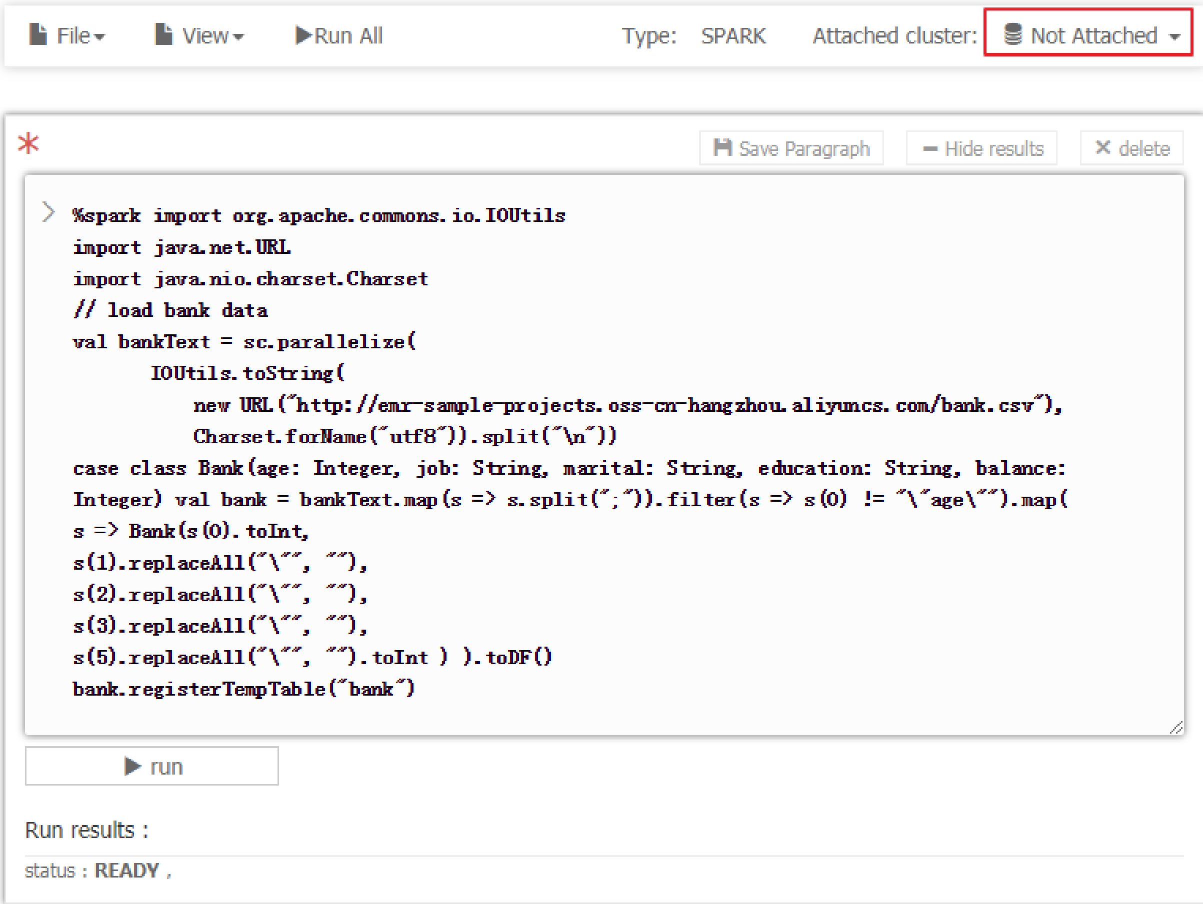
```
%spark
import org.apache.commons.io.IOUtils
import java.net.URL
import java.nio.charset.Charset
// load bank data
val bankText = sc.parallelize(
    IOUtils.toString(
        new URL("http://emr-sample-projects.oss-cn-hangzhou.aliyuncs.
com/bank.csv"),
        Charset.forName("utf8")).split("\n"))
case class Bank(age: Integer, job: String, marital: String, education
: String, balance: Integer)
val bank = bankText.map(s => s.split(";")).filter(s => s(0) ! = "\"age
\"").map(
    s => Bank(s(0).toInt,
            s(1).replaceAll("\"", ""),
            s(2).replaceAll("\"", ""),
            s(3).replaceAll("\"", ""),
            s(5).replaceAll("\"", "").toInt
        )
).toDF()
```

```
bank.registerTempTable("bank")
```



Run a paragraph

Before running a notebook, you must associate it to a created cluster. If a created notebook is not associated with a cluster, **Not Attached** is displayed in the upper right corner of the page. You can click to select a cluster in the list of available clusters. Note that the associated cluster must be EMR-2.3 or later, and has no less than three nodes, each with at least 4 cores and 8 GB of memory.



Click the**Run** button to automatically save the current paragraph and run the content. If this paragraph is the last one, a new paragraph is automatically created.

PENDING means the paragraph has not run yet and **RUNNING** means the paragraph is running. **FINISHED** means the running process has finished. **ERROR** means an error has occurred. The running result is displayed below the run button of the paragraph. FINISHED means the running process has been finished. ERROR means an error occurs. The running result is displayed below the run button of the section. During running, you can click "Cancel" below the "Run" button to cancel running. **ABORT** is displayed after running is canceled.

Save Paragraph — Hide results ✕ delete

```
%spark
import org.apache.commons.io.IOUtils
import java.net.URL
import java.nio.charset.Charset // load bank data
val bankText = sc.parallelize(
    IOUtils.toString(
        new URL("http://emr-sample-projects.oss-cn-hangzhou.aliyuncs.com/bank.csv"),
        Charset.forName("utf8")).split("\n"))
case class Bank(age: Integer, job: String, marital: String, education: String, balance: Integer)
val bank = bankText.map(s => s.split(";")).filter(s => s(0) != "\"age\"").map(
    s => Bank(s(0).toInt,
            s(1).replaceAll("\"", ""),
            s(2).replaceAll("\"", ""),
            s(3).replaceAll("\"", ""),
            s(5).replaceAll("\"", "").toInt
        )
).toDF()
bank.registerTempTable("bank")
```

▶ run

Run results :

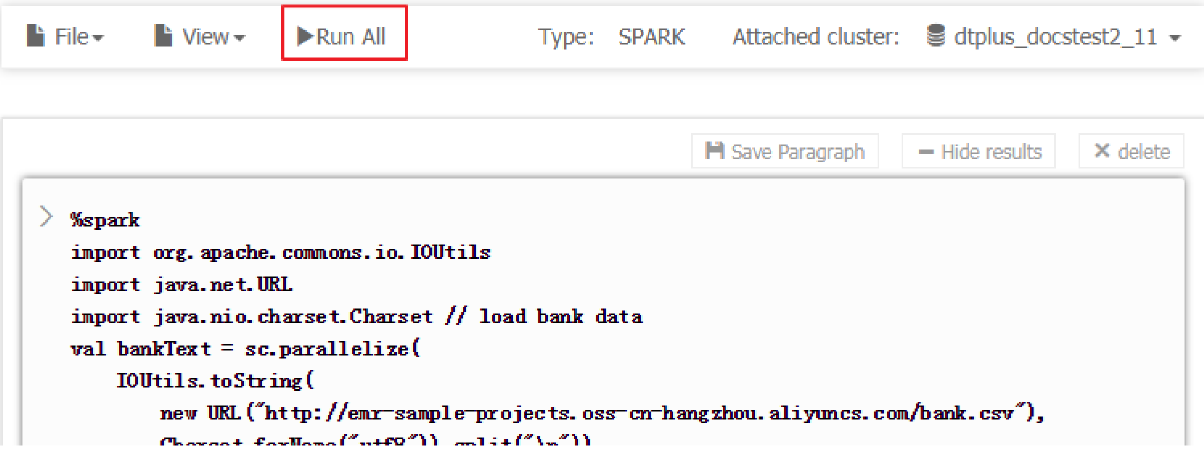
```
import org.apache.commons.io.IOUtils
import java.net.URL
import java.nio.charset.Charset
bankText: org.apache.spark.rdd.RDD[String] = ParallelCollectionRDD[29] at parallelize at <console>:36
defined class Bank
bank: org.apache.spark.sql.DataFrame = [age: int, job: string, marital: string, education: string, balance: int]
```

status : **FINISHED** , run 0second(s) , finish Time : Nov 9, 2018 11:43:32 AM

The paragraph can be run multiple times and only the result of the last running is retained. You cannot modify the entered content of the paragraph during running. The content can be modified only after running of the paragraph is finished.

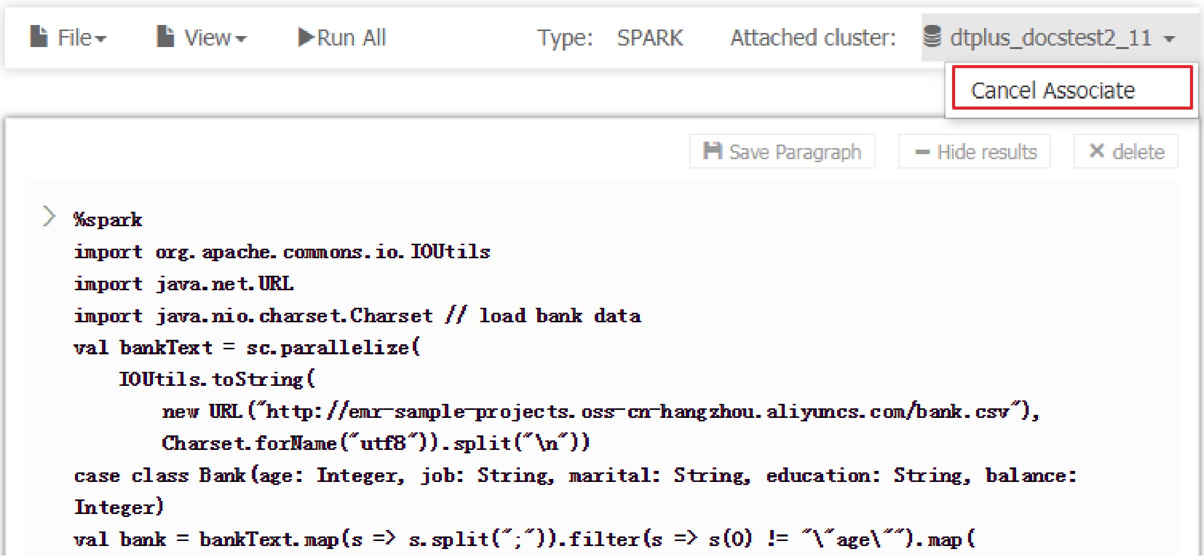
Run all

For a notebook, you can click**Run All** on the menu bar to run all paragraphs. The paragraphs are submitted sequentially for running. Different types have independent execution queues. If a notebook contains multiple paragraph types, the order for executing the paragraphs on the cluster is based on type after these paragraphs are submitted sequentially. Spark and Spark SQL support one-by-one execution. Hive supports concurrent execution and the maximum number of concurrently executed interactive paragraphs on the same cluster is 10. Note that all concurrently executed paragraphs are restricted by cluster resources. If the cluster size is small and many paragraphs need to be executed concurrently, the paragraphs still need to queue on the Yarn.



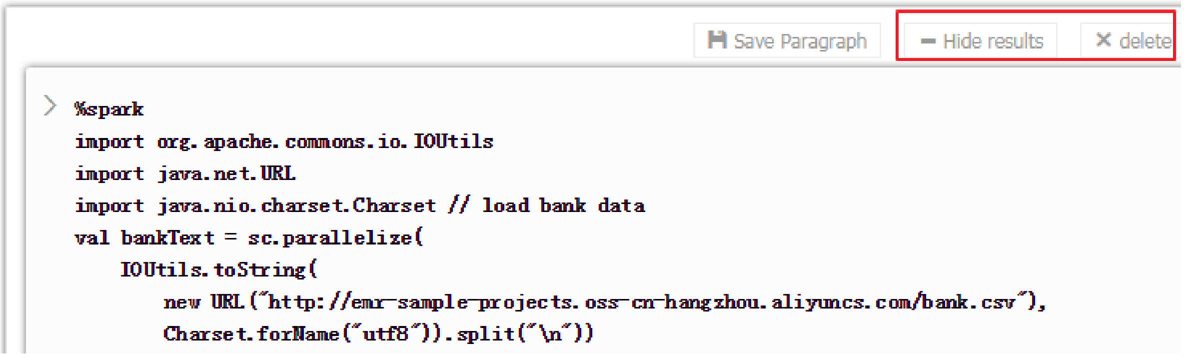
Cancel the association with clusters

After a notebook is run in a cluster, the cluster creates a process for catching of some context running environments to ensure quick response upon re-run. If you do not need to run other notebooks and you want to release the cluster resources occupied by caching, you can disassociate all notebooks that have been run from the associated clusters. In this way, you can release the memory resources occupied on the original associated clusters.



Other operations

- Paragraph operations



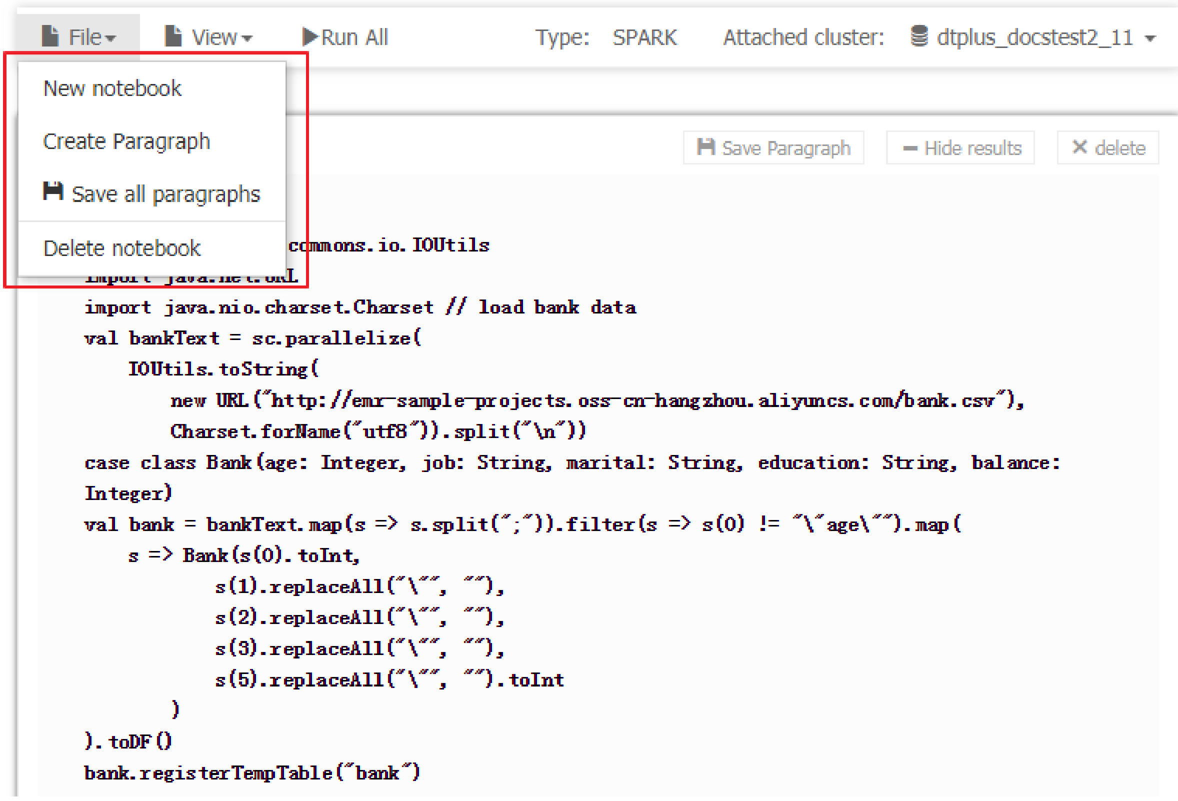
— Hide and display the results

You can hide the paragraph results and display the entered content of the paragraph only.

— Delete a paragraph

Delete the current paragraph. The paragraph that is running can also be deleted.

- File menu



— New notebook

Create a notebook and switch to the created notebook interface.

— Create Paragraph

Add a new paragraph to the end of the notebook. A notebook can only have up to 30 paragraphs.

- **Save all paragraphs**

  Save all modified paragraphs.

- **Delete notebook**

  Delete the current notebook. If the cluster has been associated, it will be disassociated.

- **View**

  Display codes only or display codes and results

  Only the entered codes for all paragraphs are displayed or both the codes and results are displayed.

16.3 Examples

16.3.1 Example of bank employee information inquiry

Section one: Create a temporary table

```
%spark
import org.apache.commons.io.IOUtils
import java.net.URL
import java.nio.charset.Charset
// Zeppelin creates and injects sc (SparkContext) and sqlContext (
HiveContext or SqlContext)
// So you don't need create them manually
// load bank data
val bankText = sc.parallelize(
    IOUtils.toString(
        new URL("http://emr-sample-projects.oss-cn-hangzhou.aliyuncs.
com/bank.csv"),
        Charset.forName("utf8")).split("\n"))
case class Bank(age: Integer, job: String, marital: String, education
: String, balance: Integer)
val bank = bankText.map(s => s.split(";")).filter(s => s(0) ! = "\"age
\"").map(
    s => Bank(s(0).toInt,
            s(1).replaceAll("\"", ""),
            s(2).replaceAll("\"", ""),
            s(3).replaceAll("\"", ""),
            s(5).replaceAll("\"", "").toInt
        )
).toDF()
bank.registerTempTable("bank")
```

Section two: Query the table structure

```
%sql
```

```
desc bank
```

Section three: Query the number of employees of each age group below 30

```
%sql select age, count(1) value from bank where age < 30 group by age
order by age
```

Section 4: Query the information of employees at the age less than or equal to 20

```
%sql select * from bank where age <= 20
```

16.3.2 Video playback data example

Data preparations

In this example, you need to download data from OSS and upload it to your OSS bucket. The data includes:

- *User Table Sample Data*
- *Video Table Sample Data*
- *Playvideo Table Sample Data*

Upload the sample data of User Table, Video Table, and Playvideo Table to the specified UserInfo , Videoinfo, and Playvideo, respectively, on your OSS bucket. For example, upload the data to Demo or UserInfo directory under Bucket Example.

In the following created table, replace the SQL [bucketname] with your bucket name, replace [region] with your OSS region name, and replace [bucketpath] with your specified path prefix of the OSS, for example, “Demo”.

Section one: Create a user table

```
%hive
CREATE EXTERNAL TABLE user_info(id int,sex int,age int, marital_st
atus int) ROW FORMAT DELIMITED FIELDS TERMINATED BY ',' LOCATION 'oss
://[bucketname].oss-cn-[region]-internal.aliyuncs.com/[bucketpath]/
userinfo'
```

Section two: Create a video table

```
%hive
CREATE EXTERNAL TABLE video_info(id int,title string,type string) ROW
 FORMAT DELIMITED FIELDS TERMINATED BY ',' LOCATION 'oss://[bucketname
].oss-cn-[region]-internal.aliyuncs.com/[bucketpath]/videoinfo'
```

Section three: Create a video play table

```
%hive
```

```
CREATE EXTERNAL TABLE play_video(user_id int,video_id int, play_time
 bigint) ROW FORMAT DELIMITED FIELDS TERMINATED BY ',' LOCATION 'oss
://[bucketname].oss-cn-[region]-internal.aliyuncs.com/[bucketpath]/
playvideo'
```

Section four: User table count

```
%sql select count(*) from user_info
```

Section five: Video table count

```
%sql select count(*) from video_info
```

Section six: Video play table count

```
%sql select count(*) from play_video
```

Section seven: Video play count of each video type

```
%sql select video.type, count(video.type) as count from play_video
 play join video_info video on (play.video_id = video.id) group by
video.type order by count desc
```

Section eight: Video information of video play top 10

```
%sql select video.id, video.title, video.type, video_count.count from
 (select video_id, count(video_id) as count from play_video group by
 video_id order by count desc limit 10) video_count join video_info
video on (video_count.video_id = video.id) order by count desc
```

Section nien: Age groups of audience watching the video with largest video play count

```
%sql select age , count(*) as count  from (select distinct(user_id)
from play_video  where video_id =49 ) play join user_info userinfo on
 (play.user_id = userinfo.id) group by userinfo.age
```

Section ten: Gender, age group, and marital status of audience watching the video with largest video play count

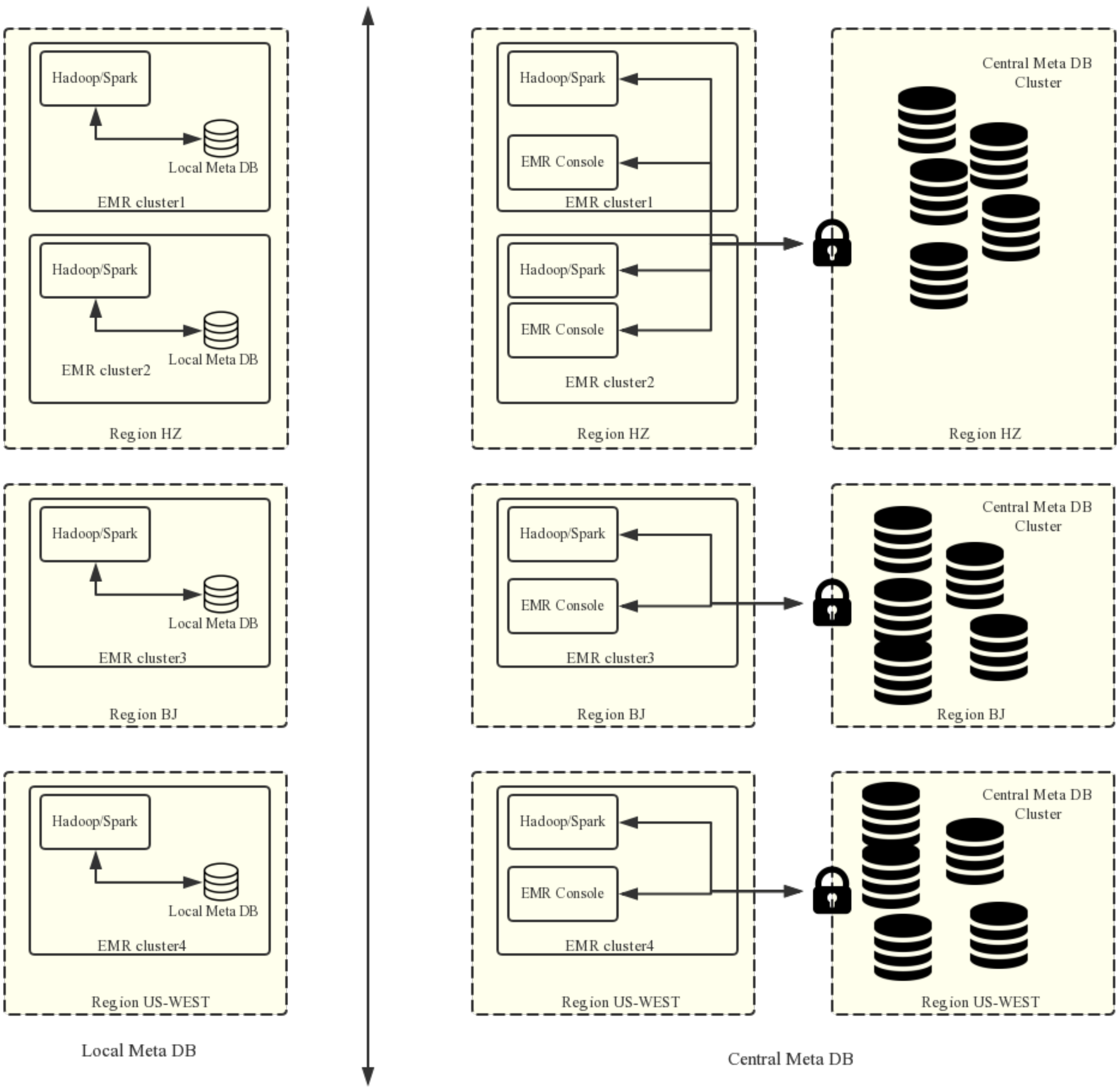
```
%sql select if(sex=0,'Female','Male') as title, count(*) as count,
 'Gender' as type from (select distinct(user_id) from play_video
where video_id =49 ) play join user_info userinfo on (play.user_id =
userinfo.id) group by userinfo.sex
union all
select case when userinfo.age<15 then 'Less than 15' when age<25 then
 '15-25' when age<35 then '25-35' else 'More than 35' end  , count
(*) as count, 'Age Group' as type from (select distinct(user_id) from
 play_video  where video_id =49) play join user_info userinfo on (play
.user_id = userinfo.id) group by case when userinfo.age<15 then 'Less
than 15' when age<25 then '15-25' when age<35 then '25-35' else 'More
than 35' end
union all
select if(marital_status=0,'Unmarried','Married') as title, count(*)
as count, 'Marital Status' as type from (select distinct(user_id) from
```

```
 play_video  where video_id =49 ) play join user_info userinfo on (
play.user_id = userinfo.id) group by marital_status
```

17 Table mangement

E-MapReduce 2.4.0 and later versions support central metadata management. In the versions earlier than E-MapReduce 2.4.0, all clusters use the local MySQL database as the Hive metadatabase. In E-MapReduce 2.4.0 and later versions, E-MapReduce supports the central highly-reliable Hive metadatabase.

Introduction



You can enable the central metadatabase function when creating a cluster to use the external metadatabase.

Note:

- The current metadatabase needs to be connected using the public IP address. Therefore, the cluster must have a public IP address. Do not change the public IP address. Otherwise, the corresponding database whitelist is invalid.
- The table management function can be used only when the central metadatabase function is enabled when a cluster is created. A local metadatabase does not support table management currently. In that case, you may use the Hue tool in the cluster for table management.

The central metadata management function can:

1. Provide long-term metadata storage.

   When metadata is stored in the local MySQL database of the cluster, metadata is lost when the cluster is released. Especially when E-MapReduce supports the flexible creation mode, clusters can be created and released anytime upon requirements. To retain the metadata, you must log on to the cluster and manually export the metadata. This issue can be resolved with the central metadata management function.
2. Separate computing and storage.

   E-MapReduce supports storing data in Alibaba Cloud OSS, which reduces the usage cost especially when the data volume is large. Meanwhile, E-MapReduce clusters are mainly used as computing resources and can be released anytime after use. Since data is stored in OSS, the metadata migration issue does not exist.
3. Implement data sharing.

   With the central metadatabase, if all data is stored in OSS, all clusters can directly access data without migrating or restructuring metadata. This enables E-MapReduce clusters to provide different services while still ensuring direct data sharing.

Note:

Before central metadata management is supported, metadata is stored in the local MySQL database of each cluster and is lost when the cluster is released. With central metadata management, releasing clusters does not clean up metadata. Before you delete the data in OSS or in the HDFS of a cluster or you release a cluster, make sure that the corresponding metadata is already deleted. That means the tables and database that store the data have been dropped. This prevents dirty metadata in the database.

Table management operations

Before E-MapReduce clusters support metadata management, you have to log on to the internal environment of a cluster to check, add, or delete tables in the cluster. If more than one clusters exist, you have to log on to the clusters one by one, which is inconvenient. With the central metadata management function, E-MapReduce enables table management on the console. This includes checking the list of databases and tables, checking table details, creating and deleting databases and tables, and previewing data.

- Database and table list
- Table details
- Data preview
- Create a database
- Create a table

  Two methods to create a table:Manual creation and Creation from a file

  - Manual creation, When no service data exists, you can manually input the table structure to create an empty table;
  - Creation from a file, When service data already exists, you can use the service data as a table directly by parsing the table interface from the file. Make sure that the separators used for creating a table must correspond to those used in the data file to have a proper table structure.

  The separators can be common characters such as commas and spaces, or special characters TAB, ^A, ^B, and ^C.

Note:

1. Databases and tables can be created and deleted only in E-MapReduce clusters.
2. The HDFS is the internal file system of each cluster and does not support cross-cluster communication without special network settings. Therefore, the E-MapReduce table management function only supports creating databases and tables based on the OSS file system.
3. The location of a database or table must be in a directory under the OSS bucket, rather than the OSS bucket.

FAQs

1. Wrong FS: `oss://yourbucket/xxx/xxx/xxx`

This error occurs when the table data on OSS is deleted while the metadata of the table is not. The table schema persists, while the actual data does not exist or is moved to another location . In this case, you can change the table location to an existing path and delete the table again.

`alter table test set location 'oss://your_bucket/your_folder'`

This can be completed on the E-MapReduce interactive console.

> **Note:**
>
> *`oss://your_bucket/your_folder`*must be an existing OSS path.

2. Wrong FS: hdfs://yourhost:9000/xxx/xxx/xxx

   This error occurs when the table data in the HDFS is deleted while the table schema persists. The error can be removed by using the preceding solution.

3. The message “java.lang.IllegalArgumentException: java.net.UnknownHostException: xxxxxxx” is displayed when the Hive database is deleted.

   This error occurs because the Hive database is created in the HDFS of a cluster and it is not cleaned up when the cluster is released. As a result, its data in the HDFS of the released cluster cannot be accessed after a new cluster is created. Therefore, when releasing a cluster, remember to clean up the databases and tables that are manually created in the HDFS of the cluster.

   Solution

   Log on to the master node of the cluster using the command line, and find the address, username, and password for accessing the Hive metadatabase in *`$HIVE_CONF_DIR/hive-site.xml`*.

```
javax.jdo.option.ConnectionUserName //Username for accessing the
database;
javax.jdo.option.ConnectionPassword //Password for accessing the
database;
javax.jdo.option.ConnectionURL //Address and name of the database ;
```

```
<property>
  <name>javax.jdo.option.ConnectionUserName</name>
  <value>${ConnectionUserName}</value>
  <description>Username to use against metastore database</description>
</property>
<property>
  <name>javax.jdo.option.ConnectionPassword</name>
  <value>${ConnectionPassword}</value>
  <description>password to use against metastore database</description>
</property>
<property>
  <name>javax.jdo.option.ConnectionURL</name>
  <value>jdbc:mysql://${DBConnectionURL}/${DBName}?createDatabaseIfNotExist=true&amp;amp;characterEncoding=UTF-8</value>
  <description>JDBC connect string for a JDBC metastore</description>
</property>
```

Log on to the Hive metadatabase on the master node of the cluster:

```
mysql -h ${DBConnectionURL} -u ${ConnectionUserName} -p [Press Enter
]
[Enter the password]${ConnectionPassword}
```

After logging on to the Hive metadatabase, change its location to an existing OSS path in the region:

```
mysql> show databases;
+--------------------------------------------------+
| Database                                         |
+--------------------------------------------------+
| information_schema                               |
| xxxxxxxxx77ac43c3bd0efae77e0bf1947d45fb4c896fb99 |
+--------------------------------------------------+

mysql> use xxxxxxxxx77ac43c3bd0efae77e0bf1947d45fb4c896fb99;

mysql> select * from dbs;
+-------+-----------------------+------------------------------------+----------+------------+------------+
| DB_ID | DESC                  | DB_LOCATION_URI                    | NAME     | OWNER_NAME | OWNER_TYPE |
+-------+-----------------------+------------------------------------+----------+------------+------------+
|     1 | Default Hive database | oss://mybucket/hive/warehouse      | default  | public     | ROLE       |
|     6 | NULL                  | hdfs://dirty-hostname/warehouse    | dirty_db | NULL       | USER       |
+-------+-----------------------+------------------------------------+----------+------------+------------+

mysql> update dbs set DB_LOCATION_URI = 'oss://your-bucket/your-db-folder' where DB_ID = 6;
```

18 Kerberos authentication

18.1 Introduction to Kerberos

E-MapReduce supports creating secure clusters from EMR-2.7.x and EMR-3.5.x where open source components in the cluster are started in the Kerberos security mode. In this mode, only authenticated clients can access the cluster service such as HDFS.

Prerequisites

Kerberos components supported by the current E-MapReduce version are shown in the following table:

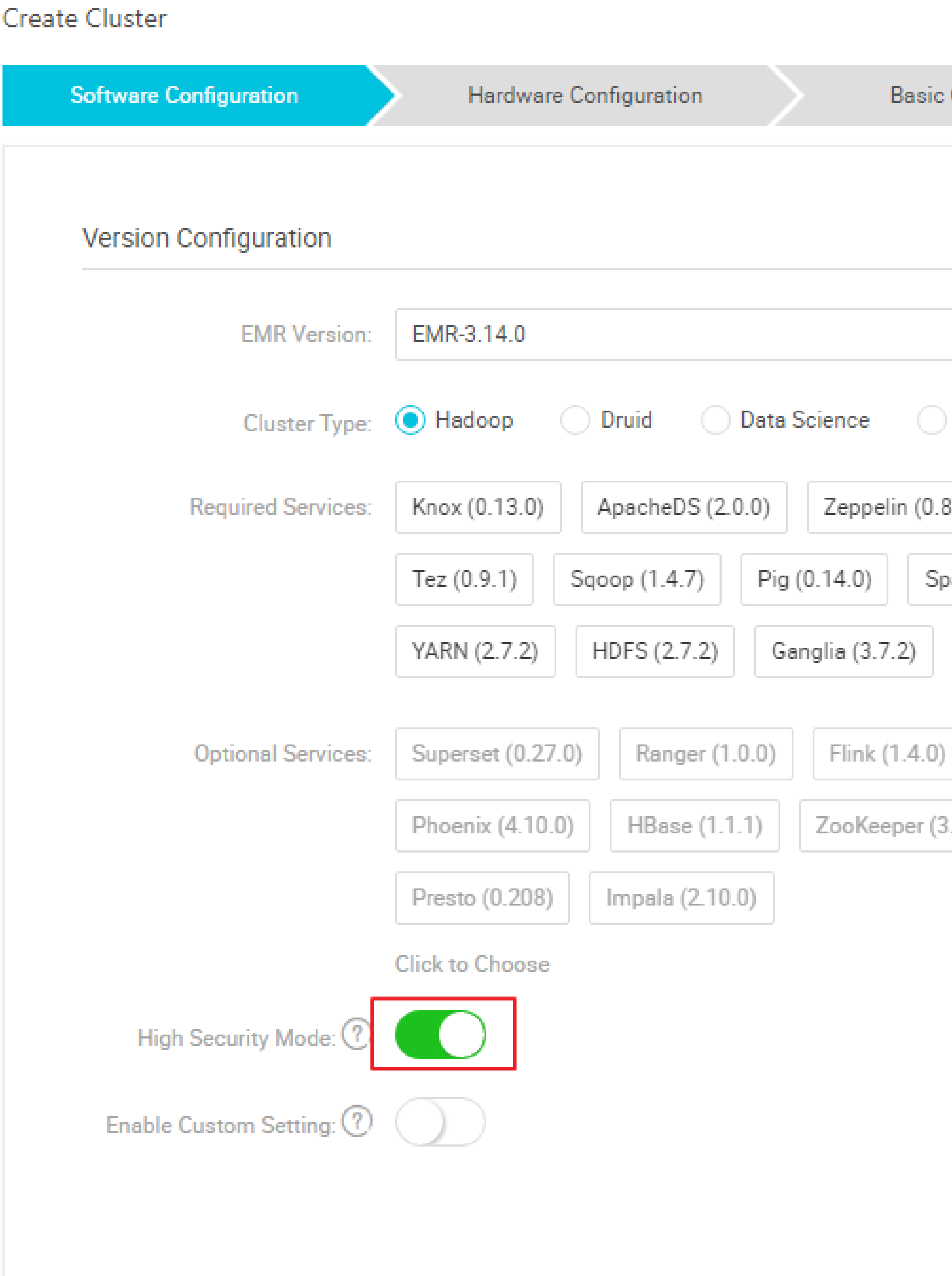
Component name	Component version
YARN	2.7.2
SPARK	2.1.1/1.6.3
HIVE	2.0.1
TEZ	0.8.4
ZOOKEEPER	3.4.6
HUE	3.12.0
ZEPPELIN	0.7.1
OOZIE	4.2.0
SQOOP	1.4.6
HBASE	1.1.1
PHOENIX	4.7.0

Note:

Remarks: Currently Kafka, Presto, and Storm do not support Kerberos.

Create a save cluster

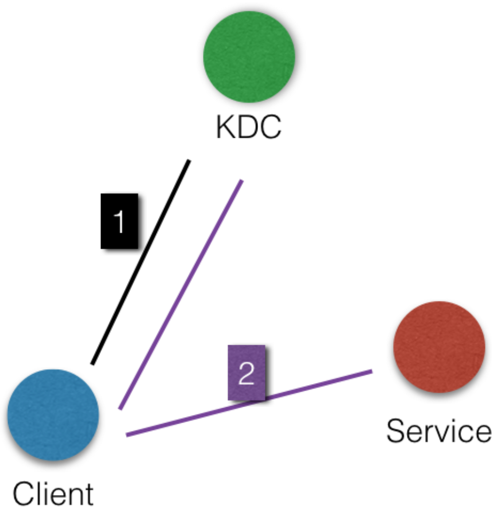
You can turn on **High Security Mode** switch on the software configuration tab of the cluster creation page as shown in the following figure:


Create Cluster
Software Configuration
Hardware Configuration
Basic
Version Configuration
EMR Version:
EMR-3.14.0
Cluster Type:
Hadoop
Druid
Data Science
Required Services:
Knox (0.13.0)
ApacheDS (2.0.0)
Tez (0.9.1)
Sqoop (1.4.7)
Pig (0.14.0)
YARN (2.7.2)
HDFS (2.7.2)
Ganglia (3.7.2)
Optional Services:
Superset (0.27.0)
Ranger (1.0.0)
Flink (1.4.0)
Phoenix (4.10.0)
HBase (1.1.1)
Presto (0.208)
Impala (2.10.0)
Click to Choose
High Security Mode:
Enable Custom Setting:

Kerberos identity authentication principle

Kerberos is an identity authentication protocol based on the symmetric key technology. As an independent third-party identity authentication service, Kerberos can provide its ID authentication function for other services, and it supports SSO (the client ican access multiple services, such as HBase and HDFS, after ID authentication).

The Kerberos protocol process is mainly divided into two stages where KDC authenticates the Client identity in the first stage, and the Service authenticates the Client identity in the second stage.



- KDC

  Kerberos server
- Client

  If a user (principal) needs to access the service, KDC and Service authenticates the principal's identity.
- Service

  Services that have integrated with Kerberos include HDFS, YARN, and HBase.
- KDC ID authentication

  Before a client user (principal) can access a service integrated with Kerberos, it must first pass the KDC ID authentication.

  After passing the KDC ID authentication, the client receives a TGT (Ticket Granting Ticket), which can be used to access a service that has integrated Kerberos.
- Service ID authentication

When a principal receives the TGT in step 2.1, it can access the Service. It uses the TGT and the name of the service that it must access (such as HDFS) to obtain an SGT (Service Granting Ticket) from KDC, and use the SGT to access Service, which uses the relevant information to conduct ID authentication on the client. After passing the ID authentication, the client can normally access the Service.

EMR practice

Services in the EMR Kerberos security cluster starts in the Kerberos security mode when creating a cluster.

- The Kerberos server is HasServer
  - Log on to the *EMR Console*,choose **Cluster** > > **Configuration Management** > **HAS** , and conduct operations including View, Modify configuration, and Restart.
  - Non-HA clusters are deployed on emr-header-1, while HA clusters are deployed on both the emr-header-1 and emr-header-2 nodes.
- Supports four ID authentication methods

  HasServer supports the following four ID authentication methods. The client can specify the method to be used by HasServer through configuring the related parameters.

  - ID authentication compatible with MIT Kerberos

    Client configuration:

    ```
    If you want to execute a client request on a cluster node, you
    must set
    hadoop.security.authentication.use.has in /etc/ecm/hadoop-conf/
    core-site.xml to false.
    In case of any jobs are running through the execution plan of the
     console, then values in the /etc/ecm/hadoop-conf/core-site.xml
    file on the master node must not be modified. Otherwise, the job
    in the execution plan fails because of the authentication failure
    . You can follow these steps:
    export HADOOP_CONF_DIR=/etc/has/hadoop-conf Export a temporary
    environment variable. The hadoop.security.authentication.use.has
    value under this path has already been set to false.
    ```

    Access method:You can use open source clients to access Service, such as HDFS client. For more information, *click here.*

  - RAM ID authentication

    Client configuration:

    ```
    If you want to run a client request on a cluster node, you must
    set
    ```

```
hadoop.security.authentication.use.has in /etc/ecm/hadoop-conf/
core-site.xml to true, and auth_type in /etc/has/has-client.conf
to RAM.
In case of any jobs are running through the execution plan of the
 console, then values in the /etc/ecm/hadoop-conf/core-site.xml
and /etc/has/has-client.conf files on the master node must not be
 modified. Otherwise, the job in the execution plan fails because
of the authentication failure. You can use the following method:
export HADOOP_CONF_DIR=/etc/has/hadoop-conf; export HAS_CONF_DIR
=/path/to/has-client.conf Export a temporary environment variable
, and then set the auth_type in the has-client.conf file of the
HAS_CONF_DIR folder to RAM.
```

Access method: The client must use a software package of the cluster (such as Hadoop and HBase). For more information, click *here*.

- LDAP ID authentication

  Client configuration:

```
If you want to execute a client request on a cluster node, you
must set
hadoop.security.authentication.use.has in /etc/ecm/hadoop-conf/
core-site.xml to true, and auth_type in /etc/has/has-client.conf
to LDAP.
In case of any jobs are running through the execution plan of the
 console, then values in the /etc/ecm/hadoop-conf/core-site.xml
and /etc/has/has-client.conf files on the master node must not be
 modified. Otherwise, the job in the execution plan fails because
of the authentication failure. You can follow these steps:
export HADOOP_CONF_DIR=/etc/has/hadoop-conf; export HAS_CONF_DIR
=/path/to/has-client.conf Export temporary environment viarables
, and then set the auth_type in the has-client.conf file of the
HAS_CONF_DIR folder to LDAP.
```

  Access method: The client must use a software package of the cluster (such as Hadoop and HBase). For more information, click*here*.

- Execution plan authentication

  If you have jobs submitted through the execution plan of the EMR console, you must not modify the default configuration of the emr-header-1 node.

  Client configuration:

```
Set hadoop.security.authentication.use.has in /etc/ecm/hadoop-conf
/core-site.xml to true, and auth_type in /etc/has/has-client.conf
on emr-header-1 to EMR.
```

  For more information, click *here*.

- Others

  Log on to the master node to access the cluster

The cluster administrator can also log on to the master node to access the cluster service. The administrator can use the has account (the default logon method is the MIT-Kerberos-compatible method) to log on to the master node and access the cluster service, which is convenient to conduct some troubleshooting or O&M tasks.

```
&gt;sudo su has
&gt;hadoop fs -ls /
```

> **Note:**
> Other accounts can also be used to log on the master node, provided that such accounts have already passed Kerberos authentication. In addition, if you must use the MIT-Kerberos-compatible method on the master node, you must first export an environment variable under this account.

`export HADOOP_CONF_DIR=/etc/has/hadoop-conf/`

18.2 Authentication method compatible with MIT Kerberos

This article will introduce the MIT Kerberos authentication process through the HDFS service.

Authentication method compatible with MIT Kerberos identity

The Kerberos server in the EMR cluster is started at the master node, and some management operations must be performed with the root account of the master node (emr-header-1).

The user test's access to the HDFS service is used as an example to introduce the relevant procedure as follows:

- Executed `hadoop fs -ls /`on the Gateway
  - Configure krb5.conf

    ```
    Use root account on the Gateway
     scp root@emr-header-1:/etc/krb5.conf /etc/
    ```
  - Add principal
    - Log on to the cluster emr-header-1 node and switch to the root account
    - Open the admin tool in Kerberos
    - ```
        sh /usr/lib/has-current/bin/hadmin-local.sh /etc/ecm/has-conf
       -k /etc/ecm/has-conf/admin.keytab
        HadminLocalTool.local: #Press Enter to view the use of the
      commands
        HadminLocalTool.local: addprinc #Input the command and press
      Enter to view the use of the specific command
      ```
      ```

```
   HadminLocalTool.local: addprinc -pw 123456 test #Add
principal for the user test, and set the password to 123456
```

- Export the keytab file

  Admin tool with Kerberos can be used to export the keytab file corresponding to the principal

  ```
  HadminLocalTool.local: ktadd -k /root/test.keytab test #Export the
   keytab file, which can be used subsequently
  ```

- Use kinit to obtain the Ticket

  On the client machine where HDFS commands are executed, such as the gateway

  - Add Linux account test`useradd test`
  - Install MITKerberos client tools

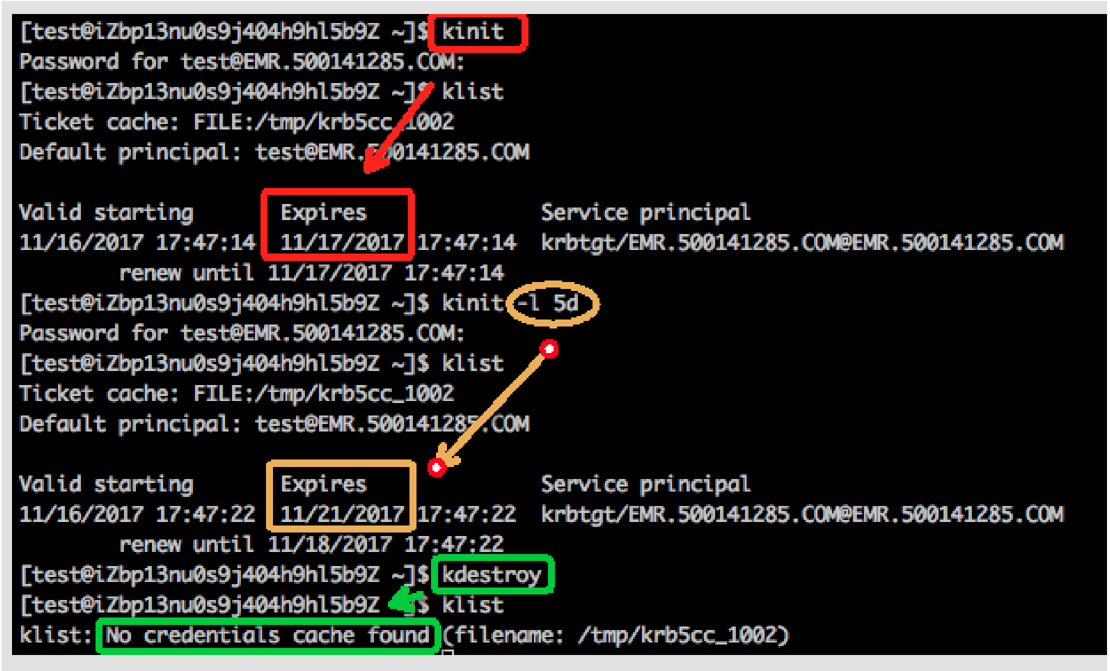
    MITKerberos tools can be used for relevant operations (such as kinit and klist). For detailed usage, see MITKerberos document

    `yum install krb5-libs krb5-workstation -y`
  - Switch to account test to execute kinit

    ```
            su test
            #If the keytab file does not exist, execute
            kinit #Press Enter
            Password for test: 123456 #Done
            #the keytab file exists, execute
            kinit -kt test.keytab test
            #View the ticket
            klist
    ```

    Note:

    Practices of MITKerberos tools



— Execute HDFS commands

When a ticket is obtained, HDFS commands can be normally executed.

```
hadoop fs -ls /
      Found 5 items
     drwxr-xr-x     - hadoop hadoop          0 2017-11-12 14:23 /
apps
     drwx------      - hbase  hadoop           0 2017-11-15 19:40
 /hbase
     drwxrwx--t+   - hadoop hadoop         0 2017-11-15 17:51 /
spark-history
     drwxrwxrwt    - hadoop hadoop         0 2017-11-13 23:25 /tmp
     drwxr-x--t      - hadoop hadoop          0 2017-11-13 16:12 /
user
```

Note:

Corresponding Linux accounts must be added to all the nodes in the cluster in advance for running yarn job (for more information, see the following [Add test account to the EMR cluster])

- Use Java code to access HDFS

— Use local ticket cache

Note:

You need to execute kinit in advance to obtain the ticket, and the application will not be normally accessed when the ticket expires.

```
public static void main(String[] args) throws IOException {
   Configuration conf = new Configuration();
```

```
    //Load the HDFS configuration, which is copied from the EMR
cluster
    conf.addResource(new Path("/etc/ecm/hadoop-conf/hdfs-site.xml
"));
    conf.addResource(new Path("/etc/ecm/hadoop-conf/core-site.xml
"));
    //kinit needs to be executed in advance to obtain the ticket
with the Linux account of the application
    UserGroupInformation.setConfiguration(conf);
    UserGroupInformation.loginUserFromSubject(null);
    FileSystem fs = FileSystem.get(conf);
    FileStatus[] fsStatus = fs.listStatus(new Path("/"));
    for(int i = 0; i < fsStatus.length; i++){
        System.out.println(fsStatus[i].getPath().toString());
    }
}
```

- Use keytab file (recommended)

Note:

keytab has long-term validity, and is independent with the local ticket

```
public static void main(String[] args) throws IOException {
  String keytab = args[0];
  String principal = args[1];
  Configuration conf = new Configuration();
  //Load the HDFS configuration, which is copied from the EMR
cluster
  conf.addResource(new Path("/etc/ecm/hadoop-conf/hdfs-site.xml
"));
  conf.addResource(new Path("/etc/ecm/hadoop-conf/core-site.xml
"));
  //Directly use keytab file, which is obtained through executing
relevant commands on master-1 in the EMR cluster [the commands are
 introduced earlier in this article]
  UserGroupInformation.setConfiguration(conf);
  UserGroupInformation.loginUserFromKeytab(principal, keytab);
  FileSystem fs = FileSystem.get(conf);
  FileStatus[] fsStatus = fs.listStatus(new Path("/"));
  for(int i = 0; i < fsStatus.length; i++){
      System.out.println(fsStatus[i].getPath().toString());
  }
  }
```

Pom dependencies are attached:

```
<dependencies>
            <dependency>
                <groupId>org.apache.hadoop</groupId>
                <artifactId>hadoop-common</artifactId>
                <version>2.7.2</version>
            </dependency>
            <dependency>
                <groupId>org.apache.hadoop</groupId>
                <artifactId>hadoop-hdfs</artifactId>
                <version>2.7.2</version>
            </dependency>
```

```
        </dependencies>
```

18.3 Ram certification

The Kerberos server in the EMR cluster supports not only the authentication method compatible with MIT Kerberos, but also the identity authentication by using RAM as the identity information.

RAM ID authentication

RAM product supports creating/managing subaccounts and using subaccounts to implement access control for various resources on the cloud.

Administrator of the master account can create a subaccount on the RAM user management page (subaccount name must comply with Linux username specifications) and download the subaccount AccessKey for the corresponding developer. The developer can then configure the AccessKey to pass Kerberos authentication and access the cluster service.

Unlike using the first type MIT Kerberos authentication, RAM identity authentication does not require adding principle to the Kerberos server in advance.

The following example uses subaccount test that has already been created to access a gateway:

- Add the test subaccount into the EMR cluster

  The EMR security cluster's yarn uses LinuxContainerExecutor. Running the yarn job on a cluster requires all cluster nodes to add the user account that is going to run the job. LinuxContainerExecutor conducts the related permission validation based on the user account during the execution process.

  The EMR cluster administrator executes the following code on the EMR cluster's master node:

  ```
  sudo su hadoop
  sh adduser.sh test 1 2
  ```

  Attachment: adduser.sh code

  ```
  # Username
   user_name=$1
   # Master node count in the cluster. For example, the HA cluster has
   two master nodes.
   master_cnt=$2
   # Worker node count in the cluster
   worker_cnt=$3
   for((i=1;i<=$master_cnt;i++))
   do
     ssh -o StrictHostKeyChecking=no emr-header-$i sudo useradd $
  user_name
   done
   for((i=1;i<=$worker_cnt;i++))
   do
  ```

```
   ssh -o StrictHostKeyChecking=no emr-worker-$i sudo useradd $
user_name
done
```

- The gateway administrator adds the test user account on the gateway machine

```
useradd test
```

- The gateway administrator configures the basic Kerberos environment

```
sudo su root
 sh config_gateway_kerberos.sh 10.27.230.10 /pathto/emrheader1
_pwd_file
 # Ensures the value of the /etc/ecm/hadoop-conf/core-site.xml file
on the Gateway is true
 <property>
    <name>hadoop.security.authentication.use.has</name>
    <value>true</value>
 property
```

Attachment: config_gateway_kerberos.sh script

```
# IP address of the emr-header-1 in the EMR cluster
 masterip=$1
 # Saves the corresponding root logon password file for masterip
 masterpwdfile=$2
 if ! type sshpass >/dev/null 2>&1; then
    yum install -y sshpass
fi
  ## Kerberos conf
 sshpass -f $masterpwdfile scp root@$masterip:/etc/krb5.conf /etc/
 mkdir /etc/has
 sshpass -f $masterpwdfile scp root@$masterip:/etc/has/has-client.
conf /etc/has
 sshpass -f $masterpwdfile scp root@$masterip:/etc/has/truststore /
etc/has/
 sshpass -f $masterpwdfile scp root@$masterip:/etc/has/ssl-client.
conf /etc/has/
 # Modifies Kerberos client configuration, changing the default
auth_type from EMR to RAM
 # This file can be manually modified
 sed -i 's/EMR/RAM/g' /etc/has/has-client.conf
```

- Test user logs on to the gateway and configures AccessKey

```
Log on the test account of Gateway
 # Run the script
 sh add_accesskey.sh test
```

Attachment: add_accesskey.sh script (modify the AccessKey)

```
user=$1
 if [[ `cat /home/$user/.bashrc | grep 'export AccessKey'` == "" ]];
then
 echo "
 # Change to the test user's AccessKeyId/AccessKeySecret
 export AccessKeyId=YOUR_AccessKeyId
 export AccessKeySecret=YOUR_AccessKeySecret
 " >>~/.bashrc
```

```
else
   echo $user AccessKey has been added to .bashrc
fi
```

- Test user executes the command

  After taking the preceding steps, the test user is now able to execute the relevant commands to access the cluster service.

  Execute HDFS commands

```
[test@gateway ~]$ hadoop fs -ls /
  17/11/19 12:32:15 INFO client.HasClient: The plugin type is: RAM
  Found 4 items
  drwxr-x---   - has    hadoop          0 2017-11-18 21:12 /apps
  drwxrwxrwt   - hadoop hadoop          0 2017-11-19 12:32 /spark-
history
  drwxrwxrwt   - hadoop hadoop          0 2017-11-18 21:16 /tmp
  drwxrwxrwt   - hadoop hadoop          0 2017-11-18 21:16 /user
```

  Run the hadoop job

```
[test@gateway ~]$ hadoop jar /usr/lib/hadoop-current/share/hadoop/
mapreduce/hadoop-mapreduce-examples-2.7.2.jar pi 10 1
```

  Run the spark job

```
[test@gateway ~]$ spark-submit --conf spark.ui.view.acls=* --class
 org.apache.spark.examples.SparkPi --master yarn-client --driver-
memory 512m --num-executors 1 --executor-memory 1g --executor-cores
2 /usr/lib/spark-current/examples/jars/spark-examples_2.11-2.1.1.jar
 10
```

18.4 LDAP authentication

EMR cluster also supports authentication based on LDAP, which manages the account system through LDAP. Kerberos client uses LDAP account information as identity for authentication.

LDAP Identity Authentication

LDAP account can be shared with other services, such as Hue. Users must only configure it on the Kerberos server. Users can use the LDAP service (ApacheDS) that has been configured in the EMR cluster or use the existing LDAP service. Users must only configure it on the Kerberos server.

Here's an example of an LDAP service (ApacheDS) that has been started by default in a cluster:

- Configure the basic environment in Gateway management (the same as that in the second part of the RAM, which can be skipped if it has been configured).

The only difference is that *auth_type* in */etc/has/has-client.conf* needs to be modified to LDAP

Or the user can also not modify */etc/has/has-client.conf*. The user test can copy the file and modify *auth_type* with their account and specify the path through environment variables, for example:

```
export HAS_CONF_DIR=/home/test/has-conf
```

- Configure LDAP manager user/password to Kerberos server end (Has) in the EMR console.

  Enter the EMR console Cluster Management - HAS software, configure the LDAP manager user name and password to the corresponding *bind_dn* and *bind_password* fields and restart the HAS service.

  In this example, the LDAP service is the ApacheDS in the EMR cluster, and related fields can be obtained from ApacheDS.

- EMR cluster manager adds user information to LDAP
  - Obtain ApacheDS LDAP service and manager user and password *manager_dn* and *manager_password* can be seen in EMR Console Cluster Configuration Management/ApacheDS Configuration
  - Add user test and password in ApacheDS

```
Log on to root account in the cluster emr-header-1 node
 Create a file test.ldif with the following content:
 dn: cn=test,ou=people,o=emr
 objectclass: inetOrgPerson
 objectclass: organizationalPerson
 objectclass: person
 objectclass: top
 cn: test
 sn: test
 mail: test@example.com
 userpassword: test1234
 #Add to LDAP, in which -w denotes that password is changed to
manager_password
 ldapmodify -x -h localhost -p 10389 -D "uid=admin,ou=system" -w "
Ns1aSe" -a -f test.ldif
 #Delete test.ldif
 rm test.ldif
```

    Provide added user name/passowrd to user test.

- User test configures LDAP information

```
Log on the test account of Gateway
 # Run the script
```

```
sh add_ldap.sh test
```

Attachment: Script add_ldap.sh (modifying LDAP account information)

```
user=$1
 if [[ `cat /home/$user/.bashrc | grep 'export LDAP_'` == "" ]];then
 echo "
 #Modify to the user test's LDAP_USER/LDAP_PWD
 export LDAP_USER=YOUR_LDAP_USER
 export LDAP_PWD=YOUR_LDAP_USER
 " >>~/.bashrc
 else
    echo $user LDAP user info has been added to .bashrc
 fi
```

- User test access to the cluster services

  Execute HDFS commands

```
[test@iZbp1cyio18s5ymggr7yhrZ ~]$ hadoop fs -ls /
  17/11/19 13:33:33 INFO client.HasClient: The plugin type is: LDAP
  Found 4 items
  drwxr-x---   - has    hadoop          0 2017-11-18 21:12 /apps
  drwxrwxrwt   - hadoop hadoop          0 2017-11-19 13:33 /spark-
history
  drwxrwxrwt   - hadoop hadoop          0 2017-11-19 12:41 /tmp
  drwxrwxrwt   - hadoop hadoop          0 2017-11-19 12:41 /user
```

  Run Hadoop/Spark job.

18.5 Execution plan authentication

E-MapReduce clusters support execution plan authentication. You can authorize subaccounts to access execution plans using the master account.

Master account access

After logging on to E-MapReduce console with the master account, you can run the corresponding execution plan on the Execution plan page. Submit the jobs to the security cluster for execution and access the related open source component services involved in the jobs using the hadoop username.

Subaccount access

After logging on to E-MapReduce console with the RAM subaccount, you can run the correspond ing execution plan on the Execution plan page. Submit the jobs to the security cluster for execution and access the related open source component services involved in the jobs using the corresponding username of the RAM subaccount.

Examples

- The master account administrator can create multiple subaccounts (such as A, B, and C) as needed and grant the *Aliyun EMR Full Access* permissions to these subaccounts from the RAM console. Then, the subaccounts can log on to the E-MapReduce console and use the related functions.
- The master account administrator may provide the subaccounts to developers.
- After job creation and plan execution, developers may start executing the execution plans to submit jobs to the cluster, and then access the relevant component services in the cluster using usernames (such as A, B, and C) corresponding to their subaccounts.

  Note:

  Currently, the periodic execution plans are uniformly executed using the hadoop account.
- Relevant permission control for component services, for example, whether Account A has the permission to access a file in hdfs or not, is performed by using the username of a subaccount.

18.6 Cross-region access

Kerberos in E-MapReduce supports the cross-region feature, that is, different Kerberos clusters can inter-access each other.

This article describe cross-region access by using Cluster-A and Cluster-B as an example.

- hostname of emr-header-1 in Cluster-A → emr-header-1.cluster-1234 ; region → EMR.1234.COM
- hostname of emr-header-1 in Cluster-B → emr-header-1.cluster-6789 ; region → EMR.6789.COM
- **Note:**

  - The hostname can be obtained through executing the command hostname on emr-header-1.
  - Region can be obtained in /etc/krb5.conf on emr-header-1.

Add principal

emr-header-1 nodes in Cluster-A and Cluster-B run the same command exactly as follows:

```
# root account
       sh /usr/lib/has-current/bin/hadmin-local.sh /etc/ecm/has-conf -
k /etc/ecm/has-conf/admin.keytab
```

```
      HadminLocalTool.local: addprinc -pw 123456 krbtgt/EMR.6789.COM@
EMR.1234.COM 6789. COM@EMR. 1234. Com
```

Note:

- 123456 is the password, which can be changed.
- EMR.6789.COM is the region of Cluster-B, namely, the region of the cluster to be accessed.
- EMR.1234.COM is the region of Cluster-A, namely, the region of the cluster that initiates the access.

Configure /etc/krb5.conf for Cluster-A

Configure [regions]/[domain_region]/[capaths] on Cluster-A as follows:

```
[libdefaults]
    kdc_realm = EMR. 1234. COM
    default_realm = EMR. 1234. COM
    udp_preference_limit = 4096
    kdc_tcp_port = 88
    kdc_udp_port = 88
    dns_lookup_kdc = false
[realms]
    EMR. 1234. COM = {
                kdc = 10.81.49.3:88
    }
    EMR. 6789. COM = {
                kdc = 10.81.49.7:88
    }
[domain_realm]
    .cluster-1234 = EMR. 1234. COM
    .cluster-6789 = EMR. 6789. COM
[capaths]
    EMR. 1234. COM = {
       EMR. 6789. COM = .
    }
    EMR. 6789. COM = {
       EMR. 1234. COM = .
    }
```

Synchronize /etc/krb5.conf to all Cluster-A nodes.

Copy the binding information (only the long domain name emr-xxx-x.cluster-xxx is needed) in the file /etc/hosts in Cluster-B to /etc/hosts for all Cluster-A nodes.

```
10.81.45.89  emr-worker-1.cluster-xxx
 10.81.46.222  emr-worker-2.cluster-xx
 10.81.44.177  emr-header-1.cluster-xxx
```

Note:

- If a job is running on Cluster-A to access Cluster-B. yarn must be restarted.

- Configure host binding information for all Cluster-A nodes.

Access services in Cluster-B

The keytab file /ticket in Kerberos of Cluster-A can be used on Cluster-A as a cache to access services in Cluster-B. Matters:

For example, access hdfs service in Cluster-B:

```
su has;
hadoop fs -ls hdfs://emr-header-1.cluster-6789:9000/
Found 4 items
-rw-r-----   2 has    hadoop         34 2017-12-05 18:15 hdfs://emr-
header-1.cluster-6789:9000/abc
drwxrwxrwt   - hadoop hadoop          0 2017-12-05 18:32 hdfs://emr-
header-1.cluster-6789:9000/spark-history
drwxrwxrwt   - hadoop hadoop          0 2017-12-05 17:53 hdfs://emr-
header-1.cluster-6789:9000/tmp
drwxrwxrwt   - hadoop hadoop          0 2017-12-05 18:24 hdfs://emr-
header-1.cluster-6789:9000/user
```

19 Component authorization

19.1 HDFS authorization

When HDFS is enabled, user access to HDFS requires legal permissions in order to operate HDFS properly, such as read data, create folders and others.

Add a configuration

Configurations related to HDFS permission are as follows:

- dfs.permissions.enabled

  Enable permission check. Even if the value is false, chmod/chgrp/chown/setfacl performs permission check.
- dfs.datanode.data.dir.perm

  The permission of the local folder used by datanode, which is 755 by default.
- fs.permissions.umask-mode
  - Permission mask, default permission settings when creating a new file/folder
  - File creation: 0666 & ^umask
  - Folder creation: 0777 & ^umask
  - Default umask value is 022, i.e. the permission of file creation is 644 (666&^022 = 644), and permission of folder creation is 755 (777&^022 = 755).
  - The default setting of Kerberos security cluster in the EMR is 027, the corresponding permission of file creation is 640, and permission of folder creation is 750.
- dfs.namenode.acls.enabled
  - Enable ACL control. This gives you permission control on owner/group, and you can also set it for other users.
  - Commands for setting ACL:

    ```
    hadoop fs -getfacl [-R] <path>
    hadoop fs -setfacl [-R] [-b |-k -m |-x <acl_spec> <path>] |[--set
     <acl_spec>   <path>]
    ```

    For example:

    ```
    su test
     #The user test creates a folder
     hadoop fs -mkdir /tmp/test
     #View the permission of the created folder
     hadoop fs -ls /tmp
    ```

```
 drwxr-x---   - test   hadoop          0 2017-11-26 21:18 /tmp/
test
 #Set ACL and grant rwx permissions to user foo
 hadoop fs -setfacl -m user:foo:rwx /tmp/test
 #View the permission of the file (+ means that ACL is set)
 hadoop fs -ls  /tmp/
 drwxrwx---+  - test   hadoop          0 2017-11-26 21:18 /tmp/
test
 #View ACL
  hadoop fs -getfacl  /tmp/test
  # file: /tmp/test
# owner: test
# group: hadoop
user::rwx
user:foo:rwx
group::r-x
mask::rwx
other::---
```

- dfs.permissions.superusergroup

  Super user group. Users in the group have super user permissions.

Restart the HDFS service

For Kerberos security clusters, HDFS permissions have been set by default (umask is set to 027), without configuration and service restart.

For non-Kerberos security clusters, a configuration must be added and the service must be restarted.

Other

- Umask value can be modified as needed.
- HDFS is a basic service, and Hive/HBase are based on HDFS. Therefore, HDFS permission control must be configured in advance when configuring other upper layer services.
- When permissions are enabled for HDFS, the services must be set up (such as /spark-history for spark, and /tmp/$user/ for yarn).
- Sticky bit:

  Sticky bit can be set for a folder to prevent users other than superuser/file owner/dir owner from deleting files/folders in the folder (even if other users have rwx permissions on the folder), for example:

```
#That is, adding numeral 1 as the first digit
hadoop fs -chmod 1777 /tmp
hadoop fs -chmod 1777 /spark-history
```

```
hadoop fs -chmod 1777 /user/hive/warehouse
```

19.2 YARN authorization

YARN authorization can be divided to service-level authorization and queue-level authorization based on the authorization entity.

Service-level authorization

For more information, see *Hadoop official documentation*.

- Control cluster service access by specific users, such as submitting jobs
- Configures hadoop-policy.xml
- Service level permission validation has a higher priority than other permission validation procedures (such as HDFS permission verification and YARN job submission control)

> **Note:**
> Generally, if HDFS permission verification and YARN job submission control have been set up, you may choose not to set the service level permission control. You can perform the relevant configurations as needed.

Queue-level authorization

YARN supports permission control over resources through queues, and it provides two queue scheduling methods, namely Capacity Scheduler and Fair Scheduler. We will take the Capacity Scheduler as an example here.

- Add a configuration

  A queue also has a two-level authorization: the authorization for job submission (submitting a job to the queue) and the authorization for queue management.

  > **Note:**
  > - The ACL control object for a queue is user/group. The users and groups can be set at the same time (separated by spaces) when you set up the relevant parameters. You can use a comma to separate different users and groups. Using only one space means that no one has the permission.
  > - ACL inheritance for a queue: If a user/group can submit an application to a queue, then this user/group can submit applications to all sub-queues of this queue. Likewise, the ACL that manages queues can also be inherited. Therefore, if you want to prevent a user/group from

submitting jobs to a queue, you must set the ACL for this queue and all its parent queues to restrict the job-submission permission of this user/group.

- yarn.acl.enable

  ACL switch, set to true
- yarn.admin.acl
  - YARN administrator setting, which enables/disables executing `yarn rmadmin/yarn kill`, and other commands. This value must be configured, otherwise, the subsequent queue-based ACL administrator settings cannot take effect.
  - As mentioned in the preceding note, you can set up user/group when setting up the values:

  ```
  user1,user2 group1,group2 #users and groups are separated by a
  space
    group1,group2 #In case there are only groups, a leading space
   is required.
  ```

  In an EMR cluster, you must configure the ACL permission for has as admin.
- yarn.scheduler.capacity.${queue-name}.acl_submit_applications
  - Set user/group that can submit jobs to this queue
  - where ${queue-name} is the queue name. Multi-level queues are supported. Note that ACL is inherited in multi-level queues, for example:

  ```
  #queue-name=root
    <property>
        <name>yarn.scheduler.capacity.root.acl_submit_applicati
  ons</name>
        <value> </value> # Space means no one can submit jobs to
  the root queue
    </property>
   #queue-name=root.testqueue
   <property>
     <name>yarn.scheduler.capacity.root.testqueue.acl_submit
  _applications</name>
        <value>test testgrp</value> #testqueue only allows the
  test user and testgrp group to submit jobs
    </property>
  ```
- yarn.scheduler.capacity.${queue-name}.acl_administer_queue
  - Set some user/group to manage the queue, such as killing a job in the queue.
  - Multi-level queue-names are supported. Note that ACL is inherited in multi-level queues.

  ```
  #queue-name=root
    <property>
  ```

```
      <name>yarn.scheduler.capacity.root.acl_administer_queue</
name>
      <value> </value>
  </property>
 #queue-name=root.testqueue
 <property>
   <name>yarn.scheduler.capacity.root.testqueue.acl_admini
ster_queue</name>
      <value>test testgrp</value>
  </property>
```

- Restart the YARN service
  - The Kerberos secure cluster has enabled ACL by default. You can configure the relevant ACL permissions for queues as needed.
  - For a non-Kerberos secure cluster, enable ACL and configure the permission control for queues in accordance with the preceding instructions, and then restart the YARN service.
- Configuration example
  - yarn-site.xml

```
<property>
        <name>yarn.acl.enable</name>
        <value>true</value>
 </property>
<property>
        <name>yarn.admin.acl</name>
        <value>has</value>
 </property>
```

  - capacity-scheduler.xml
  - Default queue: disables the default queue and do not allow any user to submit jobs or manage the queue.
  - Q1 queue: only allows the test user to submit jobs and manage the queue (such as killing the jobs).
  - Q2 queue: only allows the foo user to submit jobs and manage the queue. Q2 Queues: Only Foo users are allowed to submit jobs and manage queues.

```
<configuration>
    <property>
        <name>yarn.scheduler.capacity.maximum-applications</name>
        <value>10000</value>
        <description>Maximum number of applications that can be
pending and running.</description>
    </property>
    <property>
        <name>yarn.scheduler.capacity.maximum-am-resource-percent</
name>
        <value>0.25</value>
        <description>Maximum percent of resources in the cluster
which can be used to run application masters i.e.
            controls number of concurrent running applications.
```

```
        </description>
    </property>
    <property>
        <name>yarn.scheduler.capacity.resource-calculator</name>
        <value>org.apache.hadoop.yarn.util.resource.DefaultRes
ourceCalculator</value>
    </property>
    <property>
        <name>yarn.scheduler.capacity.root.queues</name>
        <value>default,q1,q2</value>
        <! --3 queues->
        <description>The queues at the this level (root is the root
queue).</description>
    </property>
    <property>
        <name>yarn.scheduler.capacity.root.default.capacity</name>
        <value>0</value>
        <description>Default queue target capacity.</description>
    </property>
    <property>
        <name>yarn.scheduler.capacity.root.default.user-limit-factor
</name>
        <value>1</value>
        <description>Default queue user limit a percentage from 0.0
to 1.0.</description>
    </property>
    <property>
        <name>yarn.scheduler.capacity.root.default.maximum-capacity
</name>
        <value>100</value>
        <description>The maximum capacity of the default queue.</
description>
    </property>
    <property>
        <name>yarn.scheduler.capacity.root.default.state</name>
        <value>STOPPED</value>
        <! -- Status of the default queue is set as STOPPED-->
        <description>The state of the default queue. State can be
one of RUNNING or STOPPED.</description>
    </property>
    <property>
        <name>yarn.scheduler.capacity.root.default.acl_submit
_applications</name>
        <value> </value>
        <! -- The default queue does not allow job submission-->
        <description>The ACL of who can submit jobs to the default
queue.</description>
    </property>
    <property>
        <name>yarn.scheduler.capacity.root.default.acl_admini
ster_queue</name>
        <value> </value>
        <! -- Prevent users/groups to manage the default queue-->
        <description>The ACL of who can administer jobs on the
default queue.</description>
    </property>
    <property>
        <name>yarn.scheduler.capacity.node-locality-delay</name>
        <value>40</value>
    </property>
    <property>
        <name>yarn.scheduler.capacity.queue-mappings</name>
```

```
        <value>u:test:q1,u:foo:q2</value>
        <! -- Queue mapping, automatically maps the test user to Q1
queue-->
        <description>A list of mappings that will be used to assign
jobs to queues. The syntax for this list is
            [u|g]:[name]:[queue_name][,next mapping]* Typically this
 list will be used to map users to queues,for
            example, u:%user:%user maps all users to queues with the
 same name as the user.
        </description>
    </property>
    <property>
        <name>yarn.scheduler.capacity.queue-mappings-override.enable
</name>
        <value>true</value>
        <! -- Whether or not allow the above queue-mapping to
overwrite the queue parameters set up by the client-->
        <description>If a queue mapping is present, will it override
 the value specified by the user? This can be used
            by administrators to place jobs in queues that are
different than the one specified by the user. The default
            is false.
        </description>
    </property>
    <property>
        <name>yarn.scheduler.capacity.root.acl_submit_applications</
name>
        <value> </value>
        <! -- ACL inheritance, the parent queue must have the admin
permissions-->
        <description>
            The ACL of who can submit jobs to the root queue.
        </description>
    </property>
    <property>
        <name>yarn.scheduler.capacity.root.q1.acl_submit_applicati
ons</name>
        <value>test</value>
        <! -- q1 only allows the test user to submit jobs-->
    </property>
    <property>
        <name>yarn.scheduler.capacity.root.q2.acl_submit_applicati
ons</name>
        <value>foo</value>
        <! -- q2 only allows the foo user to submit jobs-->
    </property>
    <property>
        <name>yarn.scheduler.capacity.root.q1.maximum-capacity</name
>
        <value>100</value>
    </property>
    <property>
        <name>yarn.scheduler.capacity.root.q2.maximum-capacity</name
>
        <value>100</value>
    </property>
    <property>
        <name>yarn.scheduler.capacity.root.q1.capacity</name>
        <value>50</value>
    </property>
    <property>
        <name>yarn.scheduler.capacity.root.q2.capacity</name>
```

```
        <value>50</value>
    </property>
    <property>
        <name>yarn.scheduler.capacity.root.acl_administer_queue</
name>
        <value> </value>
        <! -- ACL inheritance, the parent queue must have the admin
permissions-->
    </property>
    <property>
        <name>yarn.scheduler.capacity.root.q1.acl_administer_queue</
name>
        <value>test</value>
        <! -- q1 only allow the test user to manage the queue, such
as killing the jobs-->
    </property>
    <property>
        <name>yarn.scheduler.capacity.root.q2.acl_administer_queue</
name>
        <value>foo</value>
        <! -- q2 only allow the foo user to manage the queue, such
as killing the jobs-->
    </property>
    <property>
        <name>yarn.scheduler.capacity.root.q1.state</name>
        <value>RUNNING</value>
    </property>
    <property>
        <name>yarn.scheduler.capacity.root.q2.state</name>
        <value>RUNNING</value>
    </property>
</configuration>
```

19.3 Hive authorization

Hive has two authorization modes, storage based authorization and SQL standard based authorization. For more information, see *official Hive documentation*.

Note:

The two authorization features can be configured at the same time without conflict.

Storage based authorization is for HiveMetaStore.

Scenario:

If a user in the cluster has a direct access to data in Hive through HDFS/Hive Client, a permission control must be performed on Hive data in HDFS. Through HDFS permission control, operation permissions related to Hive SQL can be controlled.

For more information, see *Hive documents*.

Add configuration

In the cluster Configuration Management page, **Hive** > **Configuration** > **hive-site.xml** > **Add Custom Configuration**.

```
<property>
<name>hive.metastore.pre.event.listeners</name>
    <value>org.apache.hadoop.hive.ql.security.authorization.Authorizat
ionPreEventListener</value>
</property>
<property>
<name>hive.security.metastore.authorization.manager</name>
    <value>org.apache.hadoop.hive.ql.security.authorization.StorageBas
edAuthorizationProvider</value>
</property>
<property>
<name>hive.security.metastore.authenticator.manager</name>
    <value>org.apache.hadoop.hive.ql.security.HadoopDefaultMetasto
reAuthenticator</value>
</property>
```

Restart HiveMetaStore

Restart HiveMetaStore in the cluster Configuration Management page.

HDFS permission control

HDFS related permissions of warehouse in Hive has been set for Kerberos security cluster in the EMR.

For non-Kerberos security cluster, users must set basic HDFS permission through the following steps:

- EnableHDFS permissions
- Configure permissions of warehouse in Hive

  ```
  hadoop fs -chmod 1771 /user/hive/warehouse
  It can be set as follows, in which 1 denotes stick bit (i.e. cannot
  delete files/folders created by others)
  hadoop fs -chmod 1777 /user/hive/warehouse
  ```

With the basic permission set (mentioned earlier), related users/user groups can normally create/read/write tables through authorizing the folder warehouse.

```
sudo su has
      #Grant rwx permission of folder warehouse to user test
      hadoop fs -setfacl -m user:test:rwx /user/hive/warehouse
      #Grant rwx permission of folder warehouse to user hivegrp
```

```
     hadoo fs -setfacl -m group:hivegrp:rwx /user/hive/warehouse
```

With the HDFS authorization, related users/user groups can normally create/read/write tables, and data in Hive tables created by different users in HDFS can only be accessed by the users themselves.

Verification

- User test creates a table testtbl.

```
hive> create table testtbl(a string);
FAILED: Execution Error, return code 1 from org.apache.hadoop.hive
.ql.exec.DDLTask. MetaException(message:Got exception: org.apache.
hadoop.security.AccessControlException Permission denied: user=test
, access=WRITE, inode="/user/hive/warehouse/testtbl":hadoop:hadoop:
drwxrwx--t
at org.apache.hadoop.hdfs.server.namenode.FSPermissionChecker.check(
FSPermissionChecker.java:320)
at org.apache.hadoop.hdfs.server.namenode.FSPermissionChecker.check(
FSPermissionChecker.java:292)
```

An error occurs due to no permissions. Permissions should be granted to the user test.

```
#Switch from root account to has account
su has
#Add ACL and grant rwx permissions of the directory warehouse to the
 account test.
 hadoop fs -setfacl -m user:test:rwx /user/hive/warehouse
```

The account test recreates the database successfully.

```
hive> create table testtbl(a string);
OK
Time taken: 1.371 seconds
#View the directory of testtbl in HDFS. From the permissions it can
be seen that only the groups test and hadoop can read data from the
table created by the user test, while other users have no permission
s
hadoop fs -ls /user/hive/warehouse
drwxr-x---   - test hadoop          0 2017-11-25 14:51 /user/hive/
warehouse/testtbl
#Insert a record
hive>insert into table testtbl select "hz"
```

- User foo accesses to table testtbl.

```
#drop table
hive> drop table testtbl;
FAILED: Execution Error, return code 1 from org.apache.hadoop.hive.
ql.exec.DDLTask. MetaException(message:Permission denied: user=foo,
access=READ, inode="/user/hive/warehouse/testtbl":test:hadoop:drwxr-
x---
    at org.apache.hadoop.hdfs.server.namenode.FSPermissionChecker.
check(FSPermissionChecker.java:320)
    at org.apache.hadoop.hdfs.server.namenode.FSPermissionChecker.
checkPermission(FSPermissionChecker.java:219)
```

```
    at org.apache.hadoop.hdfs.server.namenode.FSPermissionChecker.
checkPermission(FSPermissionChecker.java:190)
#alter table
hive> alter table testtbl add columns(b string);
FAILED: SemanticException Unable to fetch table testtbl. java.
security.AccessControlException: Permission denied: user=foo, access
=READ, inode="/user/hive/warehouse/testtbl":test:hadoop:drwxr-x---
    at org.apache.hadoop.hdfs.server.namenode.FSPermissionChecker.
check(FSPermissionChecker.java:320)
    at org.apache.hadoop.hdfs.server.namenode.FSPermissionChecker.
checkPermission(FSPermissionChecker.java:219)
    at org.apache.hadoop.hdfs.server.namenode.FSPermissionChecker.
checkPermission(FSPermissionChecker.java:190)
    at org.apache.hadoop.hdfs.server.namenode.FSDirectory.checkPermi
ssion(FSDirectory.java:1720)
#select
hive> select * from testtbl;
FAILED: SemanticException Unable to fetch table testtbl. java.
security.AccessControlException: Permission denied: user=foo, access
=READ, inode="/user/hive/warehouse/testtbl":test:hadoop:drwxr-x---
    at org.apache.hadoop.hdfs.server.namenode.FSPermissionChecker.
check(FSPermissionChecker.java:320)
    at org.apache.hadoop.hdfs.server.namenode.FSPermissionChecker.
checkPermission(FSPermissionChecker.java:219)
```

It can be seen that the user foo cannot perform any operations on the table created by the user test. HDFS authorization is needed to grant permissions to foo.

```
su has
#Only read permission is granted, and write permission can also be
granted as needed (for example, alter)
#Note: -R: Set files in the folder testtbl to readable
hadoop fs -setfacl -R -m user:foo:r-x /user/hive/warehouse/testtbl
#The table can be selected successfully
hive> select * from testtbl;
OK
hz
Time taken: 2.134 seconds, Fetched: 1 row(s)
```

Note:

In general, a Hive user group can be created and authorized, then add new users the group.

SQL Standards Based Authorization

- Scenario

  If a cluster user can't access through a HDFS/Hive client, and the only way is to run Hive related commands through `HiveServer (beeline, jdbc, and so on)`. SQL Standards Based Authorization can be used.

  If you are able to use methods such as Hive shell, as long as no related configuration has been made to the hive-site.xml in the user's client, Hive can still be normally accessed even if the following settings are implemented.

For more information, see *Hive documentation*.

- Add configuration

  - The configuration is provided to HiveServer.
  - In the cluster Configuration Management page, click **Hive** > **Configuration** > **hive-site.xml** > **Add Custom Configuration**

```
<property>
<name>hive.security.authorization.enabled</name>
 <value>true</value>
</property>
 <property>
<name>hive.users.in.admin.role</name>
 <value>hive</value>
</property>
 <property>
<name>hive.security.authorization.createtable.owner.grants</name>
 <value>ALL</value>
</property>
```

- Restart HiveServer2

  Restart HHiveServer2 in the cluster Configuration Management page.

- Permission operation commands

  For detailed command operations, click *here*.

- Verification

  - User foo access to user test's table testtbl through beeline.

```
2: jdbc:hive2://emr-header-1.cluster-xxx:10> select * from testtbl
;
Error: Error while compiling statement: FAILED: HiveAccess
ControlException Permission denied: Principal [name=foo, type=USER
] does not have following privileges for operation QUERY [[SELECT
] on Object [type=TABLE_OR_VIEW, name=default.testtbl]] (state=
42000,code=40000)
```

  - Grant permissions.

```
Switch to account test to grant select permission to user foo
hive> grant select on table testtbl to user foo;
 OK
 Time taken: 1.205 seconds
```

  - User foo can normally select.

```
0: jdbc:hive2://emr-header-1.cluster-xxxxx:10> select * from
testtbl;
INFO  : OK
+------------+--+
| testtbl.a  |
+------------+--+
```

```
| hz          |
+------------+--+
1 row selected (0.787 seconds)
```

- Revoke permission.

```
Switch to account test, and revoke the select permission from user
 foo
  hive> revoke select from user foo;
    OK
    Time taken: 1.094 seconds
```

- Foo could not select data for testtbl.

```
User foo cannot select data from table testtbl.
Error: Error while compiling statement: FAILED: HiveAccess
ControlException Permission denied: Principal [name=foo, type=USER
] does not have following privileges for operation QUERY [[SELECT
] on Object [type=TABLE_OR_VIEW, name=default.testtbl]] (state=
42000,code=40000)
```

19.4 HBase authorization

Without authorization, any account can perform any operations on the HBase cluster that includes disable table, drop table, major compact, and others.

Note:

For clusters without Kerberos authentication, users can forge identities to access to the cluster service even when HBase authorization is enabled. Therefore, we recommend that you create a cluster with high security mode (for example, supporting Kerberos) as detailed in *Kerberos Security Document*.

Add configuration

In Configuration Management, choose **HBase** > **Configuration** > **hbase-site** > **Custom Configuration** in the HBase cluster.

Add the following parameters:

```
<property>
     <name>hbase.security.authorization</name>
     <value>true</value>
</property>
<property>
     <name>hbase.coprocessor.master.classes</name>
     <value>org.apache.hadoop.hbase.security.access.AccessController</
value>
</property>
<property>
     <name>hbase.coprocessor.region.classes</name>
 <value>org.apache.hadoop.hbase.security.token.TokenProvider,org.
apache.hadoop.hbase.security.access.AccessController</value>
```

```
</property>
<property>
  <name>hbase.coprocessor.regionserver.classes</name>
  <value>org.apache.hadoop.hbase.security.access.AccessController,org.
apache.hadoop.hbase.security.token.TokenProvider</value>
</property>
```

Restart the HBase cluster

In the HBase cluster Configuration Management page, click **HBase** > **Operations** > **RESTART All Components**.

Authorization (ACL)

- Basic concepts

  Authorization is for grant [operation permissions] of [resources in a certain scope] to [a certain entity].

  In HBase, the preceding three concepts are:

  - Resources in a certain scope
    - Superuser

      A Superuser can perform any operations, and the account running HBase service is the Superuser by default. You can also add Superusers through configuring the value of hbase.superuser in hbase-site.xml.
    - Global

      Global Scope has Admin permissions of all tables in the cluster.
    - Namespace

      It has permission control in Namespace Scope.
    - Table

      It has permission control in Table Scope.
    - ColumnFamily

      It has permission control in ColumnFamily Scope.
    - Cell

      It has permission control in Cell Scope.
  - Operation permission
    - Read (R)

Read data from resources in a certain Scope.

  - Write (W)

    Write data to resources in a certain Scope.
  - Execute (X)

    Execute co-processor in a certain Scope.
  - Create (C)

    Create/delete a table in a certain Scope.
  - Admin (A)

    Perform cluster related operations in a certain Scope, such as balance/assign.
- A certain entity
  - User

    Authorize a user
  - Group

    Authorize a user group

- Authorization command
  - grant

```
grant <user> <permissions> [<@namespace> [<table> [<column family>
 [<column qualifier>]]]
```

Note:

  - The authorization methods for users or groups are the same. A prefix @ needs to be added for group.

```
grant 'test','R','tbl1'   #grant the read permission of the
table tb11 to the user test.
  grant '@test','R','tbl1'   #grant the read permission of the
table tb11 to the user group test.
```

  - A prefix @ needs to be added for namespace.

```
grant 'test 'C','@ns_1'  #grant the create permission of the
namespace @ns_1 to the user test.
```

  - revoke
  - user_permissions (view permissions)

19.5 Kafka authorization

If Kafka authentication (for example, Kerberos authentication or simple authorization based on username and password) is disabled, users can access services with forged identities even if Kafka authorization is enabled. Therefore, we recommend that you create a high-security-mode Kafka cluster. For more information, see *Kerberos*.

Note:
The permission configurations described in this document are only for high-security mode clusters of E-MapReduce. That is, Kafka is started in Kerberos mode.

Add configurations

1. On the **Cluster Management** page, click **View Details** after the Kafka cluster.
2. In the left-side navigation pane, click the **Clusters and Services** tab, and click **Kafka** in the service list.
3. At the top of the page, click the **Configuration** tab.
4. In the upper right corner of the Service Configuration list, click **Custom Configuration** and add the following parameters:

key	value	Note
authorizer.class.name	kafka.security.auth.SimpleAclAuthorizer	None
super.users	User:kafka	User:kafka is required. Other users can be added and separated by semicolons (;).

Note:
zookeeper.set.acl is used to set the permissions for Kafka to operate data in zookeeper. It is already set to true in the E-MapReduce cluster, so you do not need to add this configuration in this step. With the configuration set to true, only the users who are named Kafka and have passed the Kerberos authentication can run the kafka-topics.sh command in the Kerberos environment. Kafka-topics.sh will directly read, write, and modify data in ZooKeeper.

Restart a Kafka cluster

1. On the **Cluster Management** page, click **View Details** after the Kafka cluster you want to operate in the Operation column.

2. In the left-side navigation pane, click the **Clusters and Services** tab , and click **Actions** at the right side of Kafka on the service list.
3. In the the drop-down menu, select **RESTART All Components**. Enter a record information and click **OK**.

Authorization (ACL)

- Basic concepts

  Definition in the official Kafka documents:

```
Kafka ACLs are defined in the general format of "Principal P is [
Allowed/Denied] Operation O From Host H On Resource R"
```

  That is, the ACL process relates to Principal, Allowed/Denied, Operation Host, and Resource.

  - Principal: username

Security protocol	Value
PLAINTEXT	ANONYMOUS
SSL	ANONYMOUS
SASL_PLAINTEXT	When the mechanism is PLAIN, the user name is specified by client_jaas.conf. When the mechanism is GSSAPI, the username is principal specified by client_jaas.conf.
SASL_SSL	

  - Allowed/Denied
  - Operation: Operations include Read, Write, Create, DeleteAlter, Describe, ClusterAction, AlterConfigs, DescribeConfigs, IdempotentWrite, and All.
  - Host: The target machine.
  - Resource: Resource objects, including Topic, Group, Cluster, and TransactionalId.

  For detailed mapping relationships between operations and resources, for example, the supporting relationships between resources and the authorization of operations, see *KIP-11 - Authorization Interface*.

- Authorization command

  Perform authorization by using the script kafka-acls.sh (/usr/lib/kafka-current/bin/kafka-acls.sh).For details about how to use this script to authorize Kafka, run the `kafka-acls.sh --help` command and view how to use the command.

Operation example

Perform related operations on the master node of the created E-MapReduce high-security mode Kafka cluster.

1. Create a user named test.

   `useradd test`

2. Create a topic.

   As mentioned in section 1 “Add configurations”, zookeeper.set.acl is set to true, and kafka-topics.sh must be run under a Kafka account. The Kafka account must pass Kerberos authentication.

   ```
   #The Kerberos authentication information related to the kafka
   account is set in kafka_client_jaas.conf.
   export KAFKA_HEAP_OPTS="-Djava.security.auth.login.config=/etc/ecm/
   kafka-conf/kafka_client_jaas.conf"
   # Change the ZooKeeper address to the actual address (run hostnamed
   to acquire) of your Kafka cluster.
   kafka-topics.sh --create --zookeeper emr-header-1:2181/kafka-1.0.0
    --replication-factor 3 --partitions 1 --topic test
   ```

3. Run kafka-console-producer.sh with the test user.

   a. Create a keytab file for the test user to authenticate ZooKeeper and Kafka.

      ```
      su root
      sh /usr/lib/has-current/bin/hadmin-local.sh /etc/ecm/has-conf -k /
      etc/ecm/has-conf/admin.keytab
      HadminLocalTool.local: # Press Enter to display the usage
      instructions on some commands.
      HadminLocalTool.local: addprinc # Enter a command and press Enter
      to display the usage instructions on the command.
      HadminLocalTool.local: addprinc -pw 123456 test # Add a principal
      for the test user and set the password to 123456.
      HadminLocalTool.local: ktadd -k /home/test/test.keytab test #
      Export the keytab file for later use.
      ```

   b. Add a kafka_client_test.conf file.

      Put the file in `/home/test/kafka_client_test.conf`. The content of the file is as follows:

      ```
      KafkaClient {
      com.sun.security.auth.module.Krb5LoginModule required
      useKeyTab=true
      storeKey=true
      serviceName="kafka"
      keyTab="/home/test/test.keytab"
      principal="test";
      };
      // Zookeeper client authentication
      Client {
      ```

```
com.sun.security.auth.module.Krb5LoginModule required
useKeyTab=true
useTicketCache=false
serviceName="zookeeper"
keyTab="/home/test/test.keytab"
principal="test";
};
```

c. Add producer.conf.

Put the file in `/home/test/producer.conf`. The content of the file is as follows:

```
security.protocol=SASL_PLAINTEXT
sasl.mechanism=GSSAPI
```

d. Run kafka-console-producer.sh.

```
su test
export KAFKA_HEAP_OPTS="-Djava.security.auth.login.config=/home/
test/kafka_client_test.conf"
kafka-console-producer.sh --producer.config /home/test/producer.
conf --topic test --broker-list emr-worker-1:9092
```

Because no ACL is set, an error is reported after the preceding command is run:

```
org.apache.kafka.common.errors.TopicAuthorizationException: Not
authorized to access topics: [test]
```

e. Set an ACL.

Similarly, the `kafka-acls.sh` command must be run under the Kafka account.

```
su kafka
export KAFKA_OPTS="-Djava.security.auth.login.config=/etc/ecm/
kafka-conf/kafka_client_jaas.conf"
kafka-acls.sh --authorizer-properties zookeeper.connect=emr-header
-1:2181/kafka-1.0.0 --add --allow-principal User:test --operation
Write --topic test
```

f. Run kafka-console-producer.sh again.

```
su test
export KAFKA_HEAP_OPTS="-Djava.security.auth.login.config=/home/
test/kafka_client_test.conf"
kafka-console-producer.sh --producer.config /home/test/producer.
conf --topic test --broker-list emr-worker-1:9092
```

Normal output:

```
[2018-02-28 22:25:36,178] INFO Kafka commitId : aaa7af6d4a11b29d (
org.apache.kafka.common.utils.AppInfoParser)
>alibaba
>E-MapReduce
>
```

4. Run `kafka-console-consumer.sh` with the test user

After kafka-console-producer.sh is successfully run and data is written to the topic, you can run `kafka-console-consumer.sh` to perform a consumption test.

a. Add consumer.conf.

Put the file in */home/test/consumer.conf*. The content of the file is as follows:

```
security.protocol=SASL_PLAINTEXT
sasl.mechanism=GSSAPI
```

b. Run kafka-console-consumer.sh.

```
su test
# Kafka_client_test.conf is used in the same way as kafka-console-
producer.sh.
export KAFKA_HEAP_OPTS="-Djava.security.auth.login.config=/home/
test/kafka_client_test.conf"
kafka-console-consumer.sh --consumer.config consumer.conf  --topic
 test --bootstrap-server emr-worker-1:9092 --group test-group  --
from-beginning
```

Because no permissions are set, an error is reported:

```
org.apache.kafka.common.errors.GroupAuthorizationException: Not
authorized to access group: test-group
```

c. Set an ACL.

```
su kafka
export KAFKA_HEAP_OPTS="-Djava.security.auth.login.config=/etc/ecm
/kafka-conf/kafka_client_jaas.conf"
# test-group permission
kafka-acls.sh --authorizer-properties zookeeper.connect=emr-header
-1:2181/kafka-1.0.0 --add --allow-principal User:test --operation
Read --group test-group
# topic permission
kafka-acls.sh --authorizer-properties zookeeper.connect=emr-header
-1:2181/kafka-1.0.0 --add --allow-principal User:test --operation
Read --topic test
```

d. Run `kafka-console-consumer.sh` again.

```
su test
# Kafka_client_test.conf is used in the same way as kafka-console-
producer.sh.
export KAFKA_HEAP_OPTS="-Djava.security.auth.login.config=/home/
test/kafka_client_test.conf"
kafka-console-consumer.sh --consumer.config consumer.conf  --topic
 test --bootstrap-server emr-worker-1:9092 --group test-group  --
from-beginning
```

Normal output:

```
alibaba
```

```
E-MapReduce
```

19.6 RANGER

20 Disaster Recovery

20.1 EMR cluster disaster tolerance

Data disaster tolerance

The Hadoop Distributed File System (HDFS) stores the data of each file in blocks, and each block has some copies (Each block has three copies by default). This makes sure these copies of data block can be stored in the different frameworks. In most situations, the storage strategy of HDFS is to store the first copy in the local framework, the second copy is stored in the same framework with the first one, but in different nodes, the last copy is stored in the different frameworks.

HDFS will scan the data copies regularly, if a data copy was lost, HDFS will make another data copy quickly to make sure the number of data copy is stable. If a node that stores a data copy was lost, HDFS will make another node to recover to data in that node. In Alibaba Cloud, if you use cloud disk, each cloud disk has three data copies in the backend, whenever any of them has some issues, the data copies will exchange and recover data to ensure the reliability of data.

HDFS is a file storage system that has stood the test of time and has high reliability. It can store massive data with high reliability. At the same time, based on the features in Alibaba Cloud, HDFS can make extra backups for the data stored in OSS, in this way, HDFS makes the data higher reliability.

Service disaster tolerance

The core components of HDFS will deploy the HA, that is, there are at least two nodes be the backups for each other, such as, YARN, HDFS, Hive Server, Hive Meta. In this way, whenever there’s a node with issues, the nodes will exchange and recover data to ensure that the services has no impact.

21 Resource pool

The Dynamic Resource Pools function is a usage strategy for the Yarn application. E-MapReduce Yarn uses the capacity scheduler by default. EMR Yarn uses the capacity scheduler by default.

Enable Resource Pool

1. Log on to the *Alibaba Cloud E-MapReduce console* and enter the cluster list page.
2. Click the **Manage** link corresponding to the cluster you want to configure.
3. In the service list, click **YARN**, and go to the Yarn configuration page.
4. At the top of the page, click the **Resource Pool** tab to go to the resource pool configuration page.
5. Click **Initialize Resource Pool** button to select a scheduler policy. E-MapReduce supports *Capacity Scheduler* and *Fair Scheduler*.

Note:

With the Resource Pool function enabled, once the Capacity Scheduler or Fair Scheduler is selected, it cannot be changed later. You can just configure relevant parameters in the resource pool.

Configure Resource Pool

When you select the scheduler policy, click the drop-down list of **More settings** for the global configuration. It is recommended that the system administrator set these configurations.

- **Capacity Scheduler**

Table 21-1: More configurations

EMR parameters	Hadoop Yarn parameters
Default configuration-maximum number of applications	Configure global parameters yarn.scheduler.capacity.maximum-applications or yarn.scheduler.capacity.<queue-path>.maximum-applications
Default configuration-maximum am ratio	Configure global parameters yarn.scheduler.capacity.maximum-am-resource-percent or yarn.scheduler.capacity.<queue-path>.maximum-am-resource-percent
Default configuration-resources calculation class	yarn.scheduler.capacity.resource-calculator

EMR parameters	Hadoop Yarn parameters
Default configuration-number of node delays	yarn.scheduler.capacity.node-locality-delay
Placement rules	Configure mappings between users/groups and queue
Placement rules: queue mapping override	yarn.scheduler.capacity.queue-mappings-override.enable
ACL settings-enable ResourceManager ACL	yarn.acl.enable on the yarn-site
ACL settings-manage ACL	yarn.admin.acl on the yarn-site
User limit-acl_submit _applications	Configure global parameter yarn.scheduler.capacity.root.<queue-path>.acl_submit_applications
User limit-acl_admini ster_queue	Configure global parameter yarn.scheduler.capacity.root.<queue-path>.acl_administer_queue

Table 21-2: Create Resource Pool

EMR parameters	Hadoop Yarn parameters
Resource Pool name	Queue name in yarn
Resource pool limit-proportion	yarn.scheduler.capacity.<queue-path>.capacity
Resource pool limit-miniUserLimit	yarn.scheduler.capacity.<queue-path>.minimum-user-limit-percent
Resource pool limit-maximumCapacity	yarn.scheduler.capacity.<queue-path>.maximum-capacity
Resource pool limit-limit on the proportion of individual users	yarn.scheduler.capacity.<queue-path>.user-limit-factor
Resource pool limit-maximum memory	yarn.scheduler.capacity.<queue-path>.maximum-allocation-mb
Resource pool limit-maximum number of cores	yarn.scheduler.capacity.<queue-path>.maximum-allocation-vcores
Resource pool limit-maximum number of applications	The priority of the parameter is higher than the global variable yarn.scheduler.capacity.maximum-applications / yarn.scheduler.capacity.<queue-path>.maximum-applications
Resource pool limit-maximum AM resource percentage	The priority of the parameter is higher than the global variable yarn.scheduler.capacity.maximum-am-resource-percent

EMR parameters	Hadoop Yarn parameters
	or yarn.scheduler.capacity.<queue-path>.maximum-am-resource-percent
Submit permission control	The priority of the parameter is higher than the global variable yarn.scheduler.capacity.root.<queue-path>.acl_submit_applications
Manage access control policies	The priority of the parameter is higher than the global variable yarn.scheduler.capacity.root.<queue-path>.acl_administer_queue

- **Fair Scheduler**

Table 21-3: More settings

EMR parameters	Hadoop Yarn parameters
ACL settings-enable ResourceManager ACL	yarn.acl.enable on the yarn-site
ACL settings-manage ACL	yarn.admin.acl on the yarn-site

Table 21-4: Create Resource Pool

EMR parameters	Hadoop Yarn parameters
Enable the preemption mode	yarn.scheduler.fair.preemption
Resource pool name	Queue name in yarn
Preemption-enable the preemption mode	yarn.scheduler.fair.preemption
Preemption-fair share preemption threshold	yarn.scheduler.fair.preemption.cluster-utilization-threshold

After the resource pool configuration is complete, click **Synchronize Configuration to Cluster** to make the configuration take effect.

Disable Resource Pool

If you want to configure the resource pool directly through XML, click **Disable Resource Pool** button first in the **Resource Pool** page, and then go to the **Configuration** page of YARN.

22 Auto-scaling

22.1 Auto-scaling introduction

This article will introduce how to enable and disable the scaling feature.

In the following scenarios, you can save cost and improve execution efficiency through E-MapReduce scaling.

- Add computing nodes according to the time period to supplement computing capability temporarily.
- Make sure that important jobs are completed on time, and expand computing nodes according to certain cluster indicators.

Note:

- The scaling feature can only expand or reduce the number of task nodes.
- The scaling feature is only available in Subscribed and Pay-As-You-Go clusters.

Enable auto-scaling

1. Log on to the *Alibaba Cloud E-MapReduce console* and enter the **Cluster Management** page.
2. At the right side of the target cluster ID, click the **Manage**.
3. In the left-side navigation pane, click the **Scaling** to enter the auto-scaling page.
4. In the top right corner of the page, click the **Enable Auto-scaling** button.

   If it is the first time to use the auto-scaling function with your account, you need to authorize the default role of Elastic Scaling Service(ESS) to your E-MapReduce account.
5. Click **Confirm** on the ESS authorization page.

Disable auto scaling

After you click the **Disable Auto-scaling** button, all task nodes expanded by auto-scaling will be released. The data stored in HDFS is located in a core node and will not be affected.

22.2 Configure auto-scaling according to time

If there are significant peaks and troughs in a Hadoop cluster computing capability during a certain period of time, you can set up a fixed period of time to expand a certain number of task nodes to supplement the computing capability. This will not only ensure the completion of jobs, but also save you costs.

The expansion nodes are billed in Pay-As-You-Go mode, and the price of the same computing capability for Pay-As-You-Go mode and Subscription mode is about 3:1. So it is necessary to design the ratio of computing capability for the Pay-As-You-Go mode and Subscription mode respectively according to expansion time you need. For example, the peak period of business lasts for 8 hours a day, and the price paid by Pay-As-You-Go mode are roughly the same as that of Subscription mode. When the peak period is more than 8 hours, the Subscription mode are more favorable than the Pay-As-You-Go mode.

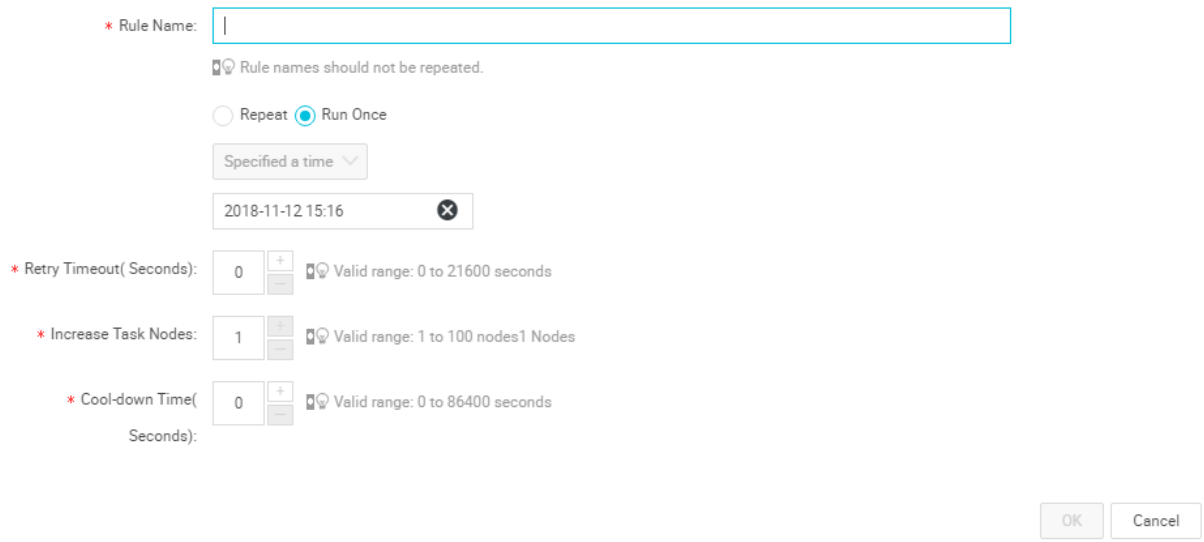
Configure scaling instance number

- Maximum number of nodes: The maximum number of the nodes that can be expanded. Once it is reached, even if the auto-scaling rule is matched, the expansion and contraction will not continue. Currently, you can set up to 1,000 task nodes.
- Minimum number of nodes: The minimum number of the nodes that can be expanded. If the expansion or contraction number of task nodes set in the auto-scaling rule is less than the minimum number of nodes here, the cluster will scale with the minimum number of nodes at the first execution.

  For example, the auto-scaling rule is set to expand 1 node at 00:00:00 of every day, but the minimum number of nodes is 3. Then the system will expand 3 nodes at the 00:00:00 of the first day.

Configure scaling rules

The auto-scaling rules include expansion rules and contraction rules. When the auto-scaling function is disabled, all rules are cleared. If auto-scaling function is enabled again, the scaling rules need to be reconfigured.



- **Rule Name**: In a cluster, the scaling rule names (including expansion rules and contraction rules) are not allowed to be repeated.
- Execution cycle:
  - **Run Once**: The cluster performs a scaling operation at a specified time.
  - **Repeat**: You can choose to perform a scaling operation at a specific time every day, every week or every month.
- **Retry Timeout**: Auto-scaling may not be performed for various reasons when the specified time is reached. With the retry expiration time set, the system will detect the condition that scaling can be performed every 30 seconds in the time range. Once the condition is met, scaling is performed. The range is 0 to 21600 seconds.

  It is assumed that the expansion operation A needs to be performed in the specified time period, if another expansion operation B is performing or the cluster is in the cooling period at that time, the operation A cannot be performed. During the retry expiration time you set, the system will detect the condition that operation A can be performed every 30 seconds. Once the conditions are met, the cluster will immediately perform scaling.
- **Increase Task Nodes**: The number of task nodes to be increased or decreased each time by cluster when the rule is triggered.
- **Cool-down Time**: The interval between scaling operation is completed and the same operation can be performed again. No scaling operation will be performed during cooling time.

Configure scaling instance specification

You can specify the hardware specifications of the scaling nodes. It can only be configured when the auto-scaling function is enabled, and can not be modified after the configution is saved. If it needs to be modified for a special case, you can disable the auto-scaling function and enable it again.

- When you select specifications for vCPU and memory, the system automatically matches the instances that meet the criteria based on your selection and displays them in the instance list below. You need to add an optional instance to the list on the right so that the cluster can scale according to the selected instance specification.
- To avoid scaling failures due to insufficient ECS stock, you can choose up to 3 ECS instance types.
- Whether you choose an efficient cloud disk or a SSD cloud disk, the data disk is set to a minimum of 40G.

22.3 Auto-scaling preemptible instances

E-MapReduce *Preemptible instances* are suitable for scenarios where there is no requirement for the successful execution of big data jobs and where the price of computing resources is important. You can purchase preemptible instances to increase the computing resources of clusters using auto scaling.

Enable auto scaling

To enable the auto scaling feature and set scaling rules, follow these steps:

1. Log on to the *Alibaba Cloud E-MapReduce console*.
2. Click **Cluster Management**.
3. Find the cluster where you want to add preemptible instances and the click **Manage**.
4. In the left-side navigation pane, click **Scaling**.
5. Click **Enable Auto Scaling**.
6. Configure scaling rules. For more information, see *Configure auto scaling according to time*.
7. In scaling configuration area, select **Preemptible instance**.

Configure preemptible instances

Note:

The price of preemptible instances is more favorable than Pay-As-You-Go instances, but Alibaba Cloud may release your instances at any time based on changes in demand resources or market transaction prices.

To configure your preemptible instance, follow these steps:

1. Select the vCPU and memory for your instance.
2. Select instance types. You can select up to three instance types. E-MapReduce filters out all other instance types to ensure that you purchase a preemptible instance that meets your requirements.
3. After you select instance types, click the maximum price of each instance type, and then click **OK**. The instance types will appear in the selected instances list. If you want to modify the price of a selected instance type, select the instance type in the selectable instances list and change the price (by hour). Your instance will run when your bid is higher than the current market price. Your final instance type will be billed at the market price.
4. The system disk is used for deploying basic services such as the OS and EMR, which are set by default. You can set the data disk type and size according to your needs.
5. The final configuration price includes the maximum bid price, system disk price and data disk price. Click **Save**.

For more information about preemptible instances, see *FAQ about preemptible instances*.

22.4 Auto-scaling records

After the auto-scaling operation is complete, you can click the **Scaling Records** tab on the top of the **Scaling** page to see the records of auto-scaling operation and the nodes number after auto-scaling operation is completed.

The execution status of auto-scaling includes the following four types:

- **Running**: Auto-scaling operation is being implemented.
- **Success**: All specified nodes involved in the scaling rule are added or removed from the cluster.
- **Partial success**: According to scaling rules, some nodes were successfully added or removed from the cluster, but some were failed due to disk quota or ECS inventory.
- **Failure**: According to scaling rules, no node is added or removed from the cluster.

23 Workflow development

23.1 Workflow project management

After creating an E-MapReduce cluster, you can create workflow projects so that multiple jobs can be run simultaneously or sequentially.

Create a project

1. At the top of the page, click the **Data Platform** tab on the top to enter the **Projects** page.

   Under the master account, you can view projects of itself and its all sub-accounts. You can only view projects with development permission in the sub-account. To authorize project development permission, you need to configure it in the primary account. For more information about authorization, see *User Management*.
2. In the upper right corner, click the **New Project** button to see the **New Project** dialog box.
3. Enter the project name and description, and click **Create**.

   > **Note:**
   > You can only create a project with the master account, that is, the **Create Project** button is only visible to the master account administrator.

User management

After creating a new project, you can authorize the RAM sub-account operational permission of the project.

1. In the **Project List** page, click the **View Details** link in the **Actions** column.
2. Click the **User Management** tab.
3. Click the **Add User** button to add RAM sub-accounts under the master account to the project.

   The added sub-accounts will be a member of the project and can be able to view and develop the jobs and workflows under the project. If you don't want to set the sub-account to be the selected project member any more, click **Delete** in the **Actions** column.

   > **Note:**
   > You can only add project members with the primary account , that is, the **User Management** tab is only visible to the primary account administrator.

Associate clusters

After creating a new project, you need to associate a cluster for the project so that the workflow in the project can run on it.

1. In the **Projects** page, click the **View Details** link in the **Actions** column.
2. Click the **Cluster Settings** tab.
3. Click the **Add Cluster** button, from the drop-down menu, you can select the created Subscription and Pay-As-You-Go clusters (clusters created by running temporary jobs are not listed here).
4. Click **OK**.

   You can click **Delete** in the Operation column to unassociate the cluster.

   > **Note:**
   > You can only associate cluster with the primary account , that is, the **Cluster Settings** tab is only visible to the primary account administrator.

Click **Modify Configuration** in the Operation column to set up the queue and user to submit jobs to the cluster. The specific configuration items are described as follows:

- Default Submit Job User: Sets the default Hadoop user who submits the job to the selected cluster in the project. The default value is hadoop, and there only can be one default user.
- Default Submit Job Queue: Sets the default queue that the jobs are submited to in the project. If you leave this blank, the job will be submitted to the default queue.
- Submit Job User Whitelist: Sets Hadoop users who can submit jobs to the selected cluster in the project. If there are more than one users, they can be separated by a half-width comma (,).
- Submit Job Queue Whitelist: Sets the queue of the selected cluster that jobs in the project can run in. If there are more than one queues, they can be separated by a half-width comma (,).
- Client whitelist: Configures the client that you can submit jobs. The E-MapReduce master node or the E-MapReduce Gateway can be selected. Currently, your self-built gateways are not listed here.

23.2 Job editing

In the project, you can create jobs such as Shell, Hive, Spark, SparkSQL, MapReduce、Sqoop, Pig and Spark Streaming.

Create a Job

1. Log on to the *Alibaba Cloud E-MapReduce console*.
2. Click the **Data Platform** tab on the top to enter the **Projects** page.
3. Click **Design Workflow** of the specified project in the **Actions** column.
4. On the left side of the job editing page, right-click on the folder you want to operate and select **New Job**.
5. In the **New Job** dialog box, enter the job name, job description, and select the job type.

   Once the job type is selected, it cannot be modified.
6. Click **OK**.

   Note:
   You can also create subfolder, rename folder, and delete folder by right-clicking on the folder.

Develop jobs

For the development guides for various types of jobs, see *Job* in the *Cite LeftE-MapReduce User GuideCite Right*.

Note:
When you insert an OSS path, if you select the OSSREF file prefix, the OSS file will be downloaded to the cluster and added to the classpath.

- Basic settings

  Click the **Job Settings** in the upper right corner of the page to enter the **Job Running Configuration** page.

  - **Number of Retries**: Sets the number of retries when this job fails during the workflow running. This option will not take effect when you run the job directly on the **Job Editing** page.
  - **Failure Policy**: Sets whether to continue running the next job or suspend the current workflow when this job fails during the workflow running.

- **Resource File**: If you add resources such as Jar packages or UDFs that the job running depends on, you need to upload the resources to OSS first. After adding the resource, you can reference the resource directly in the job code.
- **Parameter Configuration**: Specify the value of the variable referenced in the job code. You can reference variables in the code with the format *`${variable name}`*. Click the plus icon on the right to add key and value, the key is the variable name, and the value is the value of the variable. In addition, you can customize the time variable according to the schedule time. The rules are as follows:
  - yyyy indicates the year which is 4-digit.
  - MM indicates the month.
  - dd indicates the day.
  - hh24 indicates the hour, uses *hh* if 12-hour system is adopted.
  - mm indicates the minute.
  - ss indicates the second.

  The time variable can be any combination of time containing yyyy. You can also use the '+' symbol to advance time and use '-' symbol to delay time. For example, the variable *`${yyyy-MM-dd}`* indicates the current date, then:
  - The representation of 1 year later: *`${yyyy+Ny}`* or *`${yyyy-MM-dd hh:mm:ss+1y}`*.
  - The representation of 3 months later: *`${yyyyMM+Nm}`* or *`${hh:mm:ss yyyy-MM-dd +3m}`*.
  - The representation of 5 days before: *`${yyyyMMdd-Nd}`* or *`${hh:mm:ss yyyy-MM-dd-5d}`*.
- Advanced settings

  On the **Job Settings** page, click the **Advanced** tab.
  - **Mode**: Job running modes, including YARN and LOCAL. In YARN mode, the job is submitted on the YARN by the Launcher. In LOCAL mode, jobs run directly on the assigned host.
  - **Environment Variables**: Add environment variables for job running, or export environment variables directly in the job script.
  - **Scheduling Parameters**: Sets job running configuration such as the YARN queue, CPU, memory and Hadoop users. You can leave it unset, and the default value of the Hadoop cluster is adopted when the job is running.

Run job

Once the job has been developed and configured, you can click the **Run** button at the top right corner to run the job.

View log

After the job runs, you can view the running log of the job in the **View Records** tab at the bottom of the page. Click **Workflow** to jump to the detailed log page of the job, you can see information such as the job's submitting log and YARN Container log.

23.3 Ad hoc queries

You can only select HiveSQL, SparkSQL, and Shell as the type of an ad hoc query. When you execute an ad hoc query statement, the log and query results show at the bottom of the log and query page.

Create a job

When you execute a job on the Edit Jobs page and click Details, you will be directed to the Details page that shows the operation logs and run logs of this job. Ad hoc queries and jobs are used in different places. Ad hoc queries are usually used by data scientists and data analysts. In addition, you need to use SQL as a tool to implement an ad hoc query.

1. Log on to the *Alibaba Cloud E-MapReduce console*.
2. Click the **Data Platform** tab to enter the **Projects** page.
3. On the right side of the associated project, click **Design Workflow** to enter the **Edit Jobs** page.
4. In the left-side navigation pane, click the **Query** tab to enter the **Query** page.
5. In the left-side navigation pane, right-click a folder as required and select **New Job**.
6. In the **New Job**dialog box, enter the job name and job description, and select a job type.

   The job type cannot be modified once the job has been created.
7. Click **OK**.

> **Note:**
> You can right click on a folder and then select the corresponding option to perform New Subfolders, Rename Folder, and Delete Folder operations.

Develop a job

For more information about how to develop jobs with HiveSQL, SparkSQL, and Shell types, see the *Cite LeftjobsCite Right* section of E-MapReduce user guide.

Note:
When you insert an OSS UNI and select OSSREF as a File Prefix, E-MapReduce will download OSS files to your cluster and add these files to the classpath.

- Basic job settings

  In the top-right corner, click **Configure Jobs**, and then the **Job Settings** dialog box appears.

  - Resource File: If you want to add resources such as jar packages or UDF that a job execution depends on, you must upload these files to OSS. When you select a resource, you can use this resource in a job directly.
  - Parameter Configuration: specifies the values of variables used in a job. You can use variables in your code. The format is: *`${variable name}`*. Click the plus (+) icon on the right side to add key-value pairs. Key is the name of a variable and value is the value of a variable. In addition, you can follow these rules to customize time variables according to the start time of a schedule.

    - yyyy represents a 4-digit year.
    - MM represents a 2-digit month.
    - dd represents a 2-digit day.
    - hh24 indicates that the 24-hour clock is used. hh indicates that the 12-hour clock is used.
    - mm represent a 2-digit minute.
    - ss represents a 2-digit second.

      A time variable consists of the combination of a 4-digit year and one or more other time formats. In addition, you can use plus (+) and minus (-) to add or reduce a period of time for the current time. For example, the *`${yyyy-MM-dd}`* variable represents the current date.

      - One year after the current date can be represented as *`${yyyy+Ny}`* or *`${yyyy-MM-dd hh:mm:ss+1y}`*.
      - Three months after the current date can be represented as: *`${yyyyMM+Nm}`* or *`${hh:mm:ss yyyy-MM-dd+3m}`*.

- Five days before the current date can be represented as:*`${yyyyMMdd-Nd}`* or *`${hh:mm:ss yyyy-MM-dd-5d}`*.

- Advanced job settings

  In the **Job Settings** dialog box, click the **Advanced** tab.

  - Mode: includes the YARN and LOCAL modes. YARN: Jobs are submitted by allocating resources on YARN through Launcher. LOCAL: The job runs on a specified local host.
  - Scheduling parameters: Includes information, such as YARN queues of a job, vCPU, memory, and Hadoop user. If you do not specify these parameters, a job uses the default values of the Hadoop cluster.

Execute a job

After you develop and configure a job, in the top-right corner, you can click the **Run** button to execute a job.

View logs

After you execute a job, you can view run logs on the **Log** tab at the bottom of the query page.

23.4 Workflow management

You can run big data jobs parallelly in a DAG manner by E-MapReduce workflows. In addition, you can suspend, stop, rerun workflows, and view the running status of workflows in WebUI.

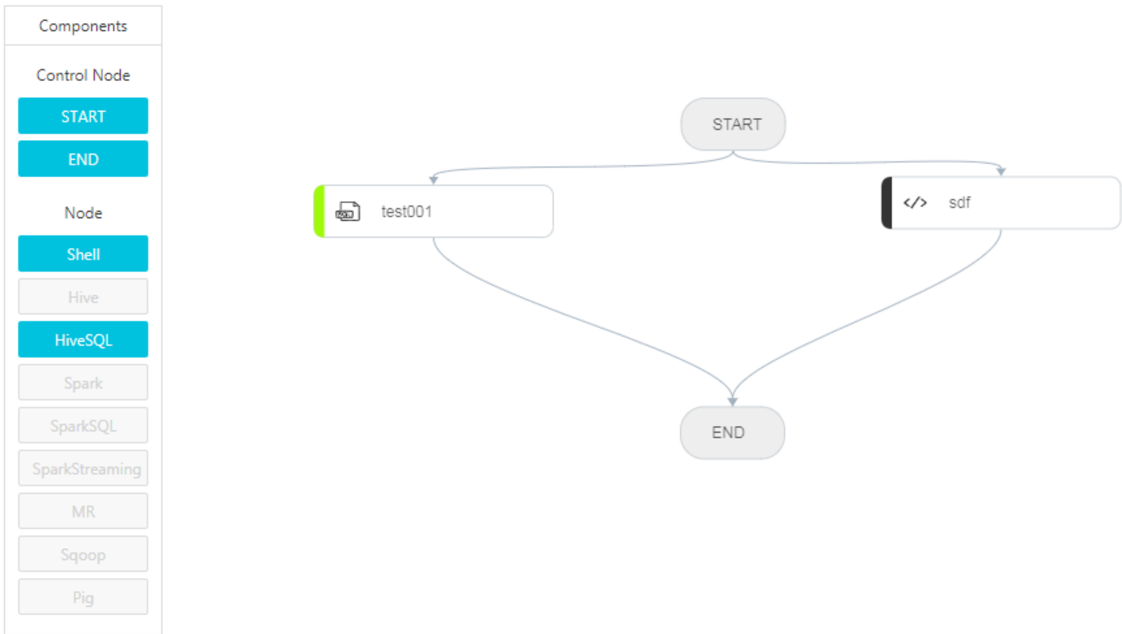
Creating a workflow

1. Log on to the *Alibaba Cloud E-MapReduce console*.
2. At the top of the page, click the **Data Platform** tab.
3. Click **Design Workflow** of the specified project in the **Actions** column, and then select the **Design Workflow** tab.
4. On the left side, right-click on the folder you want to operate and select **New Workflow**.
5. In the **New Workflow** dialog box, enter the workflow name, workflow description, and select the E-MapReduce cluster where the workflow is to run.

   You can select a Subscription and Pay-As-You-Go E-MapReduce cluster that has been created and is associated with the project for the workflow running, or a new temporary cluster can be created through the cluster template to run the workflow.
6. Click **OK**.

Editing workflow

You can drag different types of jobs to the workflow editing canvas, and specify the order of job instances by curve. After the jobs needed to run has been dragged, drag the **END** component from the control node area to the canvas, which indicates that the entire workflow is complete.



Configure workflow

On the right side of the **Workflow Design** page, click **Configure** button to configure the workflow scheduling.

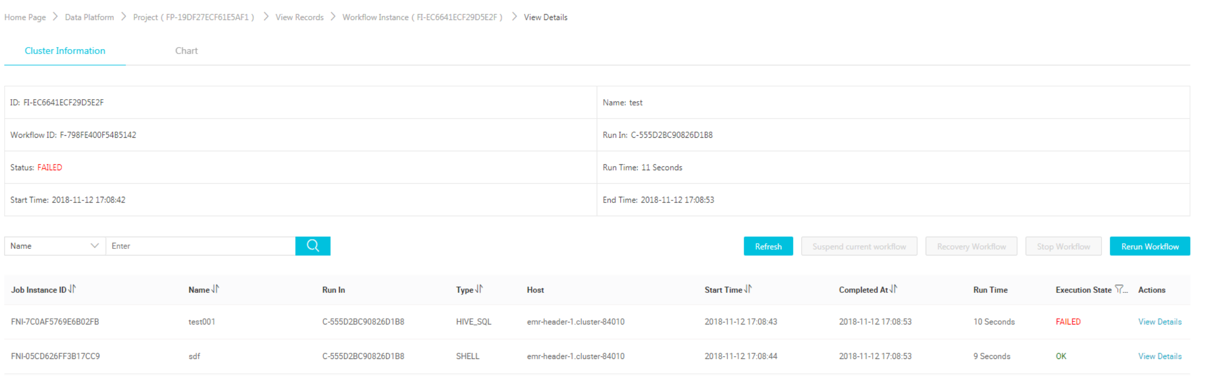
- **Run In**: The E-MapReduce cluster where the workflow is to run can be modified.
- **Scheduling Policy**: After workflow scheduling is enabled, you can choose a scheduling policy, including time scheduling and dependency scheduling.
  - **Time Scheduler**: Sets the start time and end time of the workflow scheduling, the system will run the workflow according to the schedule you set during the time scope.
  - **Dependency**: From the selected project, select the dependency workflow of the current workflow. After the dependency workflow is completed, the current workflow will be scheduled to run. Currently, only one workflow can be selected.

Run a workflow

Once the workflow is designed and configured, you can run the workflow by clicking the **Run** button in the upper right corner.

View and operate workflow instances

After the workflow is running, click the **View Records** tab on the left to view the running status of the workflow instance. Click the **View Details** of the workflow instance to view the running status of the job instance. You can also suspend, resume, stop, and rerun the workflow instance.



- Suspend workflow: The running job instance will continue to run, but the subsequent job instances will not. You can click **Resume Workflow** and the system will continue to run the subsequent jobs after the job instance is suspended.
- Stop workflow: All running job instances stop immediately.
- Rerun workflow Instance: The system will run the workflow from the start component.