Cloud Container Engine

Best Practices

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1 Checklist for Deploying Containerized Applications in the Cloud

Overview

Security, efficiency, stability, and availability are common requirements on all cloud services. To meet these requirements, the system availability, data reliability, and O&M stability must be coordinated. This checklist describes the check items for deploying containerized applications on the cloud to help you efficiently migrate services to CCE, reducing potential cluster or application exceptions caused by improper use.

Check Items

Table 1-1 System availability

Category	Check Item	Type	Impact	FAQ & Example
Cluster	Before creating a cluster, properly plan the node network and container network based on service requirements to allow subsequent service expansion.	Network planning	If the subnet or container CIDR block where the cluster resides is small, the number of available nodes supported by the cluster may be less than required.	• **Network Planning** • **Planning CIDR Blocks for a Cluster** • **How Do I Set the VPC CIDR Block and Subnet CIDR Block for a CCE Cluster?**

Category	Check Item	Type	Impact	FAQ & Example
	Before creating a cluster, properly plan CIDR blocks for the related Direct Connect, peering connection, container network, service network, and subnet to avoid IP address conflicts.	Network planning	If CIDR blocks are not properly set and IP address conflicts occur, service access will be affected.	• **Connectivity** • **Planning CIDR Blocks for a Cluster**
	When a cluster is created, the default security group is automatically created and bound to the cluster. You can set custom security group rules based on service requirements.	Deployment	Security groups are key to security isolation. Improper security policy configuration may cause security risks and service connectivity problems.	• **Security Groups and Security Group Rules** • **How Do I Prevent Cluster Nodes from Being Exposed to Public Networks?**

Category	Check Item	Type	Impact	FAQ & Example
	Enable the multi-master node mode, and set the number of master nodes to **3** when creating a cluster.	Reliability	After the multi-master node mode is enabled, three master nodes will be created. If a master node is faulty, the cluster can still be available without affecting service functions. In commercial scenarios, it is advised to enable the multi-master node mode.	**How Do I Check Whether a Cluster Is in Multi-Master Mode?** Once a cluster is created, the number of master nodes cannot be changed. Exercise caution when setting the number of master nodes.
	When creating a cluster, select a proper network model as needed. • Select **VPC network** or **Tunnel network** for your CCE standard cluster. • Select **Cloud Native Network 2.0** for your CCE Turbo cluster.	Deployment	After a cluster is created, the network model cannot be changed. Exercise caution when selecting a network model.	**Network Model Comparison**

Category	Check Item	Type	Impact	FAQ & Example
Workload	When creating a workload, set the CPU and memory limits to improve service robustness.	Deployment	When multiple applications are deployed on the same node, if the upper and lower resource limits are not set for an application, resource leakage occurs. As a result, resources cannot be allocated to other applications, and the application monitoring information will be inaccurate.	None
	When creating a workload, you can set probes for container health check, including **liveness probe** and **readiness probe**.	Reliability	If the health check function is not configured, a pod cannot detect service exceptions or automatically restart the service to restore it. This results in a situation where the pod status is normal but the service in the pod is abnormal.	• **Setting Health Check for a Container** • **Enabling ICMP Security Group Rules**

Category	Check Item	Type	Impact	FAQ & Example
	When creating a workload, select a proper access mode (Service). Currently, the following types of Services are supported: ClusterIP, NodePort, DNAT, and LoadBalancer.	Deployment	Improper Service configuration may cause logic confusion for internal and external access and resource waste.	• **Network Overview**
	When creating a workload, do not set the number of replicas for a single pod. Set a proper node scheduling policy based on your service requirements.	Reliability	For example, if the number of replicas of a single pod is set, the service will be abnormal when the node or pod is abnormal. To ensure that your pods can be successfully scheduled, ensure that the node has idle resources for container scheduling after you set the scheduling rule.	None

Category	Check Item	Type	Impact	FAQ & Example
	Properly set affinity and anti-affinity.	Reliability	If affinity and anti-affinity are both configured for an application that provides Services externally, Services may fail to be accessed after the application is upgraded or restarted.	**Scheduling Policy (Affinity/Anti-affinity)** **Negative example:** For application A, nodes 1 and 2 are set as affinity nodes, and nodes 3 and 4 are set as anti-affinity nodes. Application A exposes a Service through the ELB, and the ELB listens to node 1 and node 2. When application A is upgraded, it may be scheduled to a node other than nodes 1, 2, 3, and 4, and it cannot be accessed through the Service. **Cause:** Scheduling of application A does not need to meet both affinity and anti-affinity policies. A node will be selected for application A according to either of the policies. In this example, the node selection is based on the anti-affinity scheduling policy.

Category	Check Item	Type	Impact	FAQ & Example
	When creating a workload, set the pre-stop processing command (**Lifecycle** > **Pre-Stop**) to ensure that the services running in the pods can be completed in advance in the case of application upgrade or pod deletion.	Reliability	If the pre-stop processing command is not configured, the pod will be directly killed and services will be interrupted during application upgrade.	• **Setting Container Lifecycle Parameters** • **When Is Pre-stop Processing Used?**

Table 1-2 Data reliability

Category	Check Item	Type	Impact	FAQ & Example
Container data persistency	Select a proper data volume type based on service requirements.	Reliability	When a node is faulty and cannot be recovered, data in the local disk cannot be recovered. Therefore, you are advised to use cloud storage volumes to ensure data reliability.	• **Storage Overview**
Backup	Back up application data.	Reliability	Data cannot be restored after being lost.	**What Are the Differences Among CCE Storage Classes in Terms of Persistent Storage and Multi-node Mounting?**

Table 1-3 O&M reliability

Category	Check Item	Type	Impact	FAQ & Example
Project	The quotas of ECS, VPC, subnet, EIP, and EVS resources must meet customer requirements.	Deployment	If the quota is insufficient, resources will fail to be created. Specifically, users who have configured auto scaling must have sufficient resource quotas.	• **Which Resource Quotas Should I Pay Attention To When Using CCE?** • **Notes and Constraints**
	You are not advised to modify kernel parameters, system configurations, cluster core component versions, security groups, and ELB-related parameters on cluster nodes, or install software that has not been verified.	Deployment	Exceptions may occur on CCE clusters or Kubernetes components on the node, making the node unavailable for application deployment.	For details, see **High-Risk Operations and Solutions**. **Negative example:** 1. The container network is interrupted after the node kernel is upgraded. 2. The container network is interrupted after an open-source Kubernetes network add-on is installed on a node. 3. The **/var/paas** or **/mnt/paas/kubernetes** directory is deleted from a node, which causes exceptions on the node.

Category	Check Item	Type	Impact	FAQ & Example
	Do not modify information about resources created by CCE, such as security groups and EVS disks. Resources created by CCE are labeled **cce**.	Deployment	CCE cluster functions may be abnormal.	**Negative example:** 1. On the ELB console, a user changes the name of the listener created by CCE. 2. On the VPC console, a user modifies the security group created by CCE. 3. On the EVS console, a user deletes or uninstalls data disks mounted to CCE cluster nodes. 4. On the IAM console, a user deletes **cce_admin_trust**. All the preceding actions will cause CCE cluster functions to be abnormal.

Category	Check Item	Type	Impact	FAQ & Example
Proactive O&M	CCE provides multi-dimensional monitoring and alarm reporting functions, allowing users to locate and rectify faults as soon as possible. • Application Operations Management (AOM): The default basic resource monitoring of CCE covers detailed container-related metrics and provides alarm reporting functions. • Open source Prometheus: A monitoring tool for cloud native applications. It integrates an independent alarm system to provide more	Monitoring	If the alarms are not configured, the standard of container cluster performance cannot be established. When an exception occurs, you cannot receive alarms and will need to manually locate the fault.	• **Monitoring Overview** • **Monitoring Custom Metrics Using the Cloud Native Monitoring Add-on**

Category	Check Item	Type	Impact	FAQ & Example
	flexible monitoring and alarm reporting functions.			

2 Containerization

2.1 Containerizing an Enterprise Application (ERP)

2.1.1 Solution Overview

This chapter provides CCE best practices to walk you through the application containerization.

What Is a Container?

A container is a lightweight high-performance resource isolation mechanism implemented based on the Linux kernel. It is a built-in capability of the operating system (OS) kernel.

CCE is an enterprise-class container service based on open-source Kubernetes. It is a high-performance and high-reliability service through which enterprises can manage containerized applications. CCE supports native Kubernetes applications and tools, allowing you to easily set up a container runtime in the cloud.

Why Is a Container Preferred?

- More efficient use of system resources

  A container does not require extra costs such as fees for hardware virtualization and those for running a complete OS. Therefore, a container has higher resource usage. Compared with a VM with the same configurations, a container can run more applications.

- Faster startup

  A container directly runs on the host kernel and does not need to start a complete OS. Therefore, a container can be started within seconds or even milliseconds, greatly saving the development, testing, and deployment time.

- Consistent runtime environment

  A container image provides a complete runtime environment to ensure environment consistency. In this case, problems (for example, some code runs properly on machine A but fails to run on machine B) will not occur.

- Easier application migration, maintenance, and scaling

  A consistent runtime environment makes application migration easier. In addition, the in-use storage and image technologies facilitate the reuse of repeated applications and simplifies the expansion of images based on base images.

Containerization Modes

The following modes are available for containerizing applications:

- Mode 1: Containerize a single application as a whole. Application code and architecture remain unchanged.
- Mode 2: Separate the components that are frequently upgraded or have high requirements on auto scaling from an application, and then containerize these components.
- Mode 3: Transform an application to microservices and then containerize the microservices one by one.

Table 2-1 lists the advantages and disadvantages of the three modes.

Table 2-1 Containerization modes

Containerization Mode	Advantage	Disadvantage
Method 1: Containerize a single application as a whole.	• Zero modification on services: The application architecture and code require no change. • The deployment and upgrade efficiency is improved. Applications can be packed as container images to ensure application environment consistency and improve deployment efficiency. • Reduce resource costs: Containers use system resources more efficiently. Compared with a VM with the same configurations, a container can run more applications.	• Difficult to expand the entire architecture of an application. As the code size increases, code update and maintenance would be complicated. • Difficult to launch new functions, languages, frameworks, and technologies.

Containerization Mode	Advantage	Disadvantage
Method 2: Containerize first the application components that are frequently updated or have high requirements on auto scaling.	• Progressive transformation: Reconstructing the entire architecture involves a heavy workload. This mode containerizes only a part of components, which is easy to accept for customers. • Flexible scaling: Application components that have high requirements on auto scaling are containerized. When the application needs to be scaled, you only need to scale the containers, which is flexible and reduces the required system resources. • Faster rollout of new features: Application components that are frequently upgraded are containerized. In subsequent upgrades, only these containers need to be upgraded. This shortens the time to market (TTM) of new features.	Need to decouple some services.

Containerization Mode	Advantage	Disadvantage
Method 3: Transform an application to microservices and then containerize the microservices one by one.	• Independent scaling: After an application is split into microservices, you can independently increase or decrease the number of instances for each microservice. • Increased development speed: Microservices are decoupled from one another. Code development of a microservice does not affect other microservices. • Security assurance through isolation: For an overall application, if a security vulnerability exists, attackers can use this vulnerability to obtain the permission to all functions of the application. However, in a microservice architecture, if a service is attacked, attackers can only obtain the access permission to this service, but cannot intrude other services. • Breakdown isolation: If one microservice breaks down, other microservices can still run properly.	Need to transform the application to microservices, which involves a large number of changes.

Mode 1 is used as an example in this tutorial to illustrate how to containerize an enterprise resource planning (ERP) system.

2.1.2 Resource and Cost Planning

NOTICE

The fees listed here are estimates. The actual fees vary with regions and will be displayed on the Huawei Cloud console.

The following table lists the resources needed in this practice.

Table 2-2 Resource and cost planning

Resource	Description	Quantity	Estimated Fee
ECS	Pay-per-use recommended • VM type: general computing-plus • Node flavor: 4 vCPUs | 8 GiB • OS: Ubuntu 22.04 • System disk: 40 GiB | General purpose SSD • EIP specification: billed by bandwidth, 5 Mbit/s	1	USD0.3123/ hour
Cloud Container Engine (CCE)	Pay-per-use recommended • Cluster type: CCE cluster • Cluster version: v1.25 • Cluster scale: 50 nodes • HA: Yes	1	USD0.42/hour
	Pay-per-use recommended • Node type: general computing-plus • Node flavor: 4 vCPUs | 8GiB • OS: EulerOS 2.9 • System disk: 50 GiB | General purpose SSD • Data disk: 100 GiB | General purpose SSD	1	USD0.2096/ hour
Elastic Volume Service (EVS)	Pay-per-use recommended • EVS disk specification: 100 GiB • EVS disk type: General purpose SSD	1	USD0.0157/ hour

2.1.3 Procedure

2.1.3.1 Containerizing an Entire Application

This tutorial describes how to containerize an ERP system by migrating it from a VM to CCE.

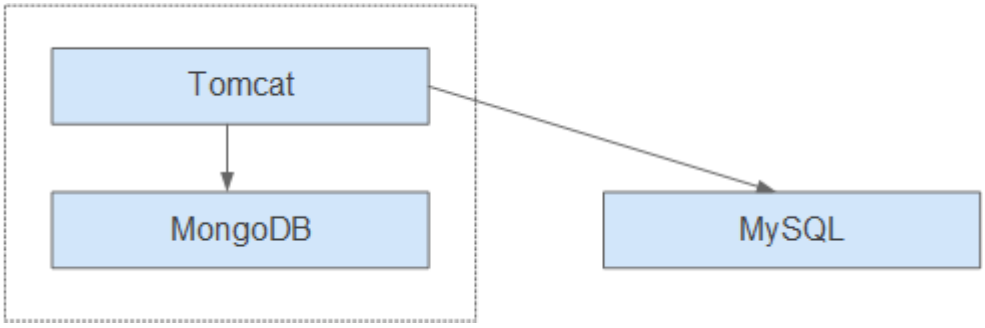
No recoding or re-architecting is required. You only need to pack the entire application into a container image and deploy the container image on CCE.

Introduction

In this example, the **enterprise management application** is developed by enterprise A. This application is provided for third-party enterprises for use, and enterprise A is responsible for application maintenance.

When a third-party enterprise needs to use this application, a suit of **Tomcat application** and **MongoDB database** must be deployed for the third-party enterprise. The MySQL database, used to store data of third-party enterprises, is provided by enterprise A.

Figure 2-1 Application architecture



As shown in **Figure 2-1**, the application is a standard Tomcat application, and its backend interconnects with MongoDB and MySQL databases. For this type of applications, there is no need to split the architecture. The entire application is built as an image, and the MongoDB database is deployed in the same image as the Tomcat application. In this way, the application can be deployed or upgraded through the image.

- Interconnecting with the MongoDB database for storing user files.
- Interconnecting with the MySQL database for storing third-party enterprise data. The MySQL database is an external cloud database.

Benefits

In this example, the application was deployed on a VM. During application deployment and upgrade, a series of problems is encountered, but application containerization has solved these problems.

By using containers, you can easily pack application code, configurations, and dependencies and convert them into easy-to-use building blocks. This achieves the environmental consistency and version management, as well as improves the development and operation efficiency. Containers ensure quick, reliable, and consistent deployment of applications and prevent applications from being affected by deployment environment.

Table 2-3 Comparison between the two deployment modes

Category	Before: Application Deployment on VM	After: Application Deployment Using Containers
Deployment	High deployment cost. A VM is required for deploying a system for a customer.	More than 50% cost reduced. Container services achieve multi-tenant isolation, which allows you to deploy systems for different enterprises on the same VM.
Upgrade	Low upgrade efficiency. During version upgrades, log in to VMs one by one and manually configure the upgrades, which is inefficient and error-prone.	Per-second level upgrade. Version upgrades can be completed within seconds by replacing the image tag. In addition, CCE provides rolling updates, ensuring zero service downtime during upgrades.
Operation and maintenance (O&M)	High O&M cost. As the number of applications deployed for customer grows, the number of VMs that need to be maintained increases accordingly, which requires a large sum of maintenance cost.	Automatic O&M Enterprises can focus on service development without paying attention to VM maintenance.

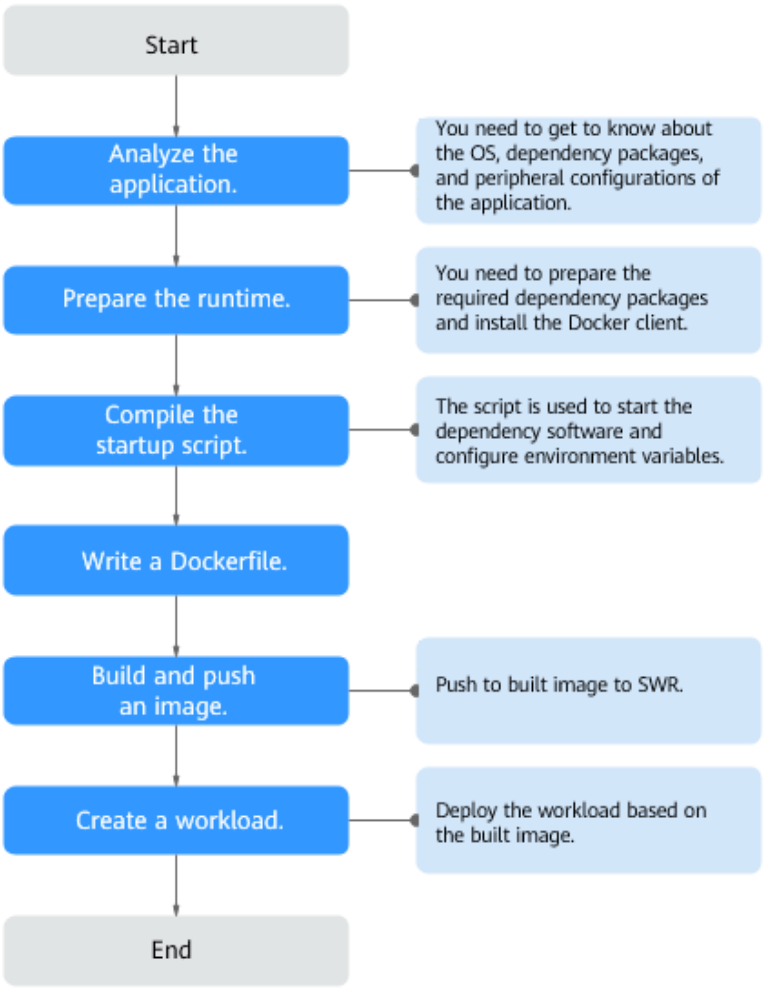
2.1.3.2 Containerization Process

To fully containerize an application, you must go through the entire process.

This involves analyzing the application, setting up the runtime environment for the application, compiling the startup script and Dockerfile, creating and uploading images, and creating containerized workloads.

For details about each step of the containerization, see **Containerization Process**.

Figure 2-2 Process of containerizing an application



2.1.3.3 Analyzing the Application

Before containerizing an application, analyze the running environment and dependencies of the application, and get familiar with the application deployment mode. For details, see **Table 2-4**.

Table 2-4 Application environment

Category	Sub-category	Description
Runtime environment	OS	OS that the application runs on, such as CentOS or Ubuntu. In this example, the application runs on CentOS 7.1.

Category	Sub-category	Description
	Runtime environment	The Java application requires Java Development Kit (JDK), the Go language requires GoLang, the web application requires Tomcat environment, and the corresponding version number needs to be confirmed. In this example, the web application of the Tomcat type is used. This application requires the runtime environment of Tomcat 7.0, and Tomcat requires JDK 1.8.
	Dependency package	Understand required dependency packages, such as OpenSSL and other system software, and their version numbers. In this example, no dependency package is required.
Deployment mode	Peripheral configurations	MongoDB database: In this example, the MongoDB database and Tomcat application are deployed on the same server. Therefore, their configurations can be fixed and there is no need to extract their configurations.

		External services with which the application needs to interconnect, such as databases and file systems.
		These configurations need to be manually configured each time you deploy an application on a VM. However, through containerized deployment, environment variables can be injected into a container, facilitating deployment.
		In this example, the application needs to interconnect with the MySQL database. Obtain the database configuration file. The server address, database name, database login username, and database login password are injected through environment variables.
		url=jdbc:mysql://*Server address*/*Database name* #Database connection URL
		username=**** #Username for logging in to the database
		password=**** #Password for logging in to the database

Category	Sub-category	Description
	Application configurations	Sort out the configuration parameters, such as configurations that need to be modified frequently and those remain unchanged during the running of the application. In this example, no application configurations need to be extracted. **NOTE** To avoid frequent image replacement, you are advised to classify configurations of the application. • For the configurations (such as peripheral interconnection information and log levels) that are frequently changed, you are advised to configure them as environment variables. • For the configurations that remain unchanged, directly write them into images.

2.1.3.4 Preparing the Application Runtime

After application analysis, you have gained the understanding of the OS and runtime required for running the application. Make the following preparations:

- **Installing Docker**: During application containerization, build a container image. To do so, you have to prepare a PC and install Docker on it.
- **Obtaining the runtime**: Obtain the runtime of the application and the MongoDB database with which the application interconnects.

Installing Docker

Docker is compatible with almost all operating systems. Select a Docker version that best suits your needs.

NOTE

SWR uses Docker 1.11.2 or later to upload images.

It is recommended that you install Docker and build images as the user **root**. Make sure to obtain the user **root** password for the host where Docker will be installed beforehand.

Step 1 Log in as user **root** to the device on which Docker is about to be installed.

Step 2 Quickly install Docker on the device running Linux. You can also manually install Docker. For details, see **Docker Engine installation**.

curl -fsSL get.docker.com -o get-docker.sh

sh get-docker.sh

Step 3 Run the following command to check the Docker version:

docker version

```
Client:
Version: 17.12.0-ce
API Version:1.35
...
```


Version indicates the version number.

----End

Obtaining the Runtime

In this example, the web application of the Tomcat type is used. This application requires the runtime of Tomcat 7.0, and Tomcat requires JDK 1.8. In addition, the application must interconnect with the MongoDB database in advance.

NOTE

Download the environment required by the application.

Step 1 Download Tomcat, JDK, and MongoDB installation packages of the specific versions.

1. Download JDK 1.8.

   Download address: **https://www.oracle.com/java/technologies/jdk8-downloads.html**.
2. Download Tomcat 7.0 from **http://archive.apache.org/dist/tomcat/tomcat-7/v7.0.82/bin/apache-tomcat-7.0.82.tar.gz**.
3. Download MongoDB 3.2 from **https://fastdl.mongodb.org/linux/mongodb-linux-x86_64-rhel70-3.2.9.tgz**.

Step 2 Log in as user **root** to the device running Docker.

Step 3 Run the following commands to create the directory where the application is to be stored: For example, set the directory to **apptest**.

mkdir apptest

cd apptest

Step 4 Use Xshell to save the downloaded dependency files to the **apptest** directory.

Step 5 Run the following commands to decompress the dependency files:

tar -zxf apache-tomcat-7.0.82.tar.gz

tar -zxf jdk-8u151-linux-x64.tar.gz

tar -zxf mongodb-linux-x86_64-rhel70-3.2.9.tgz

Step 6 Save the enterprise application (for example, **apptest.war**) in the **webapps/apptest** directory of the Tomcat runtime environment.

NOTE

apptest.war is used as an example only. Use your own application for actual configuration.

mkdir -p apache-tomcat-7.0.82/webapps/apptest

cp apptest.war apache-tomcat-7.0.82/webapps/apptest

cd apache-tomcat-7.0.82/webapps/apptest

./../../../jdk1.8.0_151/bin/jar -xf apptest.war

rm -rf apptest.war

----End

2.1.3.5 Compiling a Startup Script

During application containerization, prepare a startup script. The method of compiling this script is the same as that of compiling a shell script. The startup script is used to:

- Start up the software on which the application depends.
- Set the configurations that need to be changed as the environment variables.

NOTE

Startup scripts vary according to applications. Edit the script based on your service requirements.

Procedure

Step 1 Log in as user **root** to the device running Docker.

Step 2 Run the following command to switch to the directory where the application is to be stored:

cd apptest

Step 3 Compile a script file. The name and content of the script file vary according to applications. Edit the script file based on your application. The following example is only for your reference.

vi start_tomcat_and_mongo.sh

```
#!/bin/bash
# Load system environment variables.
source  /etc/profile
# Start MongoDB. The data is stored in /usr/local/mongodb/data.
./usr/local/mongodb/bin/mongod --dbpath=/usr/local/mongodb/data --logpath=/usr/local/mongodb/logs --port=27017 –fork
# These three script commands indicate that the contents related to the MySQL database in the environment variables are written into the configuration file when Docker is started.
sed -i "s|mysql://.*/awcp_crmtile|mysql://$MYSQL_URL/$MYSQL_DB|g" /root/apache-tomcat-7.0.82/webapps/awcp/WEB-INF/classes/conf/jdbc.properties
sed -i "s|username=.*|username=$MYSQL_USER|g" /root/apache-tomcat-7.0.82/webapps/awcp/WEB-INF/classes/conf/jdbc.properties
sed -i "s|password=.*|password=$MYSQL_PASSWORD|g" /root/apache-tomcat-7.0.82/webapps/awcp/WEB-INF/classes/conf/jdbc.properties
# Start Tomcat.
bash /root/apache-tomcat-7.0.82/bin/catalina.sh run
```

----End

2.1.3.6 Compiling the Dockerfile

An image is the basis of a container. A container runs based on the content defined in the image. An image has multiple layers. Each layer includes the modifications made based on the previous layer.

Generally, Dockerfiles are used to customize images. Dockerfile is a text file and contains various instructions. Each instruction is used to build an image layer. That is, each instruction describes how to build an image layer.

This section describes how to compile a Dockerfile file.

> **NOTE**
>
> Dockerfiles vary according to applications. Dockerfiles need to be compiled based on actual service requirements.
>
> For details on how to write a quality Dockerfile, see **Writing a Quality Dockerfile**.

Procedure

Step 1 Log in as the **root** user to the device running Docker.

Step 2 Compile a Dockerfile.

vi Dockerfile

The content is as follows:

```
# CentOS 7.1.1503 is used as the base image.
FROM centos:7.1.1503
# Create a folder to store data and dependency files. You are advised to write multiple commands into one line to reduce the image size.
RUN mkdir -p /usr/local/mongodb/data \
 && mkdir -p /usr/local/mongodb/bin \
 && mkdir -p /root/apache-tomcat-7.0.82 \
 && mkdir -p /root/jdk1.8.0_151

# Copy the files in the apache-tomcat-7.0.82 directory to the container path.
COPY ./apache-tomcat-7.0.82 /root/apache-tomcat-7.0.82
# Copy the files in the jdk1.8.0_151 directory to the container path.
COPY ./jdk1.8.0_151 /root/jdk1.8.0_151
# Copy the files in the mongodb-linux-x86_64-rhel70-3.2.9 directory to the container path.
COPY ./mongodb-linux-x86_64-rhel70-3.2.9/bin /usr/local/mongodb/bin
# Copy start_tomcat_and_mongo.sh to the /root directory of the container.
COPY ./start_tomcat_and_mongo.sh /root/

# Enter Java environment variables.
RUN chown root:root -R /root \
 && echo "JAVA_HOME=/root/jdk1.8.0_151 " >> /etc/profile  \
 && echo "PATH=\$JAVA_HOME/bin:$PATH " >> /etc/profile  \
 && echo "CLASSPATH=.:\$JAVA_HOME/lib/dt.jar:\$JAVA_HOME/lib/tools.jar" >> /etc/profile  \
 && chmod +x /root \
 && chmod +x /root/start_tomcat_and_mongo.sh

# When the container is started, commands in start_tomcat_and_mongo.sh are automatically run. The file can be one or more commands, or a script.
ENTRYPOINT ["/root/start_tomcat_and_mongo.sh"]
```

In the preceding information:

- **FROM** statement: indicates that **centos:7.1.1503** is used as the base image.
- **Run** statement: indicates that a shell command is executed in the container.
- **COPY** statement: indicates that files in the local computer are copied to the container.
- **ENTRYPOINT** statement: indicates the commands that are run after the container is started.

----End

2.1.3.7 Building and Uploading an Image

This section describes how to build an entire application into a Docker image. After building an image, you can use the image to deploy and upgrade the application. This reduces manual configuration and improves efficiency.

NOTE

When building an image, ensure that files used to build the image are stored in the same directory.

Required Cloud Services

SoftWare Repository for Container (SWR) provides easy, secure, and reliable management over container images throughout their lifecycle, facilitating the deployment of containerized services.

Basic Concepts

- Image: A Docker image is a special file system that includes everything needed to run containers: programs, libraries, resources, settings, and so on. It also includes corresponding configuration parameters (such as anonymous volumes, environment variables, and users) required within a container runtime. An image does not contain any dynamic data, and its content remains unchanged after being built.
- Container: Images become containers at runtime, that is, containers are created from images. A container can be created, started, stopped, deleted, or suspended.

Procedure

Step 1 Log in as the **root** user to the device running Docker.

Step 2 Enter the **apptest** directory.

cd apptest

Ensure that files used to build the image are stored in the same directory.

```
root@ecs-aos:~/apptest# ll
total 264456
drwxr-xr-x 5 root root      4096 Jan  2 19:59 ./
drwx------ 6 root root      4096 Jan  2 19:59 ../
drwxr-xr-x 9 root root      4096 Jan  2 19:55 apache-tomcat-7.0.82/
-rw-r--r-- 1 root root   8997403 Jan  2 19:52 apache-tomcat-7.0.82.tar.gz
-rw-r--r-- 1 root root       599 Jan  2 19:59 Dockerfile
drwxr-xr-x 8 uucp  143      4096 Sep  6 10:32 jdk1.8.0_151/
-rw-r--r-- 1 root root 189736377 Jan  2 19:54 jdk-8u151-linux-x64.tar.gz
drwxr-xr-x 3 root root      4096 Jan  2 19:55 mongodb-linux-x86_64-rhel70-3.2.9/
-rw-r--r-- 1 root root  72035914 Jan  2 19:53 mongodb-linux-x86_64-rhel70-3.2.9.tgz
-rw-r--r-- 1 root root       597 Jan  2 19:58 start_tomcat_and_mongo.sh
```

Step 3 Build an image.

docker build -t apptest:v1 .

Step 4 Upload the image to SWR. For details, see **Uploading an Image Through a Container Engine Client**.

----End

2.1.3.8 Creating a Container Workload

This section describes how to deploy a workload on CCE. When using CCE for the first time, create an initial cluster and add a node into the cluster.

NOTE

Containerized workloads are deployed in a similar way. The difference lies in:

- Whether environment variables need to be set.
- Whether cloud storage is used.

Required Cloud Services

- Cloud Container Engine (CCE): a highly reliable and high-performance service that allows enterprises to manage containerized applications. With support for Kubernetes-native applications and tools, CCE makes it simple to set up an environment for running containers in the cloud.
- Elastic Cloud Server (ECS): a scalable and on-demand cloud server. It helps you to efficiently set up reliable, secure, and flexible application environments, ensuring stable service running and improving O&M efficiency.
- Virtual Private Cloud (VPC): an isolated and private virtual network environment that users apply for in the cloud. You can configure the IP address ranges, subnets, and security groups, as well as assign elastic IP addresses and allocate bandwidth in a VPC.

Basic Concepts

- A cluster is a collection of computing resources, including a group of node resources. A container runs on a node. Before creating a containerized application, you must have an available cluster.
- A node is a virtual or physical machine that provides computing resources. You must have sufficient node resources to ensure successful operations such as creating applications.
- A workload indicates a group of container pods running on CCE. CCE supports third-party application hosting and provides the full lifecycle (from deployment to O&M) management for applications. This section describes how to use a container image to create a workload.

Procedure

Step 1 Prepare the environment as described in **Table 2-5**.

Table 2-5 Preparing the environment

No.	Category	Procedure
1	Creating a VPC	Create a VPC before you create a cluster. A VPC provides an isolated, configurable, and manageable virtual network environment for CCE clusters. If you have a VPC already, skip to the next task. 1. Log in to the management console. 2. In the service list, choose **Networking** > **Virtual Private Cloud**. 3. On the **Dashboard** page, click **Create VPC**. 4. Follow the instructions to create a VPC. Retain default settings for parameters unless otherwise specified.
2	Creating a key pair	Create a key pair before you create a containerized application. Key pairs are used for identity authentication during remote login to a node. If you have a key pair already, skip this task. 1. Log in to the management console. 2. In the service list, choose **Data Encryption Workshop** under **Security & Compliance**. 3. In the navigation pane, choose **Key Pair Service**. On the **Private Key Pairs** tab, click **Create Key Pair**. 4. Enter a key pair name, select **I agree to host the private key of the key pair.** and **I have read and agree to the Key Pair Service Disclaimer**, and click **OK**. 5. View and save the private key. For security purposes, a key pair can be downloaded only once. Keep it secure to ensure successful login.

Step 2 Create a cluster and a node.

1. Log in to the CCE console. On the **Clusters** page, click **Buy Cluster** and select the type for the cluster to be created.

   Configure cluster parameters and select the VPC created in **Step 1**. For details, see **Buying a CCE Cluster**.

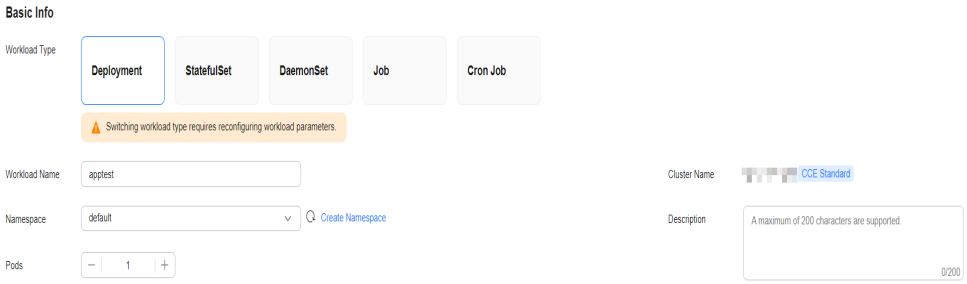
2. Buy a node and select the key pair created in **Step 1** as the login option. For details, see **Creating a Node**.

Step 3 Deploy a workload on CCE.

1. Log in to the CCE console and click the name of the cluster to access the cluster console. In the navigation pane, choose **Workloads** and click **Create Workload**.
2. Configure the following parameters, and retain the default settings for other parameters:
   - **Workload Name**: Set it to **apptest**.

– **Pods**: Set it to **1**.

Figure 2-3 Basic settings



3. In the **Container Settings** area, select the image uploaded in **Building and Uploading an Image**.
4. In the **Container Settings** area, choose **Environment Variables** and add environment variables for interconnecting with the MySQL database. The environment variables are set in the **startup script**.

   NOTE

   In this example, interconnection with the MySQL database is implemented through configuring the environment variables. Determine whether to use environment variables based on your service requirements.

Table 2-6 Configuring environment variables

Variable Name	Variable Value/Variable Reference
MYSQL_DB	Database name.
MYSQL_URL	IP address and port number of the database.
MYSQL_USER	Database username.
MYSQL_PASSWORD	Database user password.

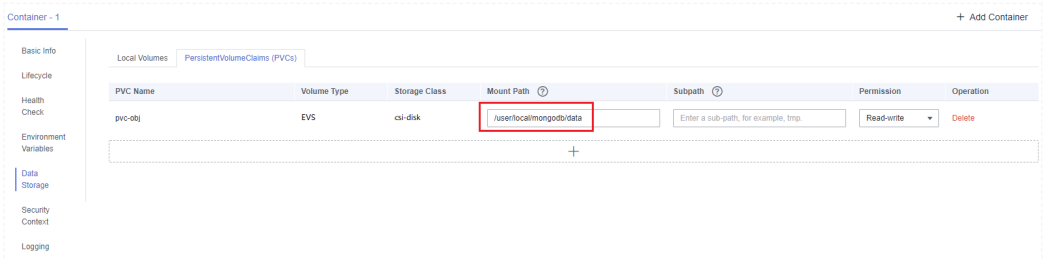
5. In the **Container Settings** area, choose **Data Storage** and configure cloud storage for persistent data storage.

   NOTE

   In this example, the MongoDB database is used and persistent data storage is also needed, so you need to configure cloud storage. Determine whether to use cloud storage based on your service requirements.

   The mounted path must be the same as the MongoDB storage path in the Docker startup script. For details, see the **startup script**. In this example, the path is **/usr/local/mongodb/data**.

Figure 2-4 Configuring cloud storage



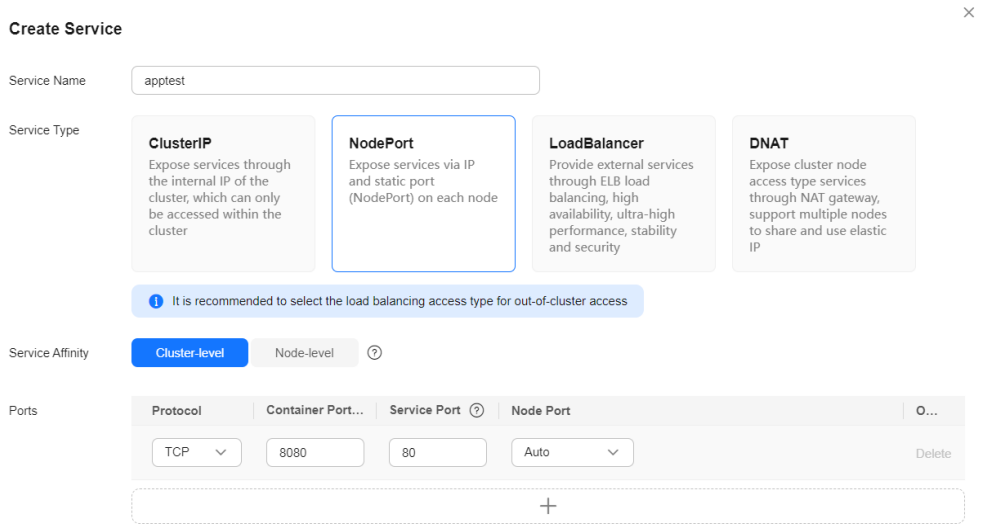
6. In the **Service Settings** area, click + to add a service, configure workload access parameters, and click **OK**.

   NOTE

   In this example, the application will be accessible from public networks by using an elastic IP address.

   - **Service Name**: name of the application that can be accessed externally. In this example, this parameter is set to **apptest**.
   - **Service Type**: Select **NodePort**.
   - **Service Affinity**
     - **Cluster-level**: The IP addresses and access ports of all nodes in a cluster can be used to access the workload associated with the Service. Service access will cause performance loss due to route redirection, and the source IP address of the client cannot be obtained.
     - **Node-level**: Only the IP address and access port of the node where the workload is located can be used to access the workload associated with the Service. Service access will not cause performance loss due to route redirection, and the source IP address of the client can be obtained.
   - **Port**
     - **Protocol**: Set it to **TCP**.
     - **Service Port**: port for accessing the Service.
     - **Container Port**: port that the application will listen on the container. In this example, this parameter is set to **8080**.
     - **Node Port**: Set it to **Auto**. The system automatically opens a real port on all nodes in the current cluster and then maps the port number to the container port.

Figure 2-5 Creating a Service



7. Click **Create Workload**.

   After the workload is created, you can view the running workload in the workload list.

----End

Verifying a Workload

After a workload is created, you can access the workload to check whether the deployment is successful.

In the preceding configuration, the NodePort mode is selected to access the workload by using **IP address:Port number**. If the access is successful, the workload is successfully deployed.

You can obtain the access mode from the **Access Mode** tab on the workload details page.

3 Migration

3.1 Migrating Container Images

3.1.1 Solution Overview

Challenges

Containers are growing in popularity. Many enterprises choose to build their own Kubernetes clusters. However, the O&M workload of on-premises clusters is heavy, and O&M personnel need to configure the management systems and monitoring solutions by themselves. For enterprises, managing a large number of images requires high O&M, labor, and management costs, and the efficiency is low.

SoftWare Repository for Container (SWR) manages container images that function on multiple architectures, such as Linux and Arm. Enterprises can migrate their image repositories to SWR to reduce costs.

This section describes three ways for migrating image repositories to SWR smoothly. You can select one as required.

Migration Solutions

Table 3-1 Comparison of migration solutions and application scenarios

Solution	Application Scenario	Precautions
Migrating Images to SWR Using Docker Commands	Small quantity of images	• Disk storage leads to the timely deletion of local images and time-cost flushing. • Docker daemon strictly restricts the number of concurrent pull/push operations, so high-concurrency synchronization cannot be performed. • Scripts are complex because HTTP APIs are needed to perform the operations that cannot be implemented through Docker CLI.
Migrating Images to SWR Using image-migrator	A large number of images	• Many-to-many image repository synchronization is supported. • Docker Registry V2-based image repositories (such as Docker Hub, Quay, and Harbor) can be migrated to SWR. • Memory- and network-dependent synchronization is fast. • Flushing the Blob information of synchronized images avoids repetition. • The number of concurrent synchronization tasks can be adjusted in the configuration file. • Automatically retrying failed synchronization tasks can resolve most network jitter during image synchronization. • Docker or other programs are not required.

Solution	Application Scenario	Precautions
Synchronizing Images Across Clouds from Harbor to SWR	A customer deploys services in multiple clouds and uses Harbor as their image repository.	Only Harbor v1.10.5 and later versions are supported.

3.1.2 Migrating Images to SWR Using Docker Commands

Scenarios

SWR provides easy-to-use image hosting and efficient distribution services. If small quantity of images need to be migrated, enterprises can use the **docker pull/push** command to migrate images to SWR.

Procedure

Step 1 Pull images from the source repository.

Run the **docker pull** command to pull the images.

Example: **docker pull nginx:latest**

Run the **docker images** command to check whether the images are successfully pulled.

```
# docker images
REPOSITORY                TAG       IMAGE ID       CREATED         SIZE
nginx                     latest    22f2bf2e2b4f   5 hours ago     22.8MB
```

Step 2 Push the images pulled in **Step 1** to SWR.

1. Log in to the VM where the target container is located and log in to SWR. For details, see **Uploading an Image Through a Container Engine Client**.
2. Tag the images.

   docker tag [Image name:Tag name] [Image repository address]/[Organization name]/[Image name:Tag name]

   Example:

   docker tag nginx:v1 swr.ap-southeast-1.myhuaweicloud.com/cloud-develop/nginx:v1
3. Run the following command to push the images to the target image repository.

   docker push [Image repository address]/[Organization name]/[Image name:Tag name]

   Example:

   docker push swr.ap-southeast-1.myhuaweicloud.com/cloud-develop/nginx:v1
4. Check whether the following information is returned. If yes, the push is successful.


```
fbce26647e70: Pushed
fb04ab8effa8: Pushed
8f736d52032f: Pushed
009f1d338b57: Pushed
678bbd796838: Pushed
d1279c519351: Pushed
f68ef921efae: Pushed
v1: digest: sha256:0cdfc7910db531bfa7726de4c19ec556bc9190aad9bd3de93787e8bce3385f8d size:
1780
```

To view the pushed image, refresh the **My Images** page.

----End

3.1.3 Migrating Images to SWR Using image-migrator

To ensure that container images can be properly pulled after cluster migration and improve container deployment efficiency, you are advised to migrate self-built image repositories to Huawei Cloud SoftWare Repository for Container (SWR).

image-migrator is an image migration tool that can automatically migrate images from a Docker registry built on Docker Registry v2 to SWR.

Preparations

Before the migration, prepare a server with kubectl installed for the connection between the source and destination clusters. The server must have at least 5 GB of local disk space and at least 8 GB of memory so that image-migrator can work properly and can store related data, such as data collected from the source cluster and recommendation data of the destination cluster.

image-migrator can run on Linux (x86 and Arm) and Windows.

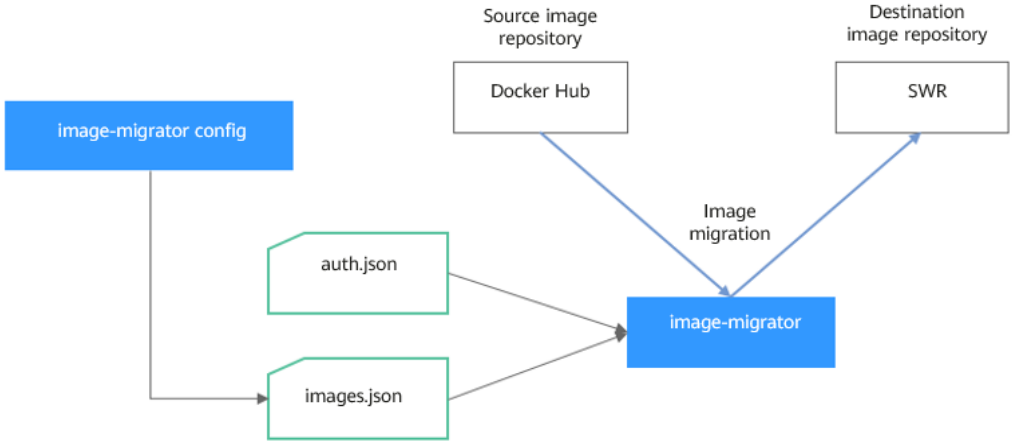
Before using image-migrator in Linux, run the **chmod u+x** *Tool name* command (for example, **chmod u+x image-migrator-linux-amd64**) to grant the execute permission.

Table 3-2 Obtaining the image-migrator package

image-migrator	image-migrator is an image migration tool that can automatically migrate images from a Docker registry built on Docker Registry v2 to SWR, or from a registry on a third-party cloud to SWR.	Linux x86: **https://ucs-migration.obs.cn-north-4.myhuaweicloud.com/toolkits/image-migrator-linux-amd64** Linux Arm: **https://ucs-migration.obs.cn-north-4.myhuaweicloud.com/toolkits/image-migrator-linux-arm64** Windows: **https://ucs-migration.obs.cn-north-4.myhuaweicloud.com/toolkits/image-migrator-windows-amd64.exe**

How image-migrator Works

Figure 3-1 How image-migrator works



When using image-migrator to migrate images to SWR, you need to prepare two files. One is the registry access permission file **auth.json**. The two objects in the file are the accounts and passwords of the source and destination registries. The other is the image list file **images.json**, which consists of multiple image synchronization rules. Each rule contains a source repository (key) and a destination repository (value). Place these two files in the directory where image-migrator is located and run a simple command to migrate the image. The two files are described as follows:

- **auth.json**

  auth.json is the registry access permission file. Each object is the username and password of a registry. Generally, you must have permission to pull images from and access image tags in the source registry and permission to push images to and create repositories in the destination registry. If you access a registry anonymously, you do not need to enter the username and password. Structure of the **auth.json** file:

  ```
  {
     "Source registry address": { },
     "Destination registry address": {
        "username": "xxxxxx",
        "password": "xxxxxx",
        "insecure": true
     }
  }
  ```

  To be more specific:

  – The *Source registry address* and *Destination registry address* can be in the *registry* or *registry/namespace* format matching that in **images.json**. The matched URL in images uses the corresponding username and password for image synchronization. The *registry/namespace* format is preferred.

    If the destination registry address is in the *registry* format, you can obtain it from the SWR console. On the **Dashboard** page, click **Generate Login Command** in the upper right corner. The domain name at the end of the login command is the SWR registry address, for example, **swr.cn-north-4.myhuaweicloud.com**. Note that the address varies depending on the region. Switch to the corresponding region to obtain the address. If

the value is in the *registry/namespace* format, replace *namespace* with the organization name of SWR.

- **username**: (Optional) username. You can set it to a specific value or use a string of the ${env} or $env type to reference an environment variable.
- **password**: (Optional) password. You can set it to a specific value or use a string of the ${env} or $env type to reference an environment variable.
- **insecure**: (Optional) whether *registry* is an HTTP service. If yes, the value of **insecure** is **true**. The default value is **false**.

NOTE

The username of the destination SWR registry is in the following format: *Regional project name*@*AK*. The password is the encrypted login key of the AK and SK. For details, see **Obtaining a Long-Term Valid Login Command**.

Example:

```
{
   "quay.io/coreos": { },
   "swr.cn-north-4.myhuaweicloud.com": {
      "username": "cn-north-4@RVHVMX******",
      "password": "cab4ceab4a1545***************",
      "insecure": true
   }
}
```

- **images.json**

  This file is essentially a list of images to migrate and consists of multiple image synchronization rules. Each rule contains a source repository (key) and a destination repository (value). The specific requirements are as follows:

  a. The largest unit that can be synchronized using one rule is repository. The entire namespace or registry cannot be synchronized using one rule.
  b. The formats of the source and destination repositories are similar to those of the image URL used by the **docker pull/push** command (*registry/namespace/repository:tag*).
  c. Both the source and destination repositories (if the destination registry is not an empty string) contain at least *registry*/*namespace*/*repository*.
  d. The source registry field cannot be empty. To synchronize data from a source registry to multiple destination registries, you need to configure multiple rules.
  e. The destination repository name can be different from the source repository name. In this case, the synchronization function is similar to docker pull + docker tag + docker push.
  f. If the source repository field does not contain tags, all tags of the repository have been synchronized to the destination repository. In this case, the destination repository cannot contain tags.
  g. If the source repository field contains tags, only one tag in the source repository has been synchronized to the destination repository. If the destination repository does not contain tags, the source tag is used by default.
  h. If the destination repository is an empty string, the source image will be synchronized to the default namespace of the default registry. The repository and tag are the same as those of the source repository. The default registry and namespace can be configured using command line parameters and environment variables.

Example:

```
{
    "quay.io/coreos/etcd:1.0.0": "swr.cn-north-4.myhuaweicloud.com/test/etcd:1.0.0",
    "quay.io/coreos/etcd": "swr.cn-north-4.myhuaweicloud.com/test/etcd",
    "quay.io/coreos/etcd:2.7.3": "swr.cn-north-4.myhuaweicloud.com/test/etcd"
}
```

We provide a config subcommand of the image-migrator tool to automatically obtain the image that is being used by the workload in the cluster. For details, see **Usage of image-migrator config**. After obtaining the **images.json** file, you can modify, add, or delete its content as needed.

How to Use image-migrator

NOTE

image-migrator can run on Linux (x86 and Arm) and Windows. The usage is similar in both environments. This section uses the Linux (x86) environment as an example.

If Linux (Arm) or Windows is used, replace **image-migrator-linux-amd64** in the following command with **image-migrator-linux-arm64** or **image-migrator-windows-amd64.exe**.

Run **./image-migrator-linux-amd64 -h** in the directory where image-migrator is located to learn about its usage.

- **--auth**: specifies the path of **auth.json**. By default, **auth.json** is stored in the directory where image-migrator is located.
- **--images**: specifies the path of **images.json**. By default, **images.json** is stored in the directory where image-migrator is located.
- **--log**: specifies the path for storing logs generated by image-migrator. The default value is **image-migrator.log** in the current directory of image-migrator.
- **--namespace**: specifies the default namespace of the destination repository. That is, if the namespace of the destination repository is not specified in **images.json**, you can specify it when running the migration command.
- **--registry**: specifies the default registry of the destination repository. That is, if the registry of the destination repository is not specified in **images.json**, you can specify it when running the migration command.
- **--retries**: specifies the number of retry times when the migration fails. The default value is **3**.
- **--workers**: specifies the number of concurrent workers for image migration. The default value is **7**.

```
$ ./image-migrator-linux-amd64 -h
A Fast and Flexible docker registry image images tool implement by Go.

Usage:
  image-migrator [flags]

Aliases:
  image-migrator, image-migrator

Flags:
      --auth string        auth file path. This flag need to be pair used with --images. (default "./auth.json")
  -h, --help               help for image-migrator
      --images string      images file path. This flag need to be pair used with --auth (default "./images.json")
      --log string         log file path (default "./image-migrator.log")
      --namespace string   default target namespace when target namespace is not given in the images
config file, can also be set with DEFAULT_NAMESPACE environment value
      --registry string    default target registry url when target registry is not given in the images config file,
```



```
can also be set with DEFAULT_REGISTRY environment value
  -r, --retries int        times to retry failed tasks (default 3)
  -w, --workers int        numbers of working goroutines (default 7)

$./image-migrator --workers=5 --auth=./auth.json --images=./images.json --namespace=test \
--registry=swr.cn-north-4.myhuaweicloud.com --retries=2
$ ./image-migrator
Start to generate images tasks, please wait ...
Start to handle images tasks, please wait ...
Images(38) migration finished, 0 images tasks failed, 0 tasks generate failed
```

Example:

./image-migrator --workers=5 --auth=./auth.json --images=./images.json --namespace=test --registry=swr.cn-north-4.myhuaweicloud.com --retries=2

The preceding command is used to migrate images in the **images.json** file to **swr.cn-north-4.myhuaweicloud.com/test**. If the migration fails, you can retry twice. A maximum of five images can be migrated at a time.

Usage of image-migrator config

The config subcommand of image-migrator can be used to obtain images used in cluster applications and generate the **images.json** file in the directory where the tool is located. You can run **./image-migrator-linux-amd64 config -h** to learn how to use the config subcommand.

- **-k, --kubeconfig**: specifies the location of the kubeconfig file of kubectl. The default value is **$HOME/.kube/config**. The kubeconfig file is used to configure access to the Kubernetes cluster. The kubeconfig file contains the authentication credentials and endpoints (access addresses) required for accessing and registering the Kubernetes cluster. For details, see the **Kubernetes documentation**.
- **-n, --namespaces**: specifies the namespace of the image to be obtained. Multiple namespaces are separated by commas (,), for example, ns1,ns2,ns3. The default value is **""**, indicating that images of all namespaces are obtained.
- **-t, --repo**: specifies the destination repository address (*registry*/*namespace*).

```
$ ./image-migrator-linux-amd64 config -h
generate images.json

Usage:
   image-migrator config [flags]

Flags:
   -h, --help               help for config
   -k, --kubeconfig string   The kubeconfig of k8s cluster's. Default is the $HOME/.kube/config. (default "/
root/.kube/config")
   -n, --namespaces string   Specify a namespace for information collection. If multiple namespaces are
specified, separate them with commas (,), such as ns1,ns2. default("") is all namespaces
   -t, --repo string         target repo,such as swr.cn-north-4.myhuaweicloud.com/test
```

Examples:

- Specify a namespace:

  ./image-migrator-linux-amd64 config -n default -t swr.cn-north-4.myhuaweicloud.com/test

- Specify multiple namespaces:

  ./image-migrator-linux-amd64 config -n default,kube-system -t swr.cn-north-4.myhuaweicloud.com/test

- If no namespace is specified, images of all namespaces are obtained:

  ./image-migrator-linux-amd64 config -t swr.cn-north-4.myhuaweicloud.com/test

Procedure

Step 1 Prepare the registry access permission file **auth.json**.

Create an **auth.json** file and modify it based on the format. If the repository is accessed anonymously, you do not need to enter information such as the username and password. Place the file in the directory where image-migrator is located.

Example:

```
{
    "quay.io/coreos": { },
    "swr.cn-north-4.myhuaweicloud.com": {
        "username": "cn-north-4@RVHVMX******",
        "password": "cab4ceab4a1545***************",
        "insecure": true
    }
}
```

For details about the parameters, see the **auth.json file**.

Step 2 Prepare the image list file **images.json**.

1. Connect to the source cluster using kubectl. For details, see **Connecting to a Cluster Using kubectl**.
2. Run the config subcommand for image migration to generate the **images.json** file.

   You can refer to the methods and examples in **Usage of image-migrator config** to obtain the image used in the source cluster application without specifying the namespace, or by specifying one or more namespaces.
3. Modify the **images.json** to make it meet the requirements in **images.json file**.

Step 3 Migrate images.

You can run the default **./image-migrator-linux-amd64** command to migrate images or configure image-migrator parameters as needed.

For example, run the following command:

./image-migrator-linux-amd64 --workers=5 --auth=./auth.json --images=./images.json --namespace=test --registry=swr.cn-north-4.myhuaweicloud.com --retries=2

Example:

```
$ ./image-migrator-linux-amd64
Start to generate images tasks, please wait ...
Start to handle images tasks, please wait ...
Images(38) migration finished, 0 images tasks failed, 0 tasks generate failed
```

Step 4 View the result.

After the preceding command is executed, information similar to the following is displayed:


```
Images(38) migration finished, 0 images tasks failed, 0 tasks generate failed
```

The preceding information indicates that 38 images have been migrated to SWR.

----End

3.1.4 Synchronizing Images Across Clouds from Harbor to SWR

Scenarios

A customer deploys services in multiple clouds and uses Harbor as their image repository. There are two scenarios for synchronizing images from Harbor to SWR:

1. Harbor accesses SWR through a public network. For details, see **Accessing SWR Through a Public Network**.
2. Harbor accesses SWR through a VPC endpoint by using a private line. For details, see **Accessing SWR Through a VPC Endpoint by Using a Private Line**.

Background

Harbor is an open source enterprise-class Docker Registry server developed by VMware. It extends the Docker Distribution by adding the functionalities such as role-based access control (RBAC), image scanning, and image replication. Harbor has been widely used to store and distribute container images.

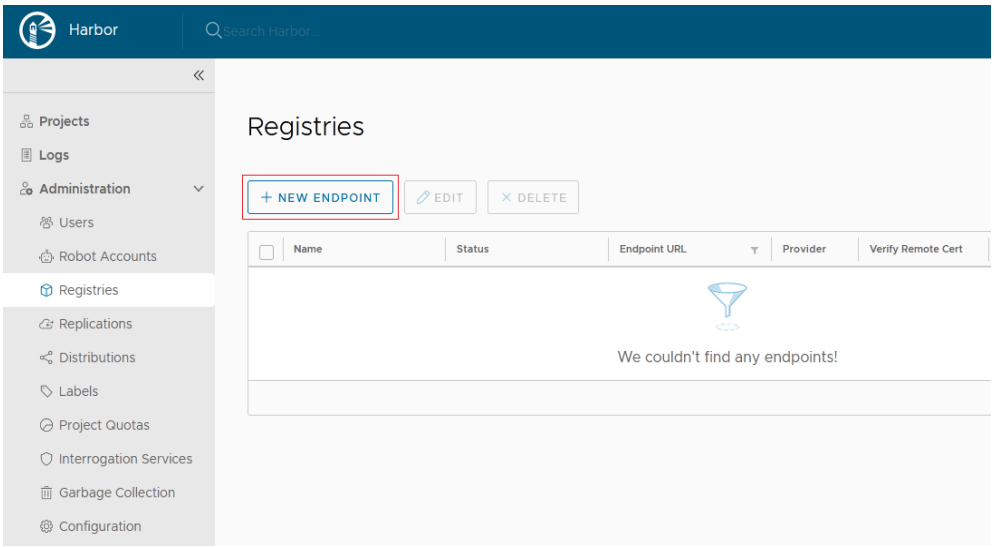
Accessing SWR Through a Public Network

Step 1 Configure a registry endpoint on Harbor.

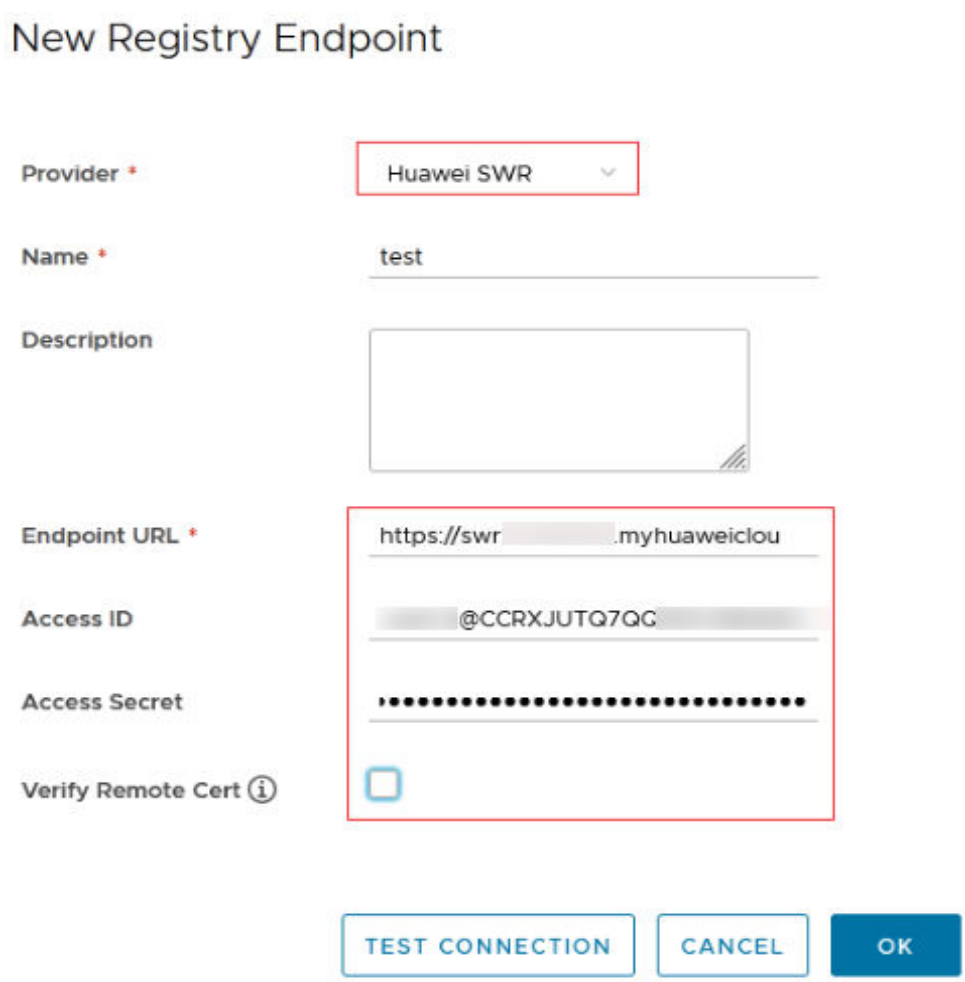
NOTE

Huawei Cloud SWR has integrated with Harbor 1.10.5 and later versions. You only need to set **Provider** to **Huawei SWR** when configuring your endpoint. This document uses Harbor 2.4.1 as an example.

1. Add an endpoint.



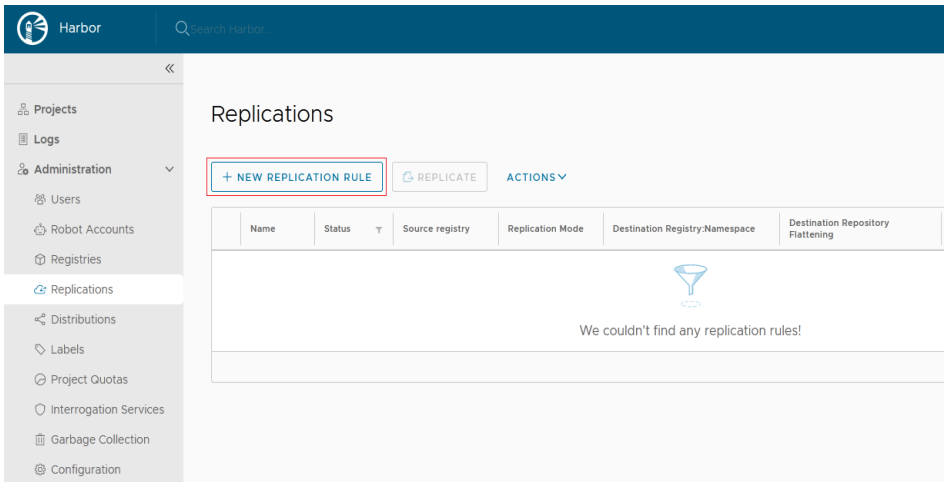
2. Configure the following parameters.



- **Provider**: Select **Huawei SWR**.
- **Name**: Enter a customized name.
- **Endpoint URL**: Enter the public network domain name of SWR in the format of **https://{*SWR image repository address*}**. To obtain the image repository address, log in to the SWR console, choose **My Images**, and click **Upload Through Client**. You can view the image repository address of the current region on the page that is displayed.
- **Access ID**: Enter an access ID in the format of **Regional project name@[AK]**.
- **Access Secret**: Enter an AK/SK. To obtain an AK/SK, see **Obtaining a Long-Term Valid Login Command**.
- **Verify Remote Cert**: **Deselect** the option (recommended).

Step 2 Configure a replication rule.

1. Create a replication rule.

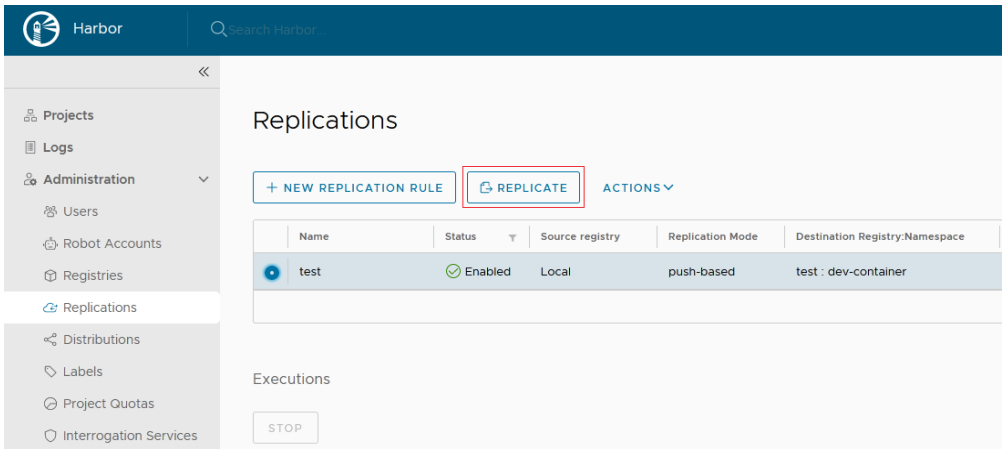


2. Configure the following parameters.
   - **Name**: Enter a customized name.
   - **Replication mode**: Select **Push-based**, indicating that images are pushed from the local Harbor to the remote repository.
   - **Source resource filter**: Filters images on Harbor based on the configured rules.
   - **Destination registry**: Select the endpoint created in **Step 1**.
   - **Destination**

     Namespace: Enter the organization name on SWR.

     Flattening: Select **Flatten All Levels**, indicating that the hierarchy of the registry is reduced when replicating images. If the directory of Harbor registry is **library/nginx** and the directory of the endpoint namespace is **dev-container**, after you flatten all levels, the directory of the endpoint namespace is **library/nginx -> dev-container/nginx**.
   - **Trigger Mode**: Select **Manual**.
   - **Bandwidth**: Set the maximum network bandwidth when executing the replication rule. The value **–1** indicates no limitation.

Step 3 After creating the replication rule, select it and click **REPLICATE** to complete the replication.



----End

Accessing SWR Through a VPC Endpoint by Using a Private Line

Step 1 Configure a VPC endpoint.

Step 2 Obtain the private network IP address and domain name of the VPC. (By default, the domain name resolution rule is automatically added to Huawei Cloud VPCs, so you only need to configure hosts for non-Huawei Cloud endpoints.) You can query the IP address and domain name in **Private Domain Name** on the VPC endpoint details page.

Step 3 Configure a registry endpoint on Harbor.

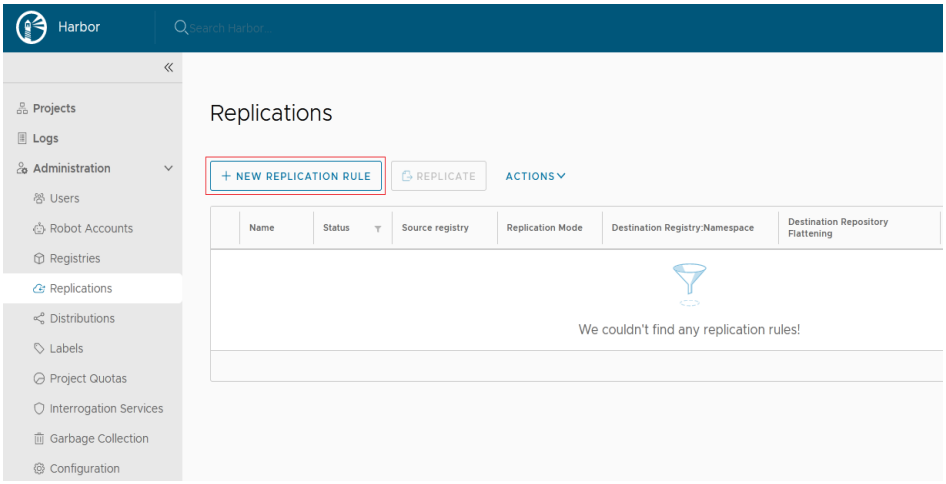
NOTE

Huawei Cloud SWR has integrated with Harbor 1.10.5 and later versions. You only need to set **Provider** to **Huawei SWR** when configuring your endpoint. This document uses Harbor 2.4.1 as an example.

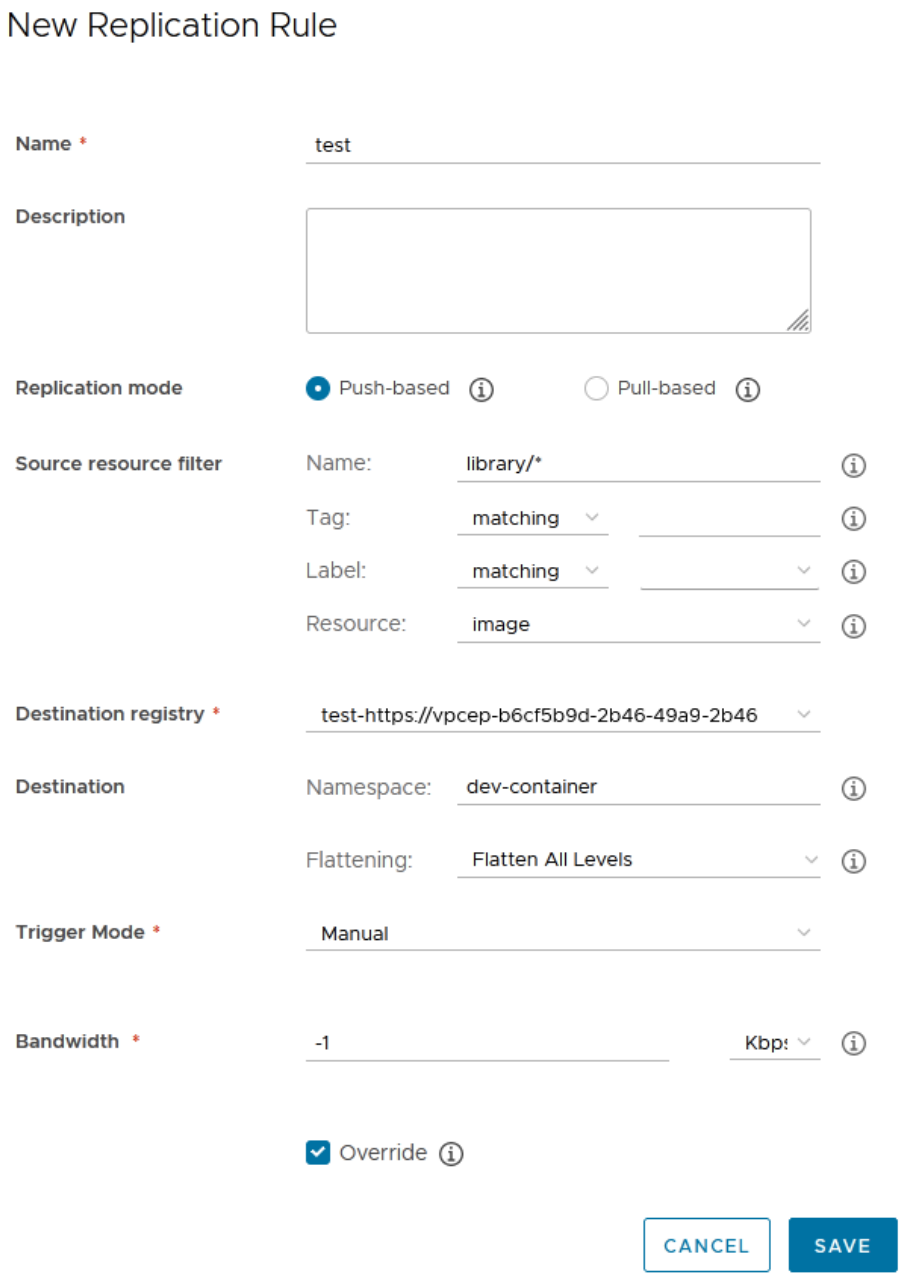
1. Add an endpoint.
2. Configure the following parameters.
   - **Provider**: Select **Huawei SWR**.
   - **Name**: Enter a customized name.
   - **Endpoint URL**: Enter **the private network domain name of the VPC endpoint**, which must start with **https**. In addition, the domain name mapping must be configured in the container where Harbor is located.
   - **Access ID**: Enter an access ID in the format of **Regional project name@[AK]**.
   - **Access Secret**: Enter an AK/SK. To obtain an AK/SK, see **Obtaining a Long-Term Valid Login Command**.
   - **Verify Remote Cert**: **Deselect** the option.

Step 4 Configure a replication rule.

1. Create a replication rule.



2. Configure the following parameters.



- **Name**: Enter a customized name.
- **Replication mode**: Select **Push-based**, indicating that images are pushed from the local Harbor to the remote repository.
- **Source resource filter**: Filters images on Harbor based on the configured rules.
- **Destination registry**: Select the endpoint created in **Step 3**.
- **Destination**

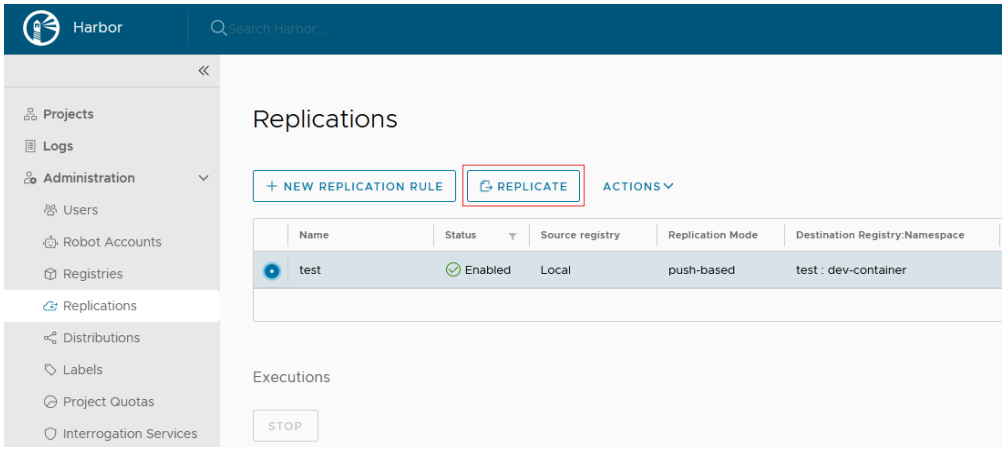
  Namespace: Enter the organization name on SWR.

  Flattening: Select **Flatten All Levels**, indicating that the hierarchy of the registry is reduced when replicating images. If the directory of Harbor registry is **library/nginx** and the directory of the endpoint namespace is

dev-container, after you flatten all levels, the directory of the endpoint namespace is **library/nginx -> dev-container/nginx**.

- **Trigger Mode**: Select **Manual**.
- **Bandwidth**: Set the maximum network bandwidth when executing the replication rule. The value **–1** indicates no limitation.

Step 5 After creating the replication rule, select it and click **REPLICATE** to complete the replication.



----End

3.2 Migrating Kubernetes Clusters to CCE

3.2.1 Solution Overview

Application Scenarios

Containers are growing in popularity and Kubernetes simplifies containerized deployment. Many companies choose to build their own Kubernetes clusters. However, the O&M workload of on-premises clusters is heavy, and O&M personnel need to configure the management systems and monitoring solutions by themselves. This increases the labor costs while decreasing the efficiency.

In terms of performance, an on-premises cluster has poor scalability due to its fixed specifications. Auto scaling cannot be implemented in case of traffic surges, which may easily result in the insufficient or waste of cluster resources. In addition, disaster recovery risks are not considered for deploying an on-premises cluster, leading to poor reliability. Once a fault occurs, the entire cluster may fail, resulting in serious production incidents.

Now you can address the preceding challenges by using CCE, a service that allows easy cluster management and flexible scaling, integrated with application service mesh and Helm charts to simplify cluster O&M and reduce operations costs. CCE is easy to use and delivers high performance, security, reliability, openness, and compatibility. This section describes the solution and procedure for migrating on-premises clusters to CCE.

Precautions

Compared with on-premises Kubernetes clusters, CCE clusters have multiple advantages. For details, see **Product Advantages**. There are some restrictions when using CCE clusters. For details, see **Notes and Constraints**. Evaluate the restrictions before using CCE clusters.

Migration Solution

This section describes a cluster migration solution, which applies to the following types of clusters:

- Kubernetes clusters built in local IDCs
- On-premises clusters built using multiple ECSs
- Cluster services provided by other cloud service providers
- CCE clusters that are no longer maintained and cannot be upgraded in place

Before the migration, analyze all resources in the source clusters and then determine the migration solution. Resources that can be migrated include resources inside and outside the clusters, as listed in the following table.

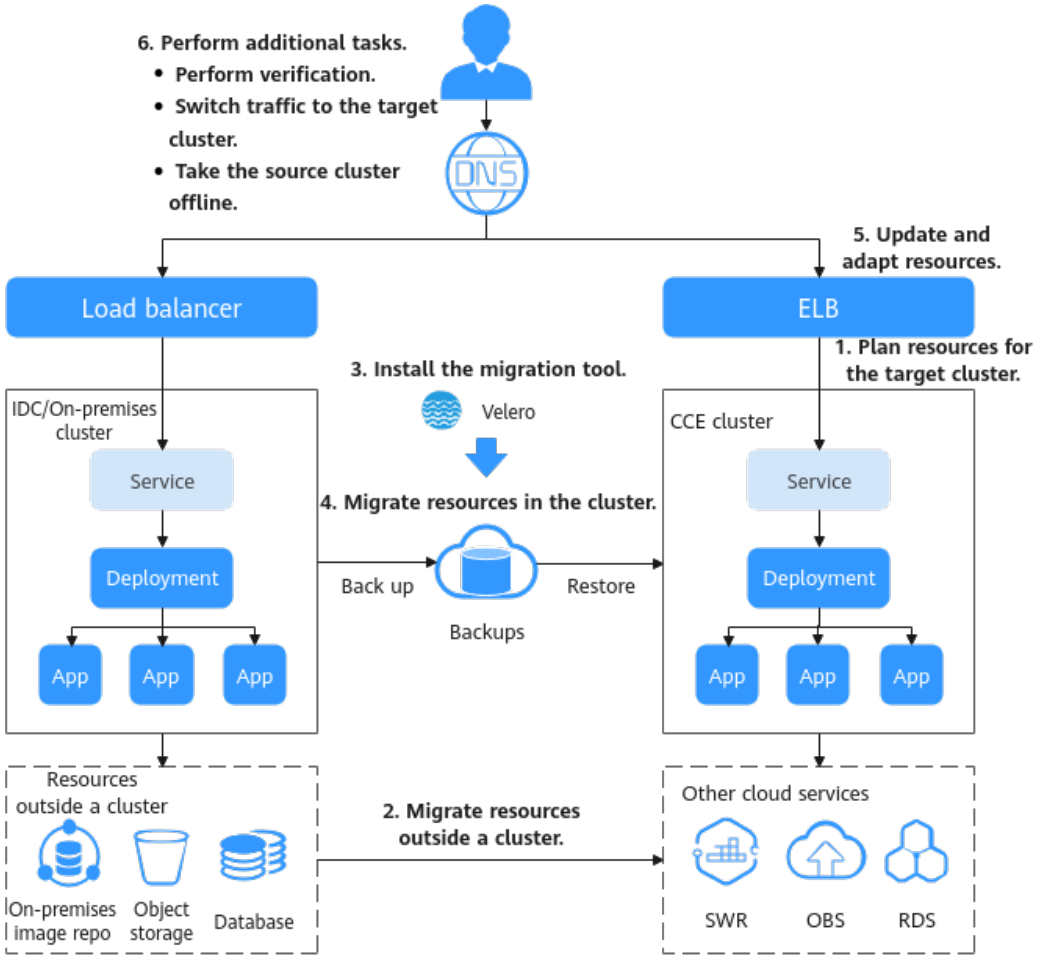
Table 3-3 Resources that can be migrated

Category	Migration Object	Remarks
Resources inside a cluster	All objects in a cluster, including pods, jobs, Services, Deployments, and ConfigMaps.	You are not advised to migrate the resources in the **velero** and **kube-system** namespaces. • **velero**: Resources in this namespace are created by the migration tool and do not need to be migrated. • **kube-system**: Resources in this namespace are system resources. If this namespace of the source cluster contains resources created by users, migrate the resources on demand. **CAUTION** If you are migrating or backing up cluster resources in CCE, for example, from a namespace to another, do not back up Secret **paas.elb**. It is because secret **paas.elb** is periodically updated. After the backup is complete, the secret may become invalid when it is restored. As a result, network storage functions are affected.

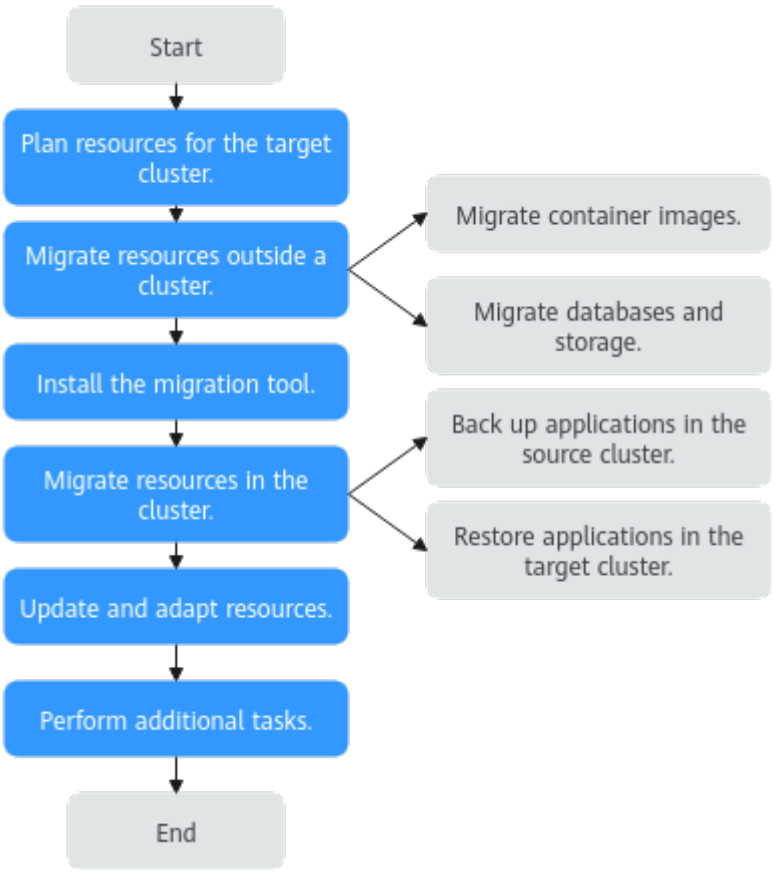
Category	Migration Object	Remarks
	PersistentVolumes (PVs) mounted to containers	Due to restrictions of the Restic tool, migration is not supported for the hostPath storage volume. For details about how to solve the problem, see **Storage Volumes of the HostPath Type Cannot Be Backed Up**.
Resources outside a cluster	On-premises image repository	Resources can be migrated to SoftWare Repository for Container (SWR).
	Non-containerized database	Resources can be migrated to Relational Database Service (RDS).
	Non-local storage, such as object storage	Resources can be migrated to Object Storage Service (OBS).

Figure 3-2 shows the migration process. You can migrate resources outside a cluster as required.

Figure 3-2 Migration solution diagram



Migration Process



The cluster migration process is as follows:

Step 1 Plan resources for the target cluster.

For details about the differences between CCE clusters and on-premises clusters, see **Key Performance Parameter** in **Planning Resources for the Target Cluster**. Plan resources as required and ensure that the performance configuration of the target cluster is the same as that of the source cluster.

Step 2 Migrate resources outside a cluster.

To migrate resources outside the cluster, see **Migrating Resources Outside a Cluster**.

Step 3 Install the migration tool.

After resources outside a cluster are migrated, you can use a migration tool to back up and restore application configurations in the source and target clusters. For details about how to install the tool, see **Installing the Migration Tool**.

Step 4 Migrate resources in the cluster.

Use Velero to back up resources in the source cluster to OBS and restore the resources in the target cluster. For details, see **Migrating Resources in a Cluster (Velero)**.

- **Backing Up Applications in the Source Cluster**

To back up resources, use the Velero tool to create a backup object in the original cluster, query and back up cluster data and resources, package the data, and upload the package to the object storage that is compatible with the S3 protocol. Cluster resources are stored in the JSON format.

- **Restoring Applications in the Target Cluster**

  During restoration in the target cluster, Velero specifies the temporary object bucket that stores the backup data, downloads the backup data to the new cluster, and redeploys resources based on the JSON file.

Step 5 Update resources accordingly.

After the migration, cluster resources may fail to be deployed. Update the faulty resources. The possible adaptation problems are as follows:

- **Updating Images**
- **Updating Services**
- **Updating the Storage Class**
- **Updating Databases**

Step 6 Perform additional tasks.

After cluster resources are properly deployed, verify application functions after the migration and switch service traffic to the target cluster. After confirming that all services are running properly, bring the source cluster offline.

----End

3.2.2 Planning Resources for the Target Cluster

CCE allows you to customize cluster resources to meet various service requirements. **Table 3-4** lists the key performance parameters of a cluster and provides the planned values. You can set the parameters based on your service requirements. It is recommended that the performance configuration be the same as that of the source cluster.

NOTICE

After a cluster is created, the resource parameters marked with asterisks (*) in **Table 3-4** cannot be modified.

Table 3-4 CCE cluster planning

Resource	Key Performance Parameter	Description	Example Value
Cluster	*Cluster Type	• **CCE cluster**: supports VM nodes. You can run your containers in a secure and stable container runtime environment based on a high-performance network model. • **CCE Turbo cluster**: runs on a cloud native infrastructure that features software-hardware synergy to support passthrough networking, high security and reliability, and intelligent scheduling, and BMS nodes.	CCE cluster
	*Network Model	• **VPC network**: The container network uses VPC routing to integrate with the underlying network. This network model is applicable to performance-intensive scenarios. The maximum number of nodes allowed in a cluster depends on the route quota in a VPC network. • **Tunnel network**: The container network is an overlay tunnel network on top of a VPC network and uses the VXLAN technology. This network model is applicable when there is no high requirements on performance. • **Cloud Native Network 2.0**: The container network deeply integrates the elastic network interface (ENI) capability of VPC, uses the VPC CIDR block to allocate container addresses, and supports passthrough networking to containers through a load balancer.	VPC network
	*Number of master nodes	• **3**: Three master nodes will be created to deliver better DR performance. If one master node is faulty, the cluster can still be available without affecting service functions. • **1**: A single master node will be created. This mode is not recommended in commercial scenarios.	3

Resource	Key Performance Parameter	Description	Example Value
Node	OS	• EulerOS • CentOS • Ubuntu	EulerOS

Resource	Key Performance Parameter	Description	Example Value
	Node Specifications (vary depending on the actual region)	• **General-purpose**: provides a balance of computing, memory, and network resources. It is a good choice for many applications. General purpose nodes can be used for web servers, workload development, workload testing, and small-scale databases. • **Memory-optimized**: provides higher memory capacity than general-purpose nodes and is suitable for relational databases, NoSQL, and other workloads that are both memory-intensive and data-intensive. • **General computing-basic**: provides a balance of computing, memory, and network resources and uses the vCPU credit mechanism to ensure baseline computing performance. Nodes of this type are suitable for applications requiring burstable high performance, such as light-load web servers, enterprise R&D and testing environments, and low- and medium-performance databases. • **GPU-accelerated**: provides powerful floating-point computing and is suitable for real-time, highly concurrent massive computing. Graphical processing units (GPUs) of P series are suitable for deep learning, scientific computing, and CAE. GPUs of G series are suitable for 3D animation rendering and CAD. GPU-accelerated nodes can be added only to clusters of v1.11 or later. • **High-performance computing**: provides stable and ultra-high computing performance and is suitable for scientific computing and workloads that demand ultra-high computing power and throughput. • **General computing-plus**: provides stable performance and exclusive resources to enterprise-class workloads with high and stable computing performance.	General-purpose (node specifications: 4 vCPUs and 8 GiB memory)

Resource	Key Performance Parameter	Description	Example Value
		• **Disk-intensive**: supports local disk storage and provides high networking performance. It is designed for workloads requiring high throughput and data switching, such as big data workloads. • **Ultra-high I/O**: delivers ultra-low SSD access latency and ultra-high IOPS performance. This type of specifications is ideal for high-performance relational databases, NoSQL databases (such as Cassandra and MongoDB), and Elasticsearch. • **Ascend-accelerated**: Ascend-accelerated nodes powered by HiSilicon Ascend 310 AI processors are applicable to scenarios such as image recognition, video processing, inference computing, and machine learning.	
	System Disk	• **High I/O**: The backend storage media is SAS disks. • **Ultra-high I/O**: The backend storage media is SSD disks.	High I/O

Resource	Key Performance Parameter	Description	Example Value
	Storage Type	• **EVS volumes**: Mount an EVS volume to a container path. When containers are migrated, the attached EVS volumes are migrated accordingly. This storage mode is suitable for data that needs to be permanently stored. • **SFS volumes**: Create SFS volumes and mount them to a container path. The file system volumes created by the underlying SFS service can also be used. SFS volumes are applicable to persistent storage for frequent read/write in multiple workload scenarios, including media processing, content management, big data analysis, and workload analysis. • **OBS volumes**: Create OBS volumes and mount them to a container path. OBS volumes are applicable to scenarios such as cloud workload, data analysis, content analysis, and hotspot objects. • **SFS Turbo volumes**: Create SFS Turbo volumes and mount them to a container path. SFS Turbo volumes are fast, on-demand, and scalable, which makes them suitable for DevOps, containerized microservices, and enterprise office applications.	EVS volumes

3.2.3 Procedure

3.2.3.1 Migrating Resources Outside a Cluster

If your migration does not involve resources outside a cluster listed in **Table 3-3** or you do not need to use other services to update resources after the migration, skip this section.

Migrating Container Images

To ensure that container images can be properly pulled after cluster migration and improve container deployment efficiency, you are advised to migrate private images to SoftWare Repository for Container (SWR). CCE works with SWR to provide a pipeline for automated container delivery. Images are pulled in parallel, which greatly improves container delivery efficiency.

Manually migrate container images.

Step 1 Remotely log in to any node in the source cluster and run the **docker pull** command to pull all images to the local host.

Step 2 Log in to the SWR console, click **Login Command** in the upper right corner of the page, and copy the command.

Step 3 Run the copied login command on the node.

The message "Login Succeeded" will be displayed upon a successful login.

Step 4 Add tags to all local images.

```
docker tag [Image name 1:tag 1] [Image repository address]/[Organization name]/[Image name 2:tag 2]
```

- *[Image name 1:tag 1]*: name and tag of the local image to be pulled.
- *[Image repository address]*: You can obtain the image repository address on the SWR console.
- *[Organization name]*: Enter the name of the organization you created on the SWR console.
- *{Image name 2:Tag 2}*: image name and tag displayed on the SWR console.

The following is an example:

```
docker tag nginx:v1 swr.ap-southeast-1.myhuaweicloud.com/cloud-develop/mynginx:v1
```

Step 5 Run the **docker push** command to upload all local container image files to SWR.

```
docker push [Image repository address]/[Organization name]/[Image name 2:tag 2]
```

The following is an example:

```
docker push swr.ap-southeast-1.myhuaweicloud.com/cloud-develop/mynginx:v1
```

----End

Migrating Databases and Storage (On-Demand)

You can determine whether to use **Relational Database Service (RDS)** and **Object Storage Service (OBS)** based on your production requirements. After the migration is complete, reconfigure the database and storage for applications in the target CCE cluster.

Database migration

If your database is deployed without using containers and needs to be migrated to the cloud, **Data Replication Service (DRS)** can help you do this. DRS provides multiple capabilities, including online migration, backup migration, real-time disaster recovery, data synchronization, and data subscription. Contact O&M or development personnel to migrate the database. For details, see **Migrating Databases Across Cloud Platforms**. After the migration is complete, interconnect with the database by following the procedure described in **Updating Databases**.

Storage migration

If your cluster has connected to an object storage service and needs to be migrated to the cloud, **Object Storage Migration Service (OMS)** can help you migrate data to OBS. Other storage classes are not supported by official tools.

Contact O&M or development personnel to migrate object storage data. For details, see **Creating a Migration Task**. After the migration is complete, attach

the object storage to the application by referring to **Using an Existing OBS Bucket Through a Static PV**.

NOTE

Currently, you can use OMS to migrate object storage data from AWS China, Alibaba Cloud, Microsoft Azure, Baidu Cloud, Kingsoft Cloud, Ucloud, QingCloud, Qiniu Cloud, and Tencent Cloud to Huawei Cloud **OBS**.

3.2.3.2 Installing the Migration Tool

Velero is an open-source backup and migration tool for Kubernetes clusters. With Restic's PV data backup capability integrated into it, Velero can back up Kubernetes resource objects (such as Deployments, jobs, Services, and ConfigMaps) in source clusters and data in PVs mounted to pods and uploaded them to object storage. When a disaster occurs or migration is required, a target cluster can obtain the corresponding backup data from the object storage using Velero and restore cluster resources as required.

According to **Migration Solution**, prepare temporary object storage to store backup files before the migration. Velero supports OBS or **MinIO** as the object storage. The object storage requires sufficient storage space for storing backup files. You can estimate the storage space based on your cluster scale and data volume. OBS buckets are recommended for data backup. For details about how to deploy Velero, see **Installing Velero**.

Prerequisites

- The Kubernetes version of the source on-premises cluster must be 1.10 or later, and the cluster can use DNS and Internet services properly.
- If you use OBS to store backup files, obtain the AK/SK of a user who has the right to operate OBS. For details, see **Obtaining Access Keys (AK/SK)**.
- If you use MinIO to store backup files, bind an EIP to the server where MinIO is installed and enable the API and console port of MinIO in the security group.
- The target CCE cluster has been created.
- The source cluster and target cluster must each have at least one idle node. It is recommended that the node specifications be 4 vCPUs and 8 GiB memory or higher.

(Optional) Installing MinIO

MinIO is an open-source, high-performance object storage tool compatible with the S3 API protocol. If MinIO is used to store backup files for cluster migration, you need a temporary server to deploy MinIO and provide services for external systems. If you use OBS to store backup files, skip this section and go to **Installing Velero**.

MinIO can be installed in any of the following locations:

- Temporary ECS outside the cluster

  If the MinIO server is installed outside the cluster, backup files will not be affected when a catastrophic fault occurs in the cluster.

- Idle nodes in the cluster

  You can remotely log in to a node and install MinIO or install the containerized MinIO. For details, see **Velero official document**.

  NOTICE

  For example, to install MinIO in a container, run the following command:

  - The storage type in the YAML file provided by Velero is **emptyDir**. You are advised to change the storage type to **HostPath** or **Local**. Otherwise, backup files will be permanently lost after the container is restarted.
  - Ensure that the MinIO service is accessible externally. Otherwise, backup files cannot be downloaded outside the cluster. You can change the Service type to NodePort or use other types of public network access Services.

Regardless of which deployment method is used, the server where MinIO is installed must have sufficient storage space, an EIP must be bound to the server, and the MinIO service port must be enabled in the security group. Otherwise, backup files cannot be uploaded or downloaded.

In this example, MinIO is installed on a temporary ECS outside the cluster.

Step 1 Download MinIO.

```
mkdir /opt/minio
mkdir /opt/miniodata
cd /opt/minio
wget https://dl.minio.io/server/minio/release/linux-amd64/minio
chmod +x minio
```

Step 2 Set the username and password of MinIO.

The username and password configured using this method are temporary environment variables and must be reset after the service is restarted. Otherwise, the default root credential **minioadmin:minioadmin** will be used to create the service.

```
export MINIO_ROOT_USER=minio
export MINIO_ROOT_PASSWORD=minio123
```

Step 3 Create a service. In the command, **/opt/miniodata/** indicates the local disk path for MinIO to store data.

The default API port of MinIO is 9000, and the console port is randomly generated. You can use the **--console-address** parameter to specify a console port.

```
./minio server /opt/miniodata/ --console-address ":30840" &
```

NOTE

Enable the API and console ports in the firewall and security group on the server where MinIO is to be installed. Otherwise, access to the object bucket will fail.

Step 4 Use a browser to access http://{*EIP of the node where MinIO resides*}:30840. The MinIO console page is displayed.

----End

Installing Velero

Go to the OBS console or MinIO console and create a bucket named **velero** to store backup files. You can custom the bucket name, which must be used when

installing Velero. Otherwise, the bucket cannot be accessed and the backup fails. For details, see **Step 5**.

NOTICE

- Velero instances need to be installed and deployed in both the **source and target clusters**. The installation procedures are the same, which are used for backup and restoration, respectively.
- The master node of a CCE cluster does not provide a port for remote login. You can install Velero using kubectl.
- If there are a large number of resources to back up, you are advised to adjust the CPU and memory resources of Velero and node-agent to 1 vCPU and 1 GiB memory or higher. For details, see **Backup Tool Resources Are Insufficient**.
- The object storage bucket for storing backup files must be **empty**.

Download the latest, stable binary file from **https://github.com/vmware-tanzu/velero/releases**. This section uses Velero 1.13.1 as an example. The installation process in the source cluster is the same as that in the target cluster.

Step 1 Log in to a VM that can access the public network and use kubectl to access the cluster where Velero is to be installed.

Step 2 Download the binary file of Velero 1.13.1.

```
wget https://github.com/vmware-tanzu/velero/releases/download/v1.13.1/velero-v1.13.1-linux-amd64.tar.gz
```

Step 3 Install the Velero client.

```
tar -xvf velero-v1.13.1-linux-amd64.tar.gz
cp ./velero-v1.13.1-linux-amd64/velero /usr/local/bin
```

Step 4 Create the access key file **credentials-velero** for the backup object storage.

```
vim credentials-velero
```

Replace the AK/SK in the file based on the site requirements. When you use OBS, you can obtain the AK/SK by referring to **Obtaining Access Keys (AK/SK)**. If MinIO is used, the AK/SK are the username and password created in **Step 2**.

```
[default]
aws_access_key_id = {AK}
aws_secret_access_key = {SK}
```

Step 5 Deploy the Velero server. Change the value of **--bucket** to the name of the created object storage bucket. In this example, the bucket name is **velero**. For more information about custom installation parameters, see **Customize Velero Install**.

```
velero install \
  --provider aws \
  --plugins velero/velero-plugin-for-aws:v1.9.1 \
  --bucket velero \
  --secret-file ./credentials-velero \
  --use-node-agent \
  --use-volume-snapshots=false \
  --backup-location-config region=ap-southeast-1,s3ForcePathStyle="true",s3Url=http://obs.ap-southeast-1.myhuaweicloud.com
```


Table 3-5 Installation parameters of Velero

Parameter	Description
--provider	AWS S3 component to be used
--plugins	API component compatible with AWS S3. Both OBS and MinIO support the S3 protocol.
--bucket	Name of the object storage bucket for storing backup files. The bucket must be created in advance.
--secret-file	Secret file for accessing the object storage, that is, the **credentials-velero** file created in **Step 4**.
--use-node-agent	Whether to enable PV data backup. You are advised to enable this function. Otherwise, storage volume resources cannot be backed up.
--use-volume-snapshots	Whether to create the VolumeSnapshotLocation object for PV snapshot, which requires support from the snapshot program. Set this parameter to **false**.
--backup-location-config	OBS bucket configurations, including region, s3ForcePathStyle, and s3Url.
region	Region to which object storage bucket belongs. • If OBS is used, set this parameter according to your region, for example, **ap-southeast-1**. • If MinIO is used, set this parameter to **minio**.
s3ForcePathStyle	The value **true** indicates that the S3 file path format is used.
s3Url	API access address of the object storage bucket. • If OBS is used, set this parameter to **http://obs.*{region}*.myhuaweicloud.com** (*region* indicates the region where the object storage bucket is located). For example, if the region is Hong Kong (ap-southeast-1), the value is **http://obs.ap-southeast-1.myhuaweicloud.com**. • If MinIO is used, set this parameter to **http://*{EIP of the node where minio is located}*:9000**. The value of this parameter is determined based on the IP address and port of the node where MinIO is installed. **NOTE** – The access port in s3Url must be set to the API port of MinIO instead of the console port. The default API port of MinIO is 9000. – To access MinIO installed outside the cluster, enter the public IP address of MinIO.

Step 6 By default, a namespace named **velero** is created for the Velero instance. Run the following command to view the pod status:


```
$ kubectl get pod -n velero
NAME                    READY   STATUS    RESTARTS   AGE
node-agent-rn29c        1/1     Running   0          16s
velero-c9ddd56-tkzpk    1/1     Running   0          16s
```

NOTE

To prevent memory insufficiency during backup in the actual production environment, you are advised to change the CPU and memory allocated to node-agent and Velero by referring to **Backup Tool Resources Are Insufficient**.

Step 7 Check the interconnection between Velero and the object storage and ensure that the status is **Available**.

```
$ velero backup-location get
NAME      PROVIDER   BUCKET/PREFIX   PHASE       LAST VALIDATED                  ACCESS MODE   DEFAULT
default   aws        velero          Available   2021-10-22 15:21:12 +0800 CST   ReadWrite     true
```

----End

3.2.3.3 Migrating Resources in a Cluster (Velero)

Application Scenarios

WordPress is used as an example to describe how to migrate an application from an on-premises Kubernetes cluster to a CCE cluster. The WordPress application consists of the WordPress and MySQL components, which are containerized. The two components are bound to two local storage volumes of the Local type respectively and provide external access through the NodePort Service.

Before the migration, use a browser to access the WordPress site, create a site named **Migrate to CCE**, and publish an article to verify the integrity of PV data after the migration. The article published in WordPress will be stored in the **wp_posts** table of the MySQL database. If the migration is successful, all contents in the database will be migrated to the new cluster. You can verify the PV data migration based on the migration result.

Prerequisites

- Before the migration, clear the abnormal pod resources in the source cluster. If the pod is in the abnormal state and has a PVC mounted, the PVC is in the pending state after the cluster is migrated.
- Ensure that the cluster on the CCE side does not have the same resources as the cluster to be migrated because Velero does not restore the same resources by default.
- To ensure that container images can be properly pulled after cluster migration, migrate the images to SWR.
- CCE does not support EVS disks of the **ReadWriteMany** type. If resources of this type exist in the source cluster, change the storage type to **ReadWriteOnce**.
- Velero cannot back up or restore HostPath volumes. For details, see **Limitations**. To back up storage volumes of this type, replace the hostPath volumes with local volumes by referring to**Storage Volumes of the HostPath Type Cannot Be Backed Up**. If a backup task involves storage of the HostPath type, the storage volumes of this type will be automatically skipped and a warning message will be generated. This will not cause a backup failure.

Backing Up Applications in the Source Cluster

Step 1 (Optional) To back up the data of a specified storage volume in the pod, add an annotation to the pod. The annotation template is as follows:

```
kubectl -n <namespace> annotate <pod/pod_name> backup.velero.io/backup-volumes=<volume_name_1>,<volume_name_2>,...
```

- **<namespace>**: namespace where the pod is located.
- **<pod_name>**: pod name.
- **<volume_name>**: name of the persistent volume mounted to the pod. You can run the **describe** statement to query the pod information. The **Volume** field indicates the names of all persistent volumes attached to the pod.

Add annotations to the pods of WordPress and MySQL. The pod names are **wordpress-758fbf6fc7-s7fsr** and **mysql-5ffdfbc498-c45lh**. As the pods are in the default namespace **default**, the **-n <NAMESPACE>** parameter can be omitted.

```
kubectl annotate pod/wordpress-758fbf6fc7-s7fsr backup.velero.io/backup-volumes=wp-storage
kubectl annotate pod/mysql-5ffdfbc498-c45lh backup.velero.io/backup-volumes=mysql-storage
```

Step 2 Back up the application. During the backup, you can specify resources based on parameters. If no parameter is added, the entire cluster resources are backed up by default. For details about the parameters, see **Resource filtering**.

- **--default-volumes-to-fs-backup**: indicates that the PV backup tool is used to back up all storage volumes attached to a pod. HostPath volumes are not supported. If this parameter is not specified, the storage volume specified by annotation in **Step 1** is backed up by default. This parameter is available only when **--use-node-agent** is specified during **Velero installation**.
  ```
  velero backup create <backup-name> --default-volumes-to-fs-backup
  ```
- **--include-namespaces**: backs up resources in a specified namespace.
  ```
  velero backup create <backup-name> --include-namespaces <namespace>
  ```
- **--include-resources**: backs up the specified resources.
  ```
  velero backup create <backup-name> --include-resources deployments
  ```
- **--selector**: backs up resources that match the selector.
  ```
  velero backup create <backup-name> --selector <key>=<value>
  ```

In this section, resources in the namespace **default** are backed up. **wordpress-backup** is the backup name. Specify the same backup name when restoring applications. An example is as follows:

```
velero backup create wordpress-backup --include-namespaces default --default-volumes-to-fs-backup
```

If the following information is displayed, the backup task is successfully created:

```
Backup request "wordpress-backup" submitted successfully.
Run `velero backup describe wordpress-backup` or `velero backup logs wordpress-backup` for more details.
```

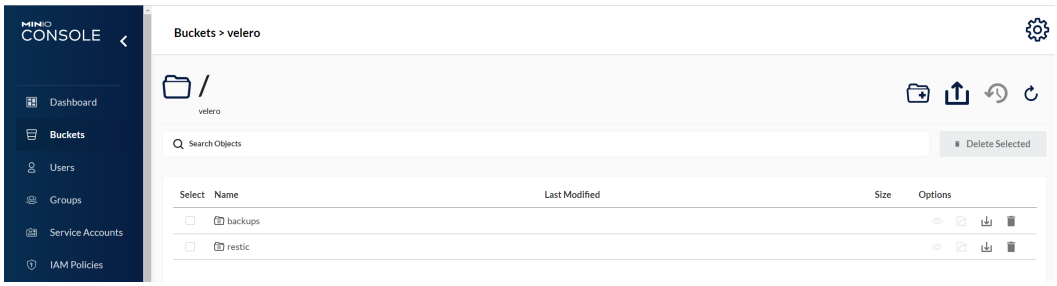
Step 3 Check the backup status.

```
velero backup get
```

Information similar to the following is displayed:

```
NAME              STATUS      ERRORS   WARNINGS   CREATED                         EXPIRES   STORAGE LOCATION   SELECTOR
wordpress-backup  Completed   0        0          2021-10-14 15:32:07 +0800 CST   29d       default            <none>
```

In addition, you can go to the object bucket to view the backup files. The backups path is the application resource backup path, and the other is the PV data backup path.



----End

Restoring Applications in the Target Cluster

The storage infrastructure of an on-premises cluster is different from that of a cloud cluster. After the cluster is migrated, PVs cannot be mounted to pods. Therefore, during the migration, update the storage class of the target cluster to shield the differences of underlying storage interfaces between the two clusters when creating a workload and request storage resources of the corresponding type. For details, see **Updating the Storage Class**. If you migrate storage by using Object Storage Migration Service (OMS), you can mount object storage buckets to pods by referring to **Using an Existing OBS Bucket Through a Static PV**.

Step 1 Use kubectl to connect to the CCE cluster. Create a storage class with the same name as that of the source cluster.

In this example, the storage class name of the source cluster is **local** and the storage type is local disk. Local disks completely depend on the node availability. The data DR performance is poor. When the node is unavailable, the existing storage data is affected. Therefore, EVS volumes are used as storage resources in CCE clusters, and SAS disks are used as backend storage media.

NOTE

- When an application containing PV data is restored in a CCE cluster, the defined storage class dynamically creates and mounts storage resources (such as EVS volumes) based on the PVC.
- The storage resources of the cluster can be changed as required, not limited to EVS volumes. To mount other types of storage, such as file storage and object storage, see **Updating the Storage Class**.

YAML file of the migrated cluster:

```
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: local
provisioner: kubernetes.io/no-provisioner
volumeBindingMode: WaitForFirstConsumer
```

The following is an example of the YAML file of the migration cluster:

```
allowVolumeExpansion: true
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: local
  selfLink: /apis/storage.k8s.io/v1/storageclasses/csi-disk
parameters:
  csi.storage.k8s.io/csi-driver-name: disk.csi.everest.io
  csi.storage.k8s.io/fstype: ext4
```



```
  everest.io/disk-volume-type: SAS
  everest.io/passthrough: "true"
provisioner: everest-csi-provisioner
reclaimPolicy: Delete
volumeBindingMode: Immediate
```

Step 2 Use the Velero tool to create a restore and specify a backup named **wordpress-backup** to restore the WordPress application to the CCE cluster.

```
velero restore create --from-backup wordpress-backup
```

You can run the **velero restore get** statement to view the application restoration status.

Step 3 After the restoration is complete, check whether the application is running properly. If other adaptation problems may occur, rectify the fault by following the procedure described in **Updating Resources Accordingly**.

----End

3.2.3.4 Updating Resources Accordingly

Updating Images

The WordPress and MySQL images used in this example can be pulled from SWR. Therefore, the image pull failure (ErrImagePull) will not occur. If the application to be migrated is created from a private image, perform the following steps to update the image:

Step 1 Migrate the image resources to SWR. For details, see **Uploading an Image Through a Container Engine Client**.

Step 2 Log in to the SWR console and obtain the image path used after the migration.

The image path is in the following format:

```
'swr.{Region}.myhuaweicloud.com/{Organization name}/{Image name}:{Tag name}'
```

Step 3 Run the following command to modify the workload and replace the **image** field in the YAML file with the image path:

```
kubectl edit deploy wordpress
```

Step 4 Check the running status of the workload.

----End

Updating Services

After the cluster is migrated, the Service of the source cluster may fail to take effect. You can perform the following steps to update the Service. If ingresses are configured in the source cluster, connect the new cluster to ELB again after the migration. For details, see **Using kubectl to Create an ELB Ingress**.

Step 1 Connect to the cluster using kubectl.

Step 2 Edit the YAML file of the corresponding Service to change the Service type and port number.

```
kubectl edit svc wordpress
```


To update load balancer resources, connect to ELB again. Add the annotations by following the procedure described in **Using kubectl to Create a Service (Using an Existing Load Balancer)**.

```
annotations:
  kubernetes.io/elb.class: union # Shared load balancer
  kubernetes.io/elb.id: 9d06a39d-xxxx-xxxx-xxxx-c204397498a3    # Load balancer ID, which can be queried on the ELB console.
  kubernetes.io/elb.subnet-id: f86ba71c-xxxx-xxxx-xxxx-39c8a7d4bb36    # ID of the subnet where the load balancer resides
  kubernetes.io/elb.session-affinity-mode: SOURCE_IP    # Enable the sticky session based on the source IP address.
```

Step 3 Use a browser to check whether the Service is available.

----End

Updating the Storage Class

As the storage infrastructures of clusters may be different, storage volumes cannot be mounted to the target cluster. You can use either of the following methods to update the volumes:

NOTICE

Both update methods can be performed only before the application is restored in the target cluster. Otherwise, PV data resources may fail to be restored. In this case, use Velero to restore applications after the storage class update is complete. For details, see **Restoring Applications in the Target Cluster**.

Method 1: Creating a ConfigMap mapping

Step 1 Create a ConfigMap in the CCE cluster and map the storage class used by the source cluster to the default storage class of the CCE cluster.

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: change-storageclass-plugin-config
  namespace: velero
  labels:
    app.kubernetes.io/name: velero
    velero.io/plugin-config: "true"
    velero.io/change-storage-class: RestoreItemAction
data:
  {Storage class name01 in the source cluster}: {Storage class name01 in the target cluster}
  {Storage class name02 in the source cluster}: {Storage class name02 in the target cluster}
```

Step 2 Run the following command to apply the ConfigMap configuration:

```
$ kubectl create -f change-storage-class.yaml
configmap/change-storageclass-plugin-config created
```

----End

Method 2: Creating a storage class with the same name

Step 1 Run the following command to query the default storage class supported by CCE:

```
kubectl get sc
```

Information similar to the following is displayed:


```
NAME                PROVISIONER                    RECLAIMPOLICY    VOLUMEBINDINGMODE
ALLOWVOLUMEEXPANSION    AGE
csi-disk            everest-csi-provisioner        Delete           Immediate              true                    3d23h
csi-disk-topology   everest-csi-provisioner        Delete           WaitForFirstConsumer   true                    3d23h
csi-sfs             everest-csi-provisioner        Delete           Immediate              false                   3d23h
csi-obs             everest-csi-provisioner        Delete           Immediate              false                   3d23h
csi-sfsturbo        everest-csi-provisioner        Delete           Immediate              true                    3d23h
```

Table 3-6 Storage classes

Storage Class	Storage Resource
csi-disk	EVS
csi-disk-topology	EVS with delayed binding
csi-sfs	SFS
csi-obs	OBS
csi-sfsturbo	SFS Turbo

Step 2 Run the following command to export the required storage class details in YAML format:

```
kubectl get sc <storageclass-name> -o=yaml
```

Step 3 Copy the YAML file and create a new storage class.

Change the storage class name to the name used in the source cluster to call basic storage resources of the cloud.

The YAML file of csi-obs is used as an example. Delete the unnecessary information in italic under the **metadata** field and modify the information in bold. You are advised not to modify other parameters.

```
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  creationTimestamp: "2021-10-18T06:41:36Z"
  name: <your_storageclass_name>     # Use the name of the storage class used in the source cluster.
  resourceVersion: "747"
  selfLink: /apis/storage.k8s.io/v1/storageclasses/csi-obs
  uid: 4dbbe557-ddd1-4ce8-bb7b-7fa15459aac7
parameters:
  csi.storage.k8s.io/csi-driver-name: obs.csi.everest.io
  csi.storage.k8s.io/fstype: obsfs
  everest.io/obs-volume-type: STANDARD
provisioner: everest-csi-provisioner
reclaimPolicy: Delete
volumeBindingMode: Immediate
```

NOTE

- SFS Turbo file systems cannot be directly created using StorageClass. Go to the SFS Turbo console to create SFS Turbo file systems that belong to the same VPC subnet and have inbound ports (111, 445, 2049, 2051, 2052, and 20048) enabled in the security group.
- CCE does not support EVS disks of the ReadWriteMany type. If resources of this type exist in the source cluster, change the storage type to **ReadWriteOnce**.

Step 4 Restore the cluster application by referring to **Restoring Applications in the Target Cluster** and check whether the PVC is successfully created.


```
kubectl get pvc
```

In the command output, the **VOLUME** column indicates the name of the PV automatically created using the storage class.

```
NAME   STATUS   VOLUME                                     CAPACITY   ACCESS MODES   STORAGECLASS   AGE
pvc    Bound    pvc-4c8e655a-1dbc-4897-ae6c-446b502f5e77   5Gi        RWX            local          13s
```

----End

Updating Databases

In this example, the database is a local MySQL database and does not need to be reconfigured after the migration. If you use **DRS** to migrate a local database to RDS, configure database access based on site requirements after the migration.

NOTE

- If the RDS instance is in the same VPC as the CCE cluster, it can be accessed using the private IP address. Otherwise, it can only be accessed only through public networks by binding an EIP. You are advised to use the private network access mode for high security and good RDS performance.
- Ensure that the inbound rule of the security group to which RDS belongs has been enabled for the cluster. Otherwise, the connection will fail.

Step 1 Log in to the RDS console and obtain the private IP address and port number of the DB instance on the **Basic Information** page.

Step 2 Run the following command to modify the WordPress workload:

```
kubectl edit deploy wordpress
```

Set the environment variables in the **env** field.

- **WORDPRESS_DB_HOST**: address and port number used for accessing the database, that is, the internal network address and port number obtained in the previous step.
- **WORDPRESS_DB_USER**: username for accessing the database.
- **WORDPRESS_DB_PASSWORD**: password for accessing the database.
- **WORDPRESS_DB_NAME**: name of the database to be connected.

Step 3 Check whether the RDS database is properly connected.

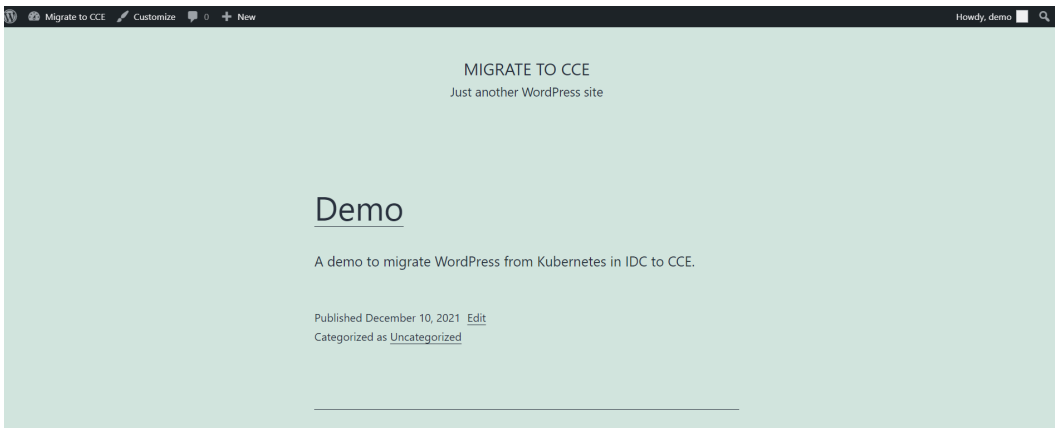
----End

3.2.3.5 Performing Additional Tasks

Verifying Application Functions

Cluster migration involves full migration of application data, which may cause intra-application adaptation problems. In this example, after the cluster is migrated, the redirection link of the article published in WordPress is still the original domain name. If you click the article title, you will be redirected to the application in the source cluster. Therefore, search for the original domain name in WordPress and replace it with the new domain name, change the values of **site_url** and primary URL in the database. For details, see **Changing The Site URL**.

Access the new address of the WordPress application. If the article published before the migration is displayed, the data of the persistent volume is successfully restored.



Switching Live Traffic to the Target Cluster

O&M personnel switch DNS to direct live traffic to the target cluster.

- DNS traffic switching: Adjust the DNS configuration to switch traffic.
- Client traffic switching: Upgrade the client code or update the configuration to switch traffic.

Bringing the Source Cluster Offline

After confirming that the service on the target cluster is normal, bring the source cluster offline and delete the backup files.

- Verify that the service on the target cluster is running properly.
- Bring the source cluster offline.
- Delete backup files.

3.2.3.6 Troubleshooting

Storage Volumes of the HostPath Type Cannot Be Backed Up

Both HostPath and Local volumes are local storage volumes. However, the Restic tool integrated in Velero cannot back up the PVs of the HostPath type and supports only the Local type. Therefore, you need to replace the storage volumes of the HostPath type with the Local type in the source cluster.

NOTE

It is recommended that Local volumes be used in Kubernetes v1.10 or later and can only be statically created. For details, see **local**.

Step 1 Create a storage class for the Local volume.

Example YAML:

```
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
```



```
  name: local
provisioner: kubernetes.io/no-provisioner
volumeBindingMode: WaitForFirstConsumer
```

Step 2 Change the **hostPath** field to the **local** field, specify the original local disk path of the host machine, and add the **nodeAffinity** field.

Example YAML:

```
apiVersion: v1
kind: PersistentVolume
metadata:
  name: mysql-pv
  labels:
    app: mysql
spec:
  accessModes:
  - ReadWriteOnce
  capacity:
    storage: 5Gi
  storageClassName: local     # Storage class created in the previous step
  persistentVolumeReclaimPolicy: Delete
  local:
    path: "/mnt/data"     # Path of the attached local disk
  nodeAffinity:
    required:
      nodeSelectorTerms:
      - matchExpressions:
        - key: kubernetes.io/hostname
          operator: Exists
```

Step 3 Run the following commands to verify the creation result:

```
kubectl get pv
```

Information similar to the following is displayed:

```
NAME       CAPACITY   ACCESS MODES   RECLAIM POLICY   STATUS      CLAIM             STORAGECLASS
REASON   AGE
mysql-pv   5Gi        RWO            Delete           Available                     local
 3s
```

----End

Backup Tool Resources Are Insufficient

In the production environment, if there are many backup resources, for example, the default resource size of the backup tool is used, the resources may be insufficient. In this case, perform the following steps to adjust the CPU and memory size allocated to the Velero and Restic:

Before installing Velero:

You can specify the size of resources used by Velero and Restic when **installing Velero**.

The following is an example of installation parameters:

```
velero install \
  --velero-pod-cpu-request 500m \
  --velero-pod-mem-request 1Gi \
  --velero-pod-cpu-limit 1000m \
  --velero-pod-mem-limit 1Gi \
  --use-node-agent \
  --node-agent-pod-cpu-request 500m \
  --node-agent-pod-mem-request 1Gi \
  --node-agent-pod-cpu-limit 1000m \
  --node-agent-pod-mem-limit 1Gi
```


After Velero is installed:

Step 1 Edit the YAML files of the Velero and node-agent workloads in the **velero** namespace.

```
kubectl edit deploy velero -n velero
kubectl edit ds node-agent -n velero
```

Step 2 Modify the resource size under the **resources** field. The modification is the same for the Velero and Restic workloads, as shown in the following:

```
resources:
  limits:
    cpu: "1"
    memory: 1Gi
  requests:
    cpu: 500m
    memory: 1Gi
```

----End

4 DevOps

4.1 Installing and Deploying Jenkins on CCE

4.1.1 Solution Overview

What Is Jenkins?

Jenkins is an open source continuous integration (CI) tool that provides user-friendly GUIs. It originates from Hudson and is used to automate all sorts of tasks related to building, testing, and delivering or deploying software.

Jenkins is written in Java and can run in popular servlet containers such as Tomcat, or run independently. It is usually used together with the version control tools (or SCM tools) and build tools. Jenkins supports various languages and is compatible with third-party build tools, such as Maven, Ant, and Gradle. It seamlessly integrates with common version control tools, such as SVN and Git, and can directly connect to source code hosting services, such as GitHub.

Constraints

- This solution can be deployed only in CCE clusters. It is not supported in DeC.
- CCE does not provide maintenance and support for Jenkins. The maintenance is provided by the developers.

Solution Architecture

You can install Jenkins using the following methods:

- You can use a single Master to install Jenkins. The Master handles jobs and builds and releases services. However, security risks may exist.
- Another one is to use Master+Agents. Master schedules build jobs to Agents for execution, and monitors Agent status. Agents execute build jobs dispatched by the Master and return the job progress and result.

You can install the Master and Agents on VMs, containers, or combination of the two. For details, see **Table 4-1**.

Table 4-1 Jenkins deployment modes

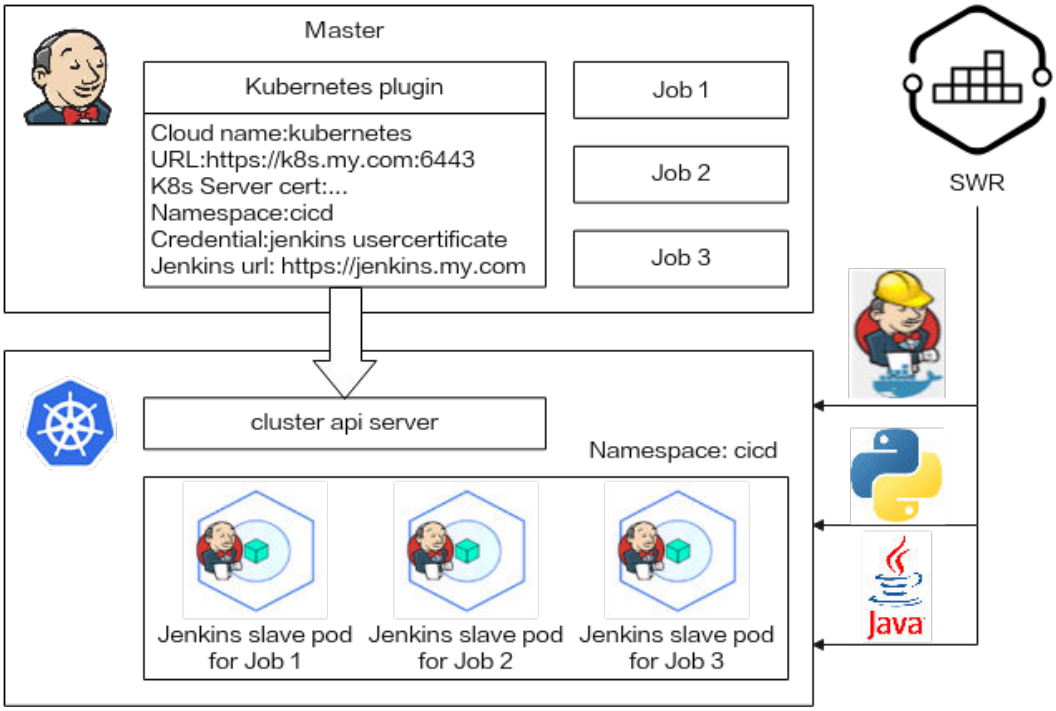
Deployment Mode	Master	Agent	Advantages and Disadvantages
Single Master	VMs	-	• Advantage: Localized construction is easy to operate. • Disadvantage: Job management and execution are performed on the same VM and the security risk is high.
Single Master	Containers	-	• Advantage: Kubernetes containers support self-healing. • Disadvantage: Job management and execution are not isolated. Security risks exist.
Master+Agents	VMs	VMs	• Advantage: Job management and execution are isolated and the security risk is low. • Disadvantage: Agents are fixed. Resources cannot be scheduled and the resource utilization is low and the maintenance cost is high.
		Containers (Kubernetes cluster)	• Advantage: Containerized Agents can be fixed or dynamic. Kubernetes schedules the dynamic Agents, improving the resource utilization. Jobs can be evenly allocated based on the scheduling policy, which is easy to maintain. • Disadvantage: The Master may break down and the recovery cost is high.

Deployment Mode	Master	Agent	Advantages and Disadvantages
Master+Agents	Containers (Kubernetes cluster)	Containers (Kubernetes cluster)	• Advantage: Containerized Agents can be fixed or dynamic. Kubernetes schedules the dynamic Agents, improving the resource utilization. The Master is self-healing and the maintenance cost is low. Agents and the Master can be deployed in the same cluster or in different clusters. • Disadvantage: The system is complex and the environment is difficult to set up.

In this section, Jenkins is installed with the containerized Master and Agents. Kubernetes schedules the dynamic Agents. For details about the architecture, see **Figure 4-1**.

- The Master handles jobs. Install Kubernetes add-ons on the Master to use the Kubernetes platform resources.
- The Kubernetes platform generates pods for Agents to execute jobs. When a job is scheduled on the Master, the Master sends a request to the Kubernetes platform using the Kubernetes add-on. After receiving the request, Kubernetes builds a pod using the pod template to send requests to the Master. After the Master is successfully connected, you can execute the job on the pod.

Figure 4-1 Installing Jenkins on Kubernetes



Procedure

Step 1 **Installing and Deploying Jenkins Master**

Jenkins Master is deployed in the CCE cluster using container images.

Step 2 **Configuring Jenkins Agent**

Jenkins can fix Agents in the cluster or use the pipeline to interconnect with CCE to provide pods for Agents to execute jobs. The dynamic Agents use Kubernetes add-ons to configure cluster authentication and user permissions.

Step 3 **Using Jenkins to Build a Pipeline**

The Jenkins pipeline interconnects with SWR and calls **docker build/login/push** commands in Agents to package and push images automatically.

You can also use pipelines to deploy and upgrade Kubernetes resources (such as Deployments, Services, ingresses, and jobs).

----End

4.1.2 Resource and Cost Planning

NOTICE

The fees listed here are estimates. The actual fees will be displayed on the Huawei Cloud console.

The required resources are as follows:

Table 4-2 Resource and cost planning

Resource	Description	Quantity	Estimated Fee (USD)
Cloud Container Engine (CCE)	Pay-per-use recommended • Cluster type: CCE cluster • CCE cluster version: v1.25 • Cluster scale: 50 nodes • HA: Yes	1	2.91/hour
VM	Pay-per-use recommended • VM type: General computing-plus • Node flavor: 4 vCPUs | 8 GiB • OS: EulerOS 2.9 • System disk: 50 GiB | General purpose SSD • Data disk: 100 GiB | General purpose SSD	1	1.00/hour
Elastic Volume Service (EVS)	Pay-per-use recommended • EVS disk specifications: 100 GiB • EVS disk type: General purpose SSD	1	0.1/hour
Load Balancer (ELB)	Pay-per-use recommended • Type: Shared • Billed By: Traffic • Bandwidth: 5 Mbit/s	1	0.32/hour + 0.80/GiB (The traffic fee is charged based on the actual outbound traffic.)

4.1.3 Procedure

4.1.3.1 Installing and Deploying Jenkins Master

NOTE

On the Jenkins page, the UI strings in Chinese and English are different. The screenshots in this section are for your reference only.

Selecting an Image

Select a relatively new, stable image from Docker Hub. For this test, select **jenkinsci/blueocean**, which is bound with all Blue Ocean add-ons and functions. There is no need to install Blue Ocean add-ons separately. For details, see **Installing Jenkins**.

Preparations

- Before creating a containerized workload, buy a cluster (the cluster must contain at least one node with four vCPUs and 8 GiB memory). For details, see **Buying a CCE Cluster**.

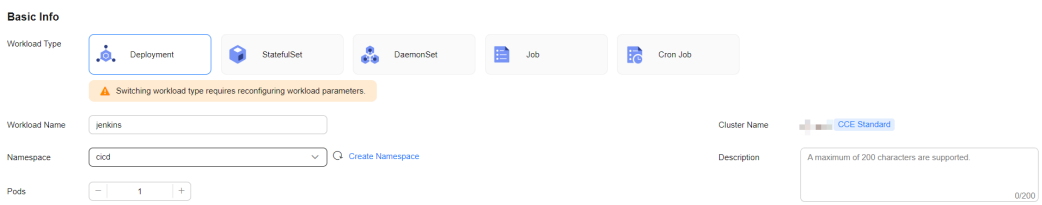
  The Docker in Docker scenario is required, which is, running the Docker commands in the container. Select the Docker container engine for the node.
- To enable external networks to access the workload, ensure that an elastic IP address (EIP) has been bound to or a load balancer has been configured for at least one node in the cluster.

Installing and Deploying Jenkins on CCE

Step 1 Log in to the CCE console, choose **Workloads** > **Deployments** and click **Create Workload** on the upper right corner.

Step 2 Configure basic workload parameters.

- **Workload Name**: jenkins (customizable)
- **Namespace**: Select the namespace where Jenkins will be deployed. You can create a namespace.
- **Pods**: Set it to **1**.

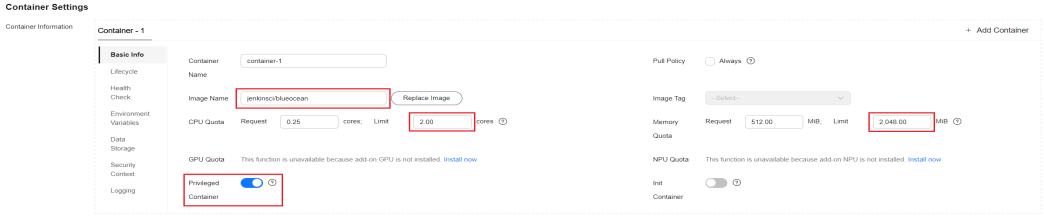


Step 3 Configure basic container parameters.

- **Image Name**: Enter **jenkinsci/blueocean**. Select an image version as required. If no version is selected, the latest version will be used by default.
- **CPU Quota**: Set **Limit** to **2** cores.
- **Memory Quota**: Set **Limit** to **2048** MiB.
- **Privileged Container**: If Jenkins with a single Master is used, the privileged container must be enabled so that the container can perform operations on the node. Otherwise, you cannot run the Docker commands in the Jenkins Master container.

Retain the default values for other parameters.

Figure 4-2 Basic container parameters



Step 4 Click **Data Storage** and add a persistent storage volume.

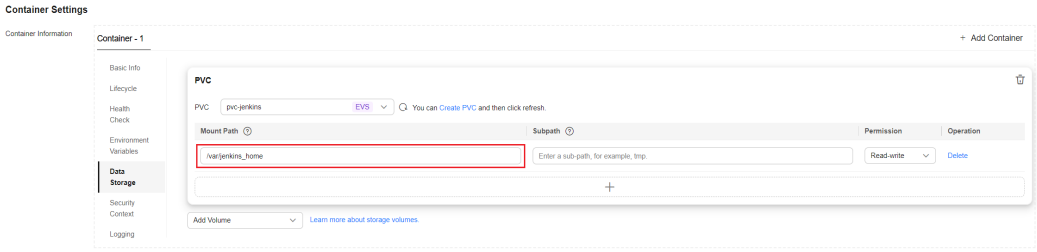
Click **Add Volume**, select **PVC** from the drop-down list, and add a storage volume. Enter **/var/jenkins_home** under **Mount Path** to mount the storage volume to **/var/jenkins_home** of the Jenkins container for persistent data storage.

NOTE

The cloud storage type can be **EVS** or **SFS**. If no cloud storage is available, click **Create PVC**.

If you select **EVS**, the AZ of the EVS disk must be the same as that of the node.

Figure 4-3 Adding a cloud volume



Step 5 Add permissions to the Jenkins container so that related commands can be executed in it.

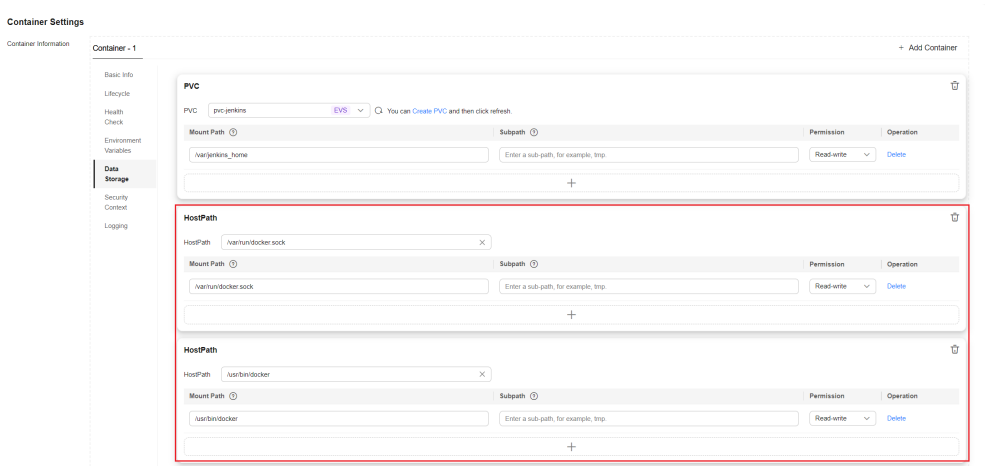
1. Ensure that **Privileged Container** is enabled in **3**.
2. Click **Data Storage**, click **Add Volume**, select **hostPath**, and mount the host path to the corresponding container path.

Table 4-3 Mounting path

Storage Type	Host Path	Mounting Path
hostPath	**/var/run/docker.sock**	**/var/run/docker.sock**
hostPath	**/usr/bin/docker**	**/usr/bin/docker**
hostPath	**/usr/lib64/libltdl.so.7**	**/usr/lib/x86_64-linux-gnu/libltdl.so.7**
hostPath	**/usr/bin/kubectl**	**/usr/local/bin/kubectl**

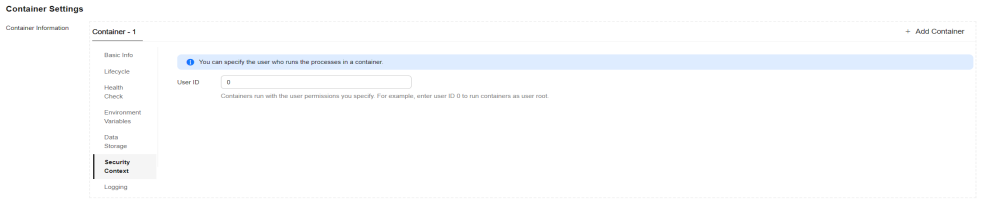
After the mounting is complete, the page shown in **Figure 4-4** is displayed.

Figure 4-4 Mounting the host paths to the corresponding container paths



3. In **Security Context**, set **User ID** to **0** (user **root**).

Figure 4-5 Configuring the user



Step 6 Specify the access mode in **Service Configuration**.

The Jenkins container image has two ports: 8080 and 50000. Configure them separately. Port 8080 is used for web login, and port 50000 is used for the connection between Master and Agent.

In this example, two Services are created:

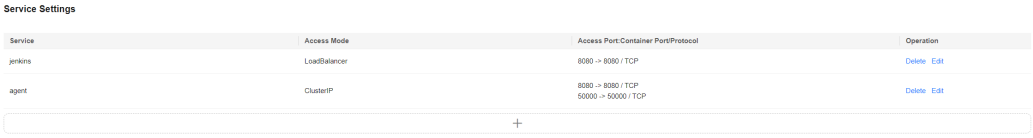
- **LoadBalancer**: provides external web access using port 8080. You can also select **NodePort** to provide external access.

  Set the Service name to **jenkins** (customizable), the container port to **8080**, the access port to **8080**, and retain the default values for other parameters.
- **ClusterIP**: used by the Agent to connect to the Master. The IP addresses of **jenkins-web** and **jenkins-agent** need to be the same. Therefore, port 8080 for web access and port 50000 for agent access are included.

  Set the Service name to **agent** (customizable), the container port 1 to **8080**, the access port 1 to **8080**, the container port 2 to **50000**, the access port 2 to **50000**, and retain the default values for other parameters.

> **NOTE**
>
> In this example, Agents and the Master are deployed in the same cluster. Therefore, the Agents can use the ClusterIP Service to connect to the Master.
>
> If Agents need to connect to the Master across clusters or through the public network, select a proper Service type. Note that the IP addresses of **Jenkins-web** and **Jenkins-agent** need to be the same. Therefore, **ports 8080 and 50000 must be enabled for the IP address connected to jenkins-agent**. For addresses used only for web access, enable only the port 8080.

Figure 4-6 Adding a Service



Step 7 Retain the default settings for **Advanced Settings** and click **Create Workload**.

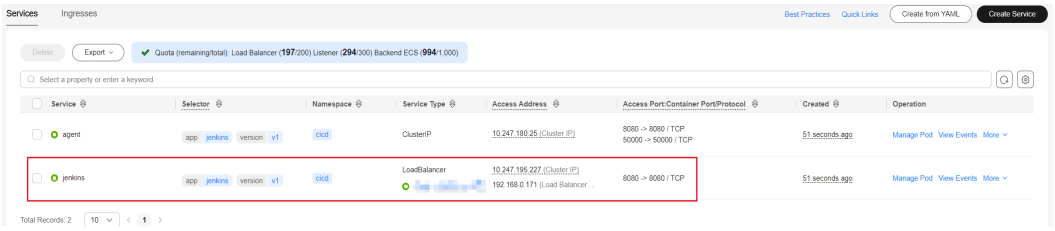
Step 8 Click **Back to Deployment List** to view the Deployment status. If the workload is in the **Running** status, the Jenkins application is accessible.

----End

Logging In and Initializing Jenkins

Step 1 On the CCE console, click the name of the target cluster to access the cluster console. Choose **Services & Ingresses** in the navigation pane. On the **Services** tab, view the Jenkins access mode.

Figure 4-7 Access mode corresponding to port 8080

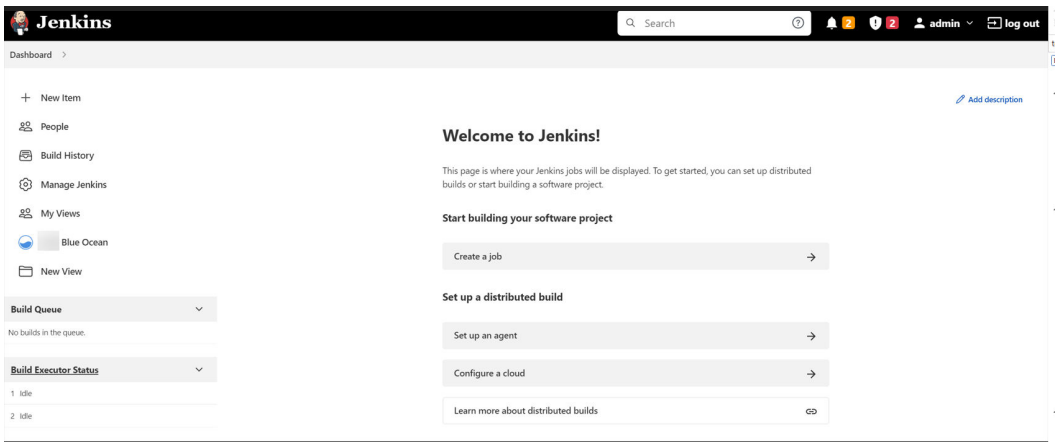


Step 2 Enter **EIP:8080** of the load balancer in the browser address box to visit the Jenkins configuration page.

When you visit the page for the first time, you are prompted to obtain the initial administrator password. You can obtain the password from the Jenkins pod. Before running the following commands, connect to the cluster using kubectl. For details, see **Connecting to a Cluster Using kubectl**.

```
# kubectl get pod -n cicd
NAME                          READY   STATUS    RESTARTS   AGE
jenkins-7c69b6947c-5gvlm      1/1     Running   0          17m
# kubectl exec -it jenkins-7c69b6947c-5gvlm -n cicd -- /bin/sh
# cat /var/jenkins_home/secrets/initialAdminPassword
b10eabe29a9f427c9b54c01a9c3383ae
```

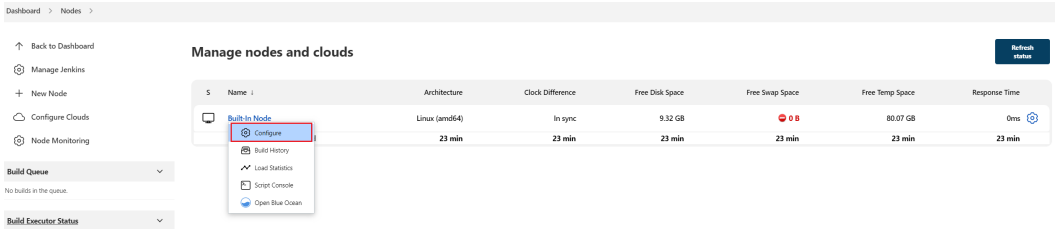

Step 3 The system prompts you to select the default recommended add-on and create an administrator upon the first login. After the initial configuration is complete, the Jenkins page is displayed.



----End

Modifying the Number of Concurrent Build Jobs

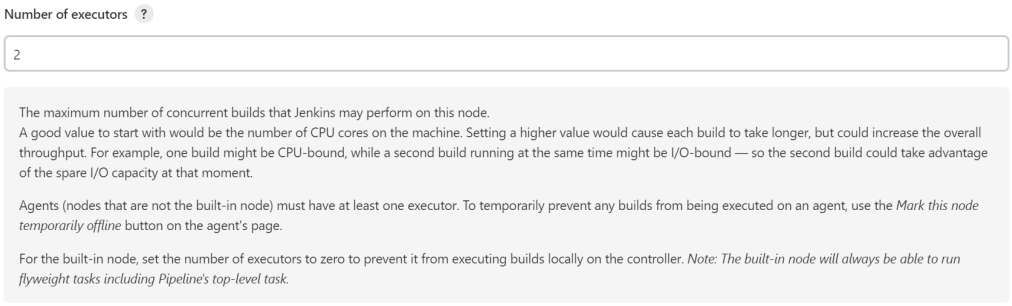
Step 1 On the Jenkins dashboard page, click **Manage Jenkins** on the left, choose **System Configuration** > **Manage nodes and clouds**, and select **Configure** from the drop-down list of the target node.



NOTE

- You can modify the number of concurrent build jobs on both Master and Agent. The following uses Master as an example.
- If the **Master is used with Agents**, you are advised to set the number of concurrent build jobs of Master to **0**. That is, all build jobs are performed using Agents. If a **single Master** is used, you do not need to change the value to **0**.

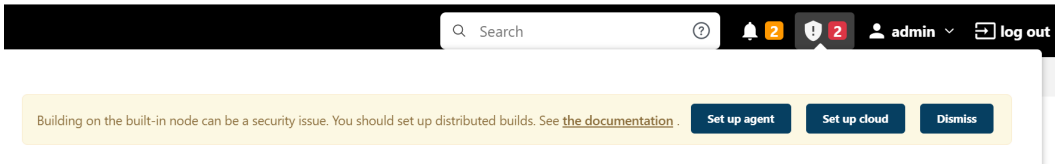
Step 2 Modify the maximum number of concurrent build jobs. In this example, the value is changed to **2**. You can change the value as required.



----End

4.1.3.2 Configuring Jenkins Agent

After Jenkins is installed, the following information may display, indicating that Jenkins uses a Master for local build and Agents are not configured.



If you install Jenkins using a Master, you can build a pipeline after performing operations in **Installing and Deploying Jenkins Master**. For details, see **Using Jenkins to Build a Pipeline**.

If you install Jenkins using a Master and Agents, you can select either of the following solutions to configure Agents.

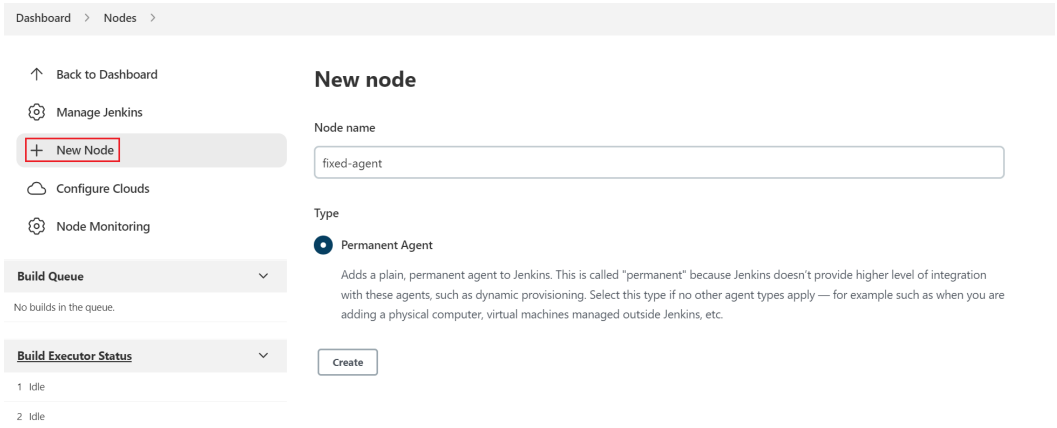
- **Fixed Agent**: The Agent container keeps running and occupying cluster resources after a job is built. This configuration is simple.
- **Dynamic Agent**: An Agent container is dynamically created during job build and is killed after the job is built. In this way, resources can be dynamically allocated and the resource utilization is high. This configuration is complex.

In this section, the Agent is containerized using the **jenkins/inbound-agent:4.13.3-1** image.

Adding a Fixed Agent to Jenkins

Step 1 Log in to the Jenkins dashboard, click **Manage Jenkins** on the left, and choose **System Configuration** > **Manage nodes and clouds**.

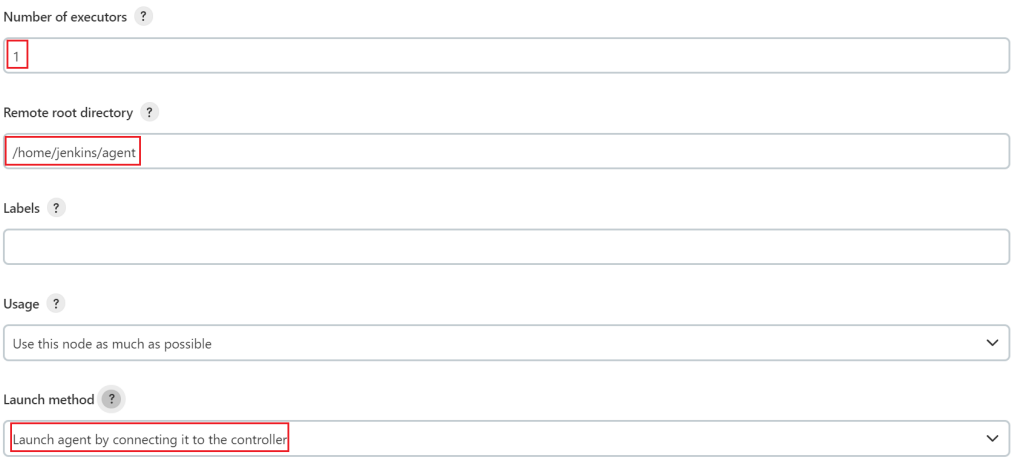
Step 2 Click **New Node** on the left, enter the node name **fixed-agent** (which can be customized), and select **Permanent Agent** for **Type**.



Step 3 Specify the following node information:

- **Number of executors**: The default value is **1**. Set this parameter as required.
- **Remote root directory**: Enter **/home/jenkins/agent**.
- Launch method: Select **Launch agent by connecting it to the controller**.

Retain the values for other parameters and click **Save**.

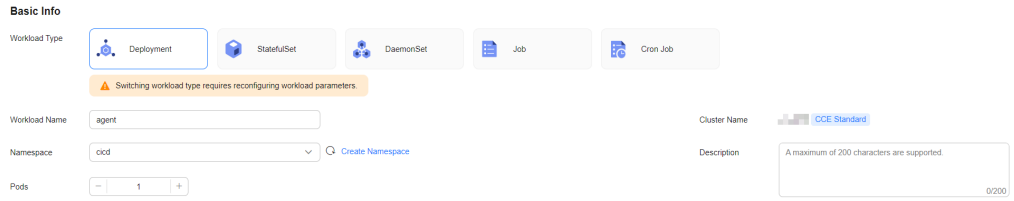


Step 4 In the **Nodes** page, click the new node. The Agent status is disconnected, and the method for connecting the node to Jenkins is provided. This command applies to VM installation. In this example, container-based installation is used. Therefore, you only need to copy the secret, as shown in the following figure.

Step 5 Log in to the CCE console, click the target cluster. Choose **Workloads** > **Deployments** and click **Create Workload** on the right.

Step 6 Configure basic workload parameters.

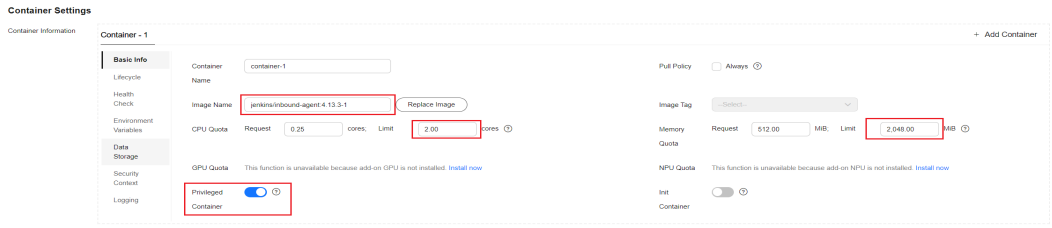
- **Workload Name**: agent (user-defined)
- **Namespace**: Select the namespace where Jenkins will be deployed. You can create a namespace.
- **Pods**: Set it to **1**.



Step 7 Configure basic container parameters.

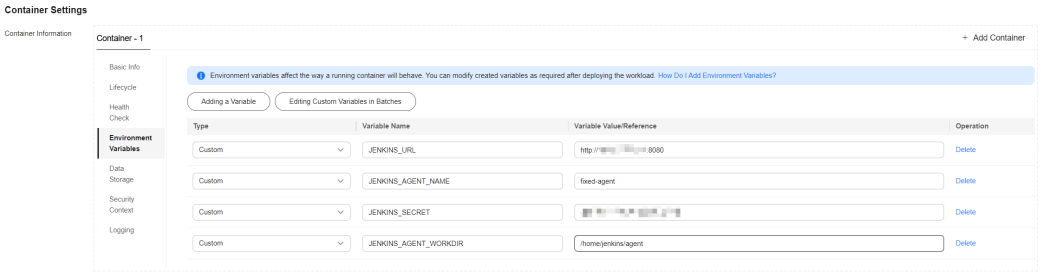
- **Image Name**: Enter **jenkins/inbound-agent:4.13.3-1**. The image version may change with time. Select an image version as required or use the latest version.
- **CPU Quota**: In this example, set **Limit** to **2** cores.
- **Memory Quota**: Set **Limit** to **2048** MiB.
- **Privileged Container**: must be enabled so that the container can obtain permissions on the host. Otherwise, Docker commands cannot be executed in the container.

Retain the default values for other parameters.



Step 8 Run the following commands to configure the environment variables:

- **JENKINS_URL**: Jenkins access path, which should be the address of port 8080 configured in **Step 6**. (**Both ports 8080 and 50000 must be enabled**.) In this example, the cluster IP address and port 8080 and cluster IP address and port 50000 are used, for example, **http://10.247.222.254:8080**.
- **JENKINS_AGENT_NAME**: name of the Agent set in **Step 2**. In this example, the value is **fixed-agent**.
- **JENKINS_SECRET**: secret copied from **Step 4**.
- **JENKINS_AGENT_WORKDIR**: remote work directory configured in **Step 3**, that is, **/home/jenkins/agent**.



Step 9 Add permissions to the Jenkins container so that Docker commands can be executed in the Jenkins container.

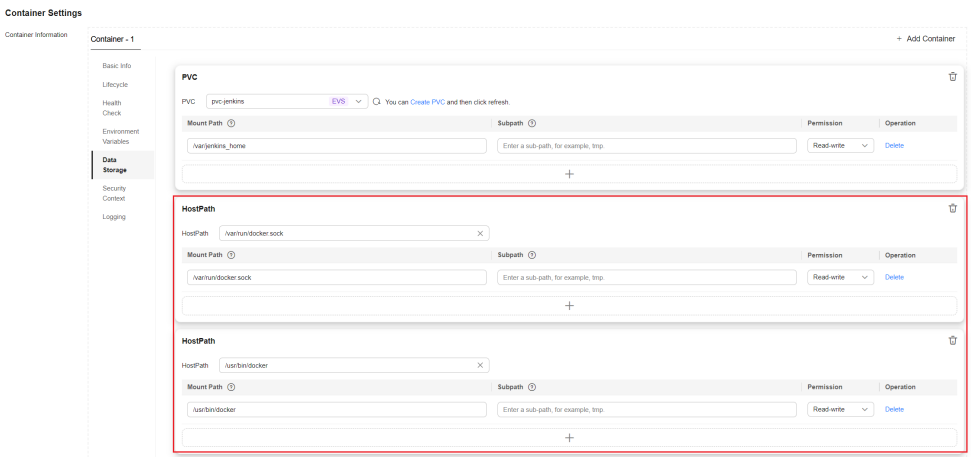
1. Ensure that **Privileged Container** is enabled in **3**.
2. Click **Data Storage**, click **Add Volume**, select **hostPath**, and mount the host path to the corresponding container path.

Table 4-4 Mounting path

Storage Type	Host Path	Mounting Path
hostPath	**/var/run/docker.sock**	**/var/run/docker.sock**
hostPath	**/usr/bin/docker**	**/usr/bin/docker**
hostPath	**/usr/lib64/libltdl.so.7**	**/usr/lib/x86_64-linux-gnu/libltdl.so.7**
hostPath	**/usr/bin/kubectl**	**/usr/local/bin/kubectl**

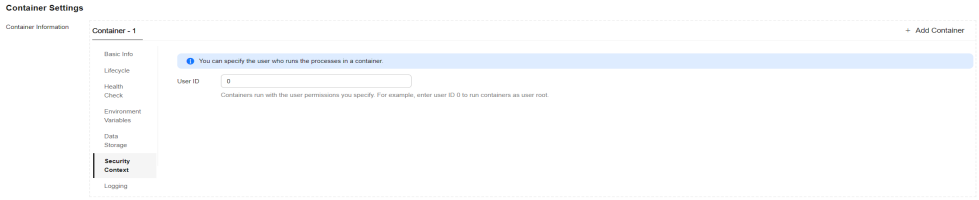
After the mounting is complete, the page shown in **Figure 4-8** is displayed.

Figure 4-8 Mounting the host paths to the corresponding container paths



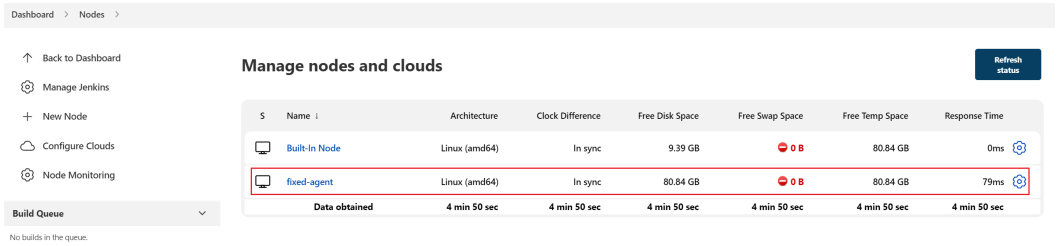
3. In **Security Context**, set **User ID** to **0** (user **root**).

Figure 4-9 Configuring the user



Step 10 Retain the default settings for **Advanced Settings** and click **Create Workload**.

Step 11 Go to the Jenkins page and refresh the node status to **In sync**.



NOTE

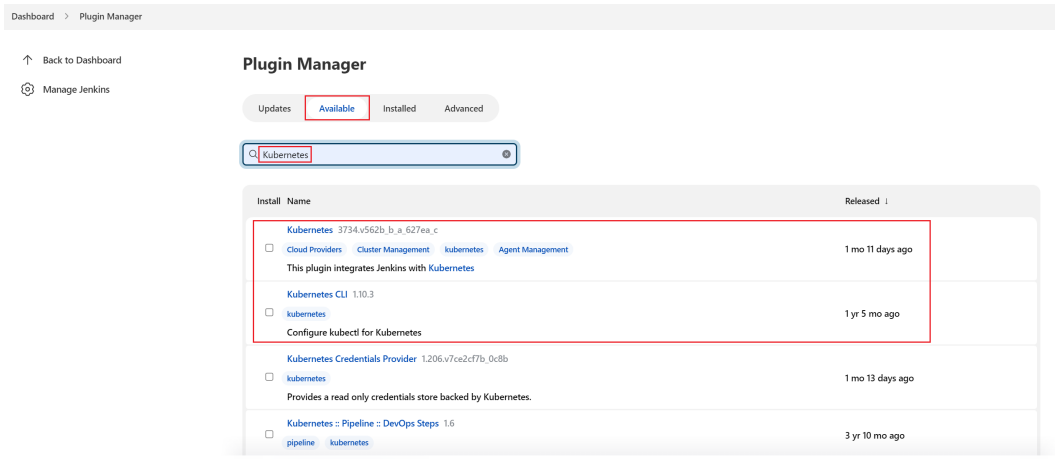
After the Agent is configured, you are advised to set the number of concurrent build jobs of the Master to **0**. That is, you use the Agent for build. For details, see **Modifying the Number of Concurrent Build Jobs**.

----End

Setting a Dynamic Agent for Jenkins

Step 1 Install the plug-in.

On the Jenkins dashboard page, click **Manage Jenkins** on the left and choose **System Configuration** > **Manage Plugins**. On the **Available** tab, search for **Kubernetes** and install **Kubernetes CLI** and **Kubernetes**.



The plug-in version may change with time. Select a plug-in version as required.

- **Kubernetes Plugin**: 3734.v562b_b_a_627ea_c

It is used to run dynamic Agents in the Kubernetes cluster, create a Kubernetes pod for each started Agent, and stop the pod after each build is complete.

- **Kubernetes CLI Plugin**: 1.10.3

  kubectl can be configured for jobs to interact with Kubernetes clusters.

NOTE

The Jenkins plugins are provided by the plugin maintainer and may be iterated due to security risks.

Step 2 Add cluster access credentials to Jenkins.

Add cluster access credentials to Jenkins in advance. For details, see **Setting Cluster Access Credentials**.

Step 3 Configure basic cluster information.

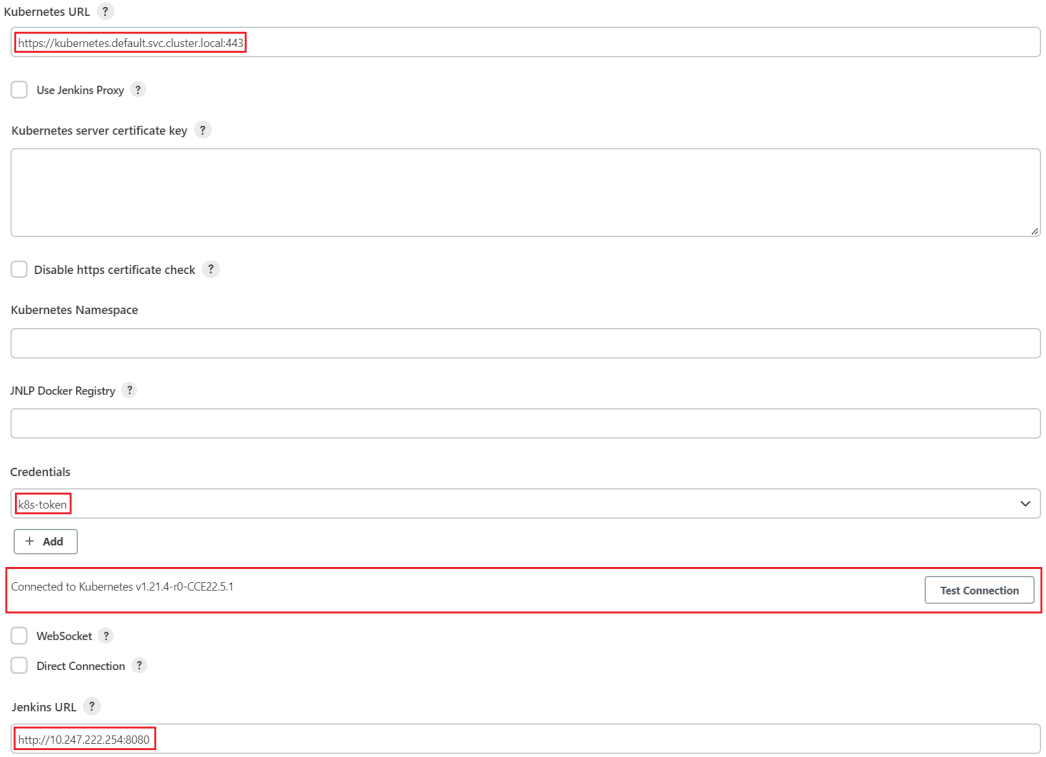
On the Jenkins dashboard page, click **Manage Jenkins** on the left and choose **System Configuration** > **Manage nodes and clouds**. Click **Configure Clouds** on the left to configure the cluster. Click **Add a new cloud** and select **Kubernetes**. The cluster name can be customized.

Step 4 Enter Kubernetes Cloud details.

Set the following cluster parameters and retain the values for other parameters, as shown in **Figure 4-10**.

- **Kubernetes URL**: cluster API server address. You can enter **https://kubernetes.default.svc.cluster.local:443**.
- **Credentials**: Select the cluster credential added in **Step 2**. You can click **Test Connection** to check whether the cluster is connected.
- **Jenkins URL**: Jenkins access path. Enter the IP address of port 8080 set in **Step 6** **(ports 8080 and 50000 must be enabled for the IP address, that is, the intra-cluster access address)**, for example, **http://10.247.222.254:8080**.

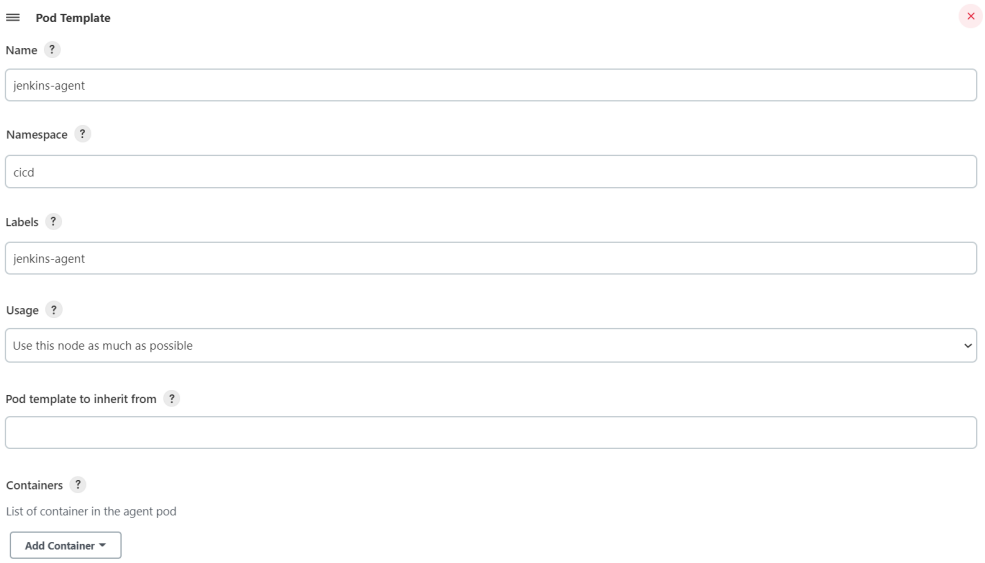
Figure 4-10 Example



Step 5 **Pod Template**: Click **Add Pod Template** > **Pod Template details** and set pod template parameters.

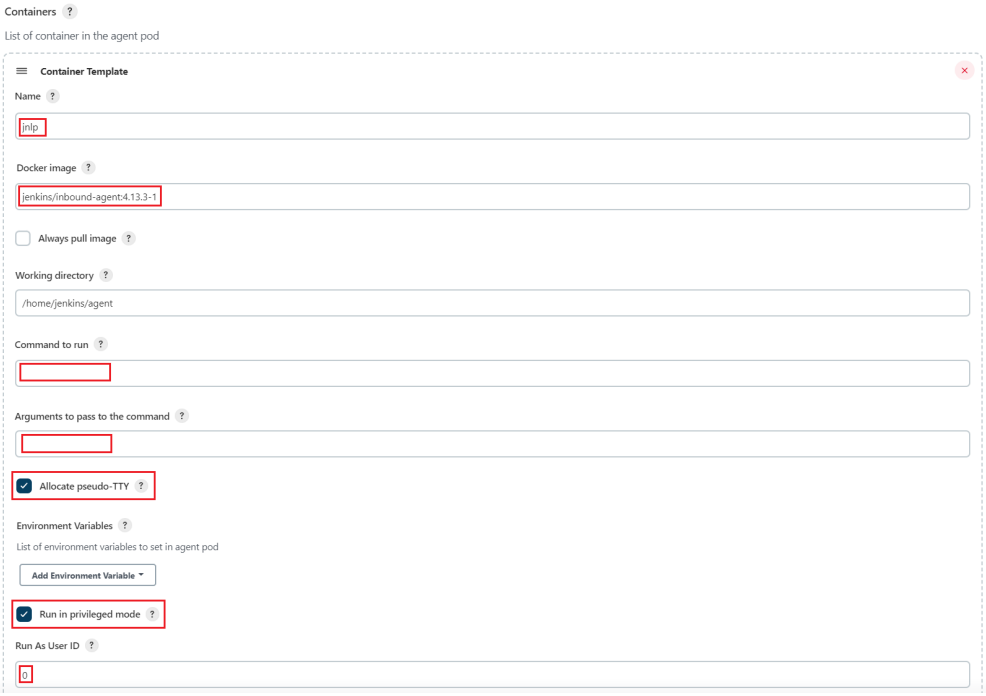
- Set the basic parameters of the pod template, as shown in **Figure 4-11**.
  - **Name**: **jenkins-agent**
  - **Namespace**: **cicd**
  - **Labels**: **jenkins-agent**
  - **Usage**: Select **Use this node as much as possible**.

Figure 4-11 Basic parameters of the pod template



- Add a container. Click **Add Container > Container Template**. Figure 4-12 shows the parameters.
  - **Name**: The value must be **jnlp**.
  - **Docker image**: **jenkins/inbound-agent:4.13.3-1**. The image version may change with time. Select an image version as required or use the latest version.
  - **Working directory**: **/home/jenkins/agent** is selected by default.
  - **Command to run**/**Arguments to pass to the command**: Delete the existing default value and leave these two parameters empty.
  - **Allocate pseudo-TTY**: Select this parameter.
  - Select **Run in privileged mode** and set **Run As User ID** to **0** (**root** user).

Figure 4-12 Container template parameters



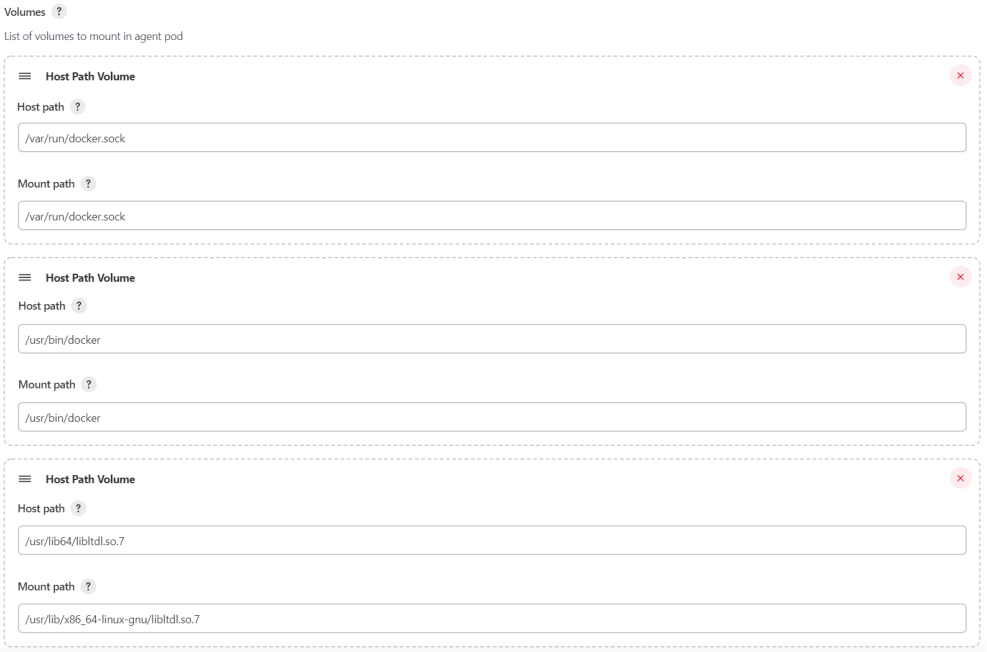
- Add a volume: Choose **Add Volume > Host Path Volume** to mount the host path in Table 4-5 to the corresponding path of the container.

Table 4-5 Mounting path

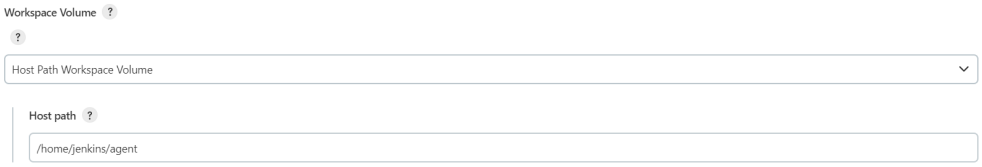
Storage Type	Host Path	Mounting Path
hostPath	**/var/run/docker.sock**	**/var/run/docker.sock**
hostPath	**/usr/bin/docker**	**/usr/bin/docker**
hostPath	**/usr/lib64/libltdl.so.7**	**/usr/lib/x86_64-linux-gnu/libltdl.so.7**
hostPath	**/usr/bin/kubectl**	**/usr/local/bin/kubectl**

After the mounting is complete, the page shown in **Figure 4-13** is displayed.

Figure 4-13 Mounting the host paths to the corresponding container paths



- **Run As User ID**: **0** (**root** user)
- **Workspace Volume**: working directory of the agent. Persistence is recommended. Select **Host Path Workspace Volume** and set **Host path** to **/home/jenkins/agent**.



Step 6 Click **Save**.

NOTE

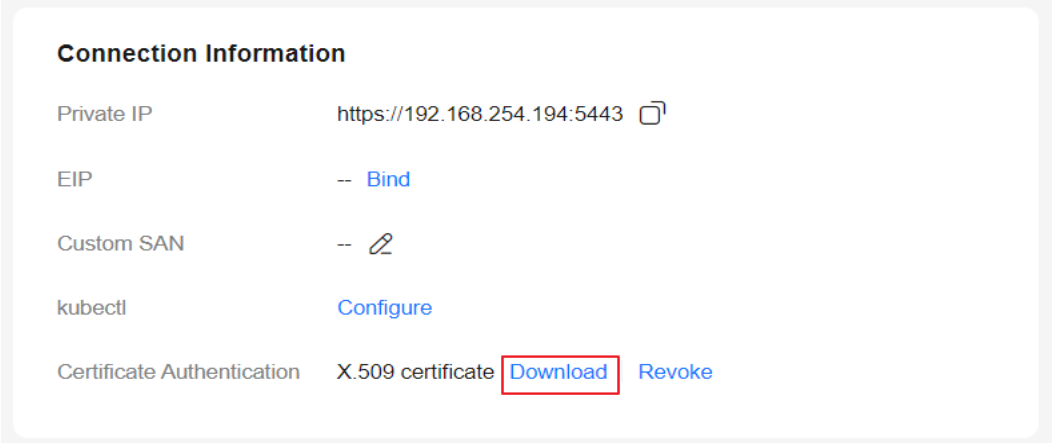
After the Agent is configured, you are advised to set the number of concurrent build jobs of the Master to **0**. That is, you use the Agent for build. For details, see **Modifying the Number of Concurrent Build Jobs**.

----End

Setting Cluster Access Credentials

The certificate file that can be identified in Jenkins is in PKCS#12 format. Therefore, convert the cluster certificate to a PFX certificate file in PKCS#12 format.

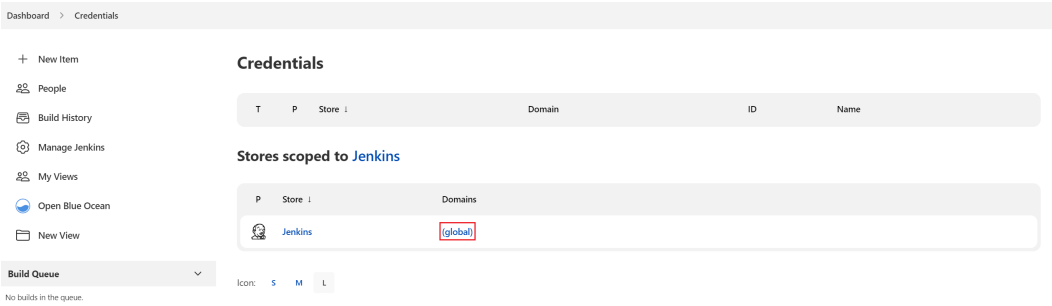
Step 1 Log in to the CCE console and click the cluster name to access the cluster console. Choose **Overview** in the navigation pane. On the page displayed, locate the **Connection Information** area, and download the cluster certificate. The certificate contains **ca.crt**, **client.crt**, and **client.key** files.



Step 2 Log in to a Linux host, place the three certificate files in the same directory, and use OpenSSL to convert the certificate into a **cert.pfx** certificate. After the certificate is generated, the system prompts you to enter a custom password.

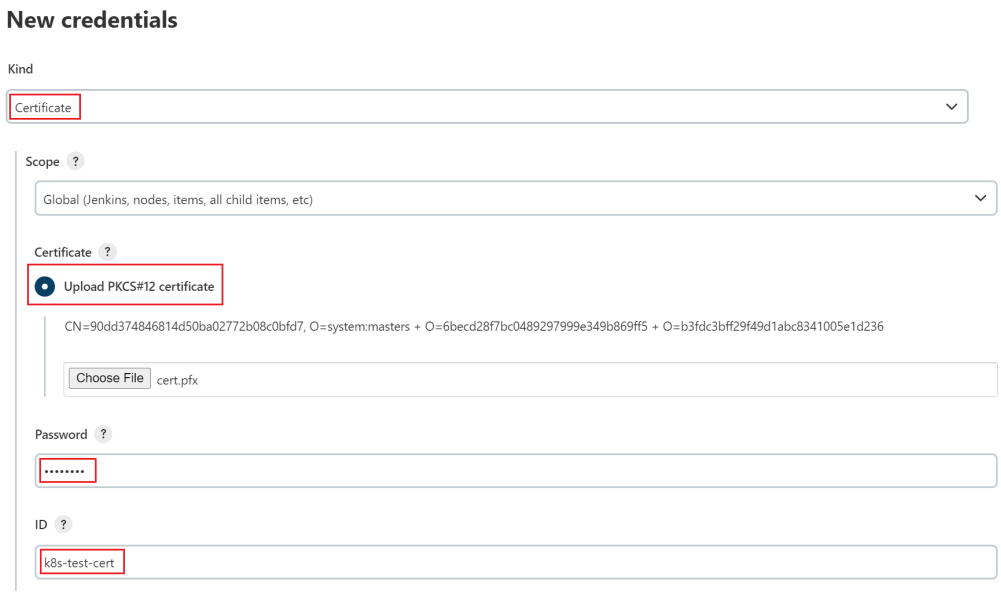
```
openssl pkcs12 -export -out cert.pfx -inkey client.key -in client.crt -certfile ca.crt
```

Step 3 On the Jenkins console, choose **Manage Jenkins** > **Manage Credentials** and click **Global**. You can also create a domain.



Step 4 Click **Add Credential**.

- **Kind**: Select **Certificate**.
- **Scope**: Select **Global**.
- **Certificate**: Select **Upload PKCS#12 certificate** and upload the **cert.pfx** file generated in **Step 2**.
- **Password**: The password customized during **cert.pfx** conversion.
- **ID**: Set this parameter to **k8s-test-cert**, which can be customized.



----End

4.1.3.3 Using Jenkins to Build a Pipeline

Obtaining a Long-Term Valid Login Command

During Jenkins installation and deployment, the Docker commands have been configured in the container (see **9**). Therefore, no additional configuration is required for interconnecting Jenkins with SWR. You can directly run the Docker commands. You only need to obtain a long-term valid SWR login command. For details, see **Obtaining a Long-Term Valid Login Command**.

For example, the command of this account is as follows:

```
docker login -u ap-southeast-1@xxxxx -p xxxxx swr.ap-southeast-1.myhuaweicloud.com
```

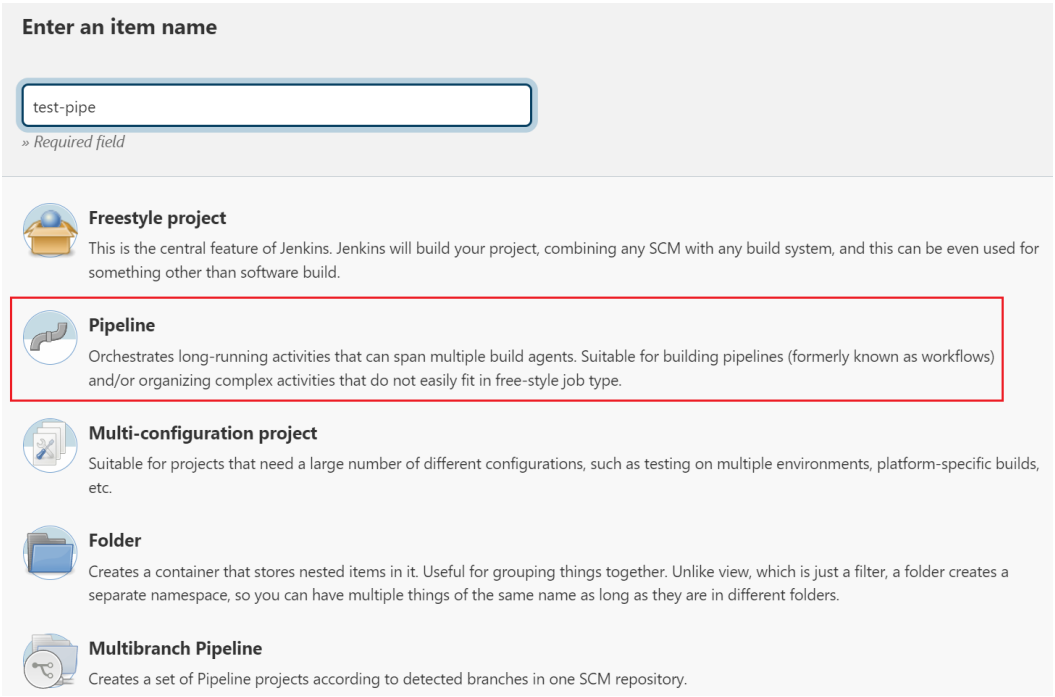
Creating a Pipeline to Build and Push Images

In this example, Jenkins is used to build a pipeline to pull code from the code repository, package the code into an image, and push the image to SWR.

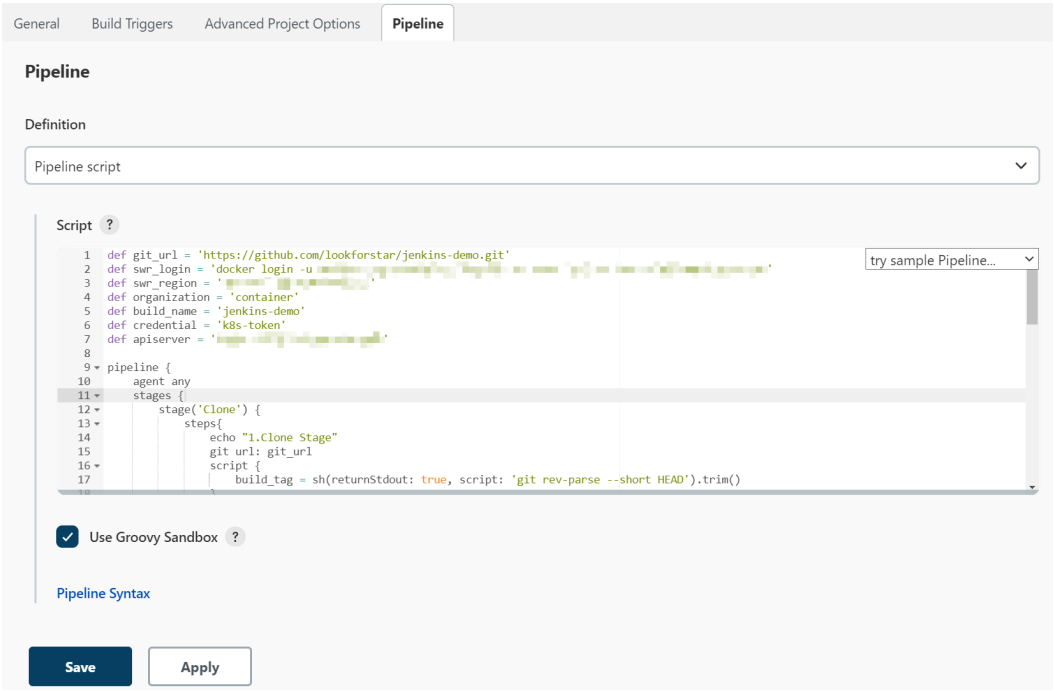
The pipeline creation procedure is as follows:

Step 1 Click **New Item** on the Jenkins page.

Step 2 Enter a task name and select **Create Pipeline**.



Step 3 Configure only the pipeline script.



The following pipeline scripts are for reference only. You can customize the script. For details about the syntax, see **Pipeline**.

Some parameters in the example need to be modified:

- **git_url**: Address of your code repository. Replace it with the actual address.
- **swr_login**: The login command obtained in **Obtaining a Long-Term Valid Login Command**.

- **swr_region**: SWR region.
- **organization**: The actual organization name in SWR.
- **build_name**: Name of the created image.
- **credential**: The cluster credential added to Jenkins. Enter the credential ID. If you want to deploy the service in another cluster, add the access credential of the cluster to Jenkins again. For details, see **Setting Cluster Access Credentials**.
- **apiserver**: IP address of the API server where the application cluster is deployed. Ensure that the IP address can be accessed from the Jenkins cluster.

```
//Define the code repository address.
def git_url = 'https://github.com/lookforstar/jenkins-demo.git'
//Define the SWR login command.

//Define the SWR region.
def swr_region = 'ap-southeast-1'
//Define the name of the SWR organization to be uploaded.
def organization = 'container'
//Define the image name.
def build_name = 'jenkins-demo'
//Certificate ID of the cluster to be deployed
def credential = 'k8s-token'
//API server address of the cluster. Ensure that the address can be accessed from the Jenkins cluster.
def apiserver = 'https://192.168.0.100:6443'

pipeline {
    agent any
    stages {
        stage('Clone') {
            steps{
                echo "1.Clone Stage"
                git url: git_url
                script {
                    build_tag = sh(returnStdout: true, script: 'git rev-parse --short HEAD').trim()
                }
            }
        }
        stage('Test') {
            steps{
                echo "2.Test Stage"
            }
        }
        stage('Build') {
            steps{
                echo "3.Build Docker Image Stage"
                sh "docker build -t swr.${swr_region}.myhuaweicloud.com/${organization}/${build_name}:${build_tag} ."
                //${build_tag} indicates that the build_tag variable is obtained as the image tag. It is the return value of the git rev-parse --short HEAD command, that is, commit ID.
            }
        }
        stage('Push') {
            steps{
                echo "4.Push Docker Image Stage"
                sh swr_login
                sh "docker push swr.${swr_region}.myhuaweicloud.com/${organization}/${build_name}:${build_tag}"
            }
        }
        stage('Deploy') {
            steps{
                echo "5. Deploy Stage"
                echo "This is a deploy step to test"
                script {
                sh "cat k8s.yaml"
                echo "begin to config kubenetes"
```



```
            try {
                withKubeConfig([credentialsId: credential, serverUrl: apiserver]) {
                    sh 'kubectl apply -f k8s.yaml'
                    //The YAML file is stored in the code repository. The following is only an example. Replace
it as required.
                }
                println "hooray, success"
            } catch (e) {
                println "oh no! Deployment failed! "
                println e
            }
            }
        }
    }
  }
}
```

Step 4 Save the settings and execute the Jenkins job.

----End

4.1.3.4 Interconnecting Jenkins with RBAC of Kubernetes Clusters (Example)

Prerequisites

RBAC must be enabled for the cluster.

Scenario 1: Namespace-based Permissions Control

Create a service account and a role, and add a RoleBinding.

```
# kubectl create ns dev
# kubectl -n dev create sa dev

# cat <<EOF > dev-user-role.yml
kind: Role
apiVersion: rbac.authorization.k8s.io/v1
metadata:
  namespace: dev
  name: dev-user-pod
rules:
- apiGroups: ["*"]
  resources: ["deployments", "pods", "pods/log"]
  verbs: ["get", "watch", "list", "update", "create", "delete"]
EOF
# kubectl create -f dev-user-role.yml

# kubectl create rolebinding dev-view-pod \
    --role=dev-user-pod \
    --serviceaccount=dev:dev \
    --namespace=dev
```

Generate the kubeconfig file of a specified service account.

NOTE

- In clusters earlier than v1.21, a token is obtained by mounting the secret of the service account to a pod. Tokens obtained this way are permanent. This approach is no longer recommended starting from version 1.21. Service accounts will stop auto creating secrets in clusters from version 1.25.

  In clusters of version 1.21 or later, you can use the **TokenRequest** API to **obtain the token** and use the projected volume to mount the token to the pod. Such tokens are valid for a fixed period. When the mounting pod is deleted, the token automatically becomes invalid. For details, see **Service Account Token Security Improvement**.
- If you need a token that never expires, you can also **manually manage secrets for service accounts**. Although a permanent service account token can be manually created, you are advised to use a short-lived token by calling the **TokenRequest** API for higher security.

Because the cluster version used in this case is v1.25, the ServiceAccount will not have a secret created automatically. This example shows how to manually create a secret named **dev-secret** and associate it with the ServiceAccount named **dev**.

NOTICE

The manually created secret must be in the same namespace as the ServiceAccount to be associated with. Otherwise, the creation may fail.

```
# kubectl apply -f - <<EOF
apiVersion: v1
kind: Secret
metadata:
  namespace: dev  # Namespace
  name: dev-secret
  annotations:
    kubernetes.io/service-account.name: dev
type: kubernetes.io/service-account-token
EOF
```

Check whether **dev-secret** has been created. If **dev-secret** is present in secrets of the **dev** namespace, then it has been created.

```
# kubectl get secrets -n dev
NAME             TYPE                                  DATA      AGE
default-secret   kubernetes.io/dockerconfigjson        1         2d22h
dev-secret       kubernetes.io/service-account-token   3         4h14m
paas.elb         cfe/secure-opaque                     1         2d22h
```

Generate a kubeconfig file using **dev-secret**.

```
# API_SERVER="https://172.22.132.51:6443"
# CA_CERT=$(kubectl -n dev get secret dev-secret -o yaml | awk '/ca.crt:/{print $2}')
# cat <<EOF > dev.conf
apiVersion: v1
kind: Config
clusters:
- cluster:
    certificate-authority-data: $CA_CERT
    server: $API_SERVER
  name: cluster
EOF

# TOKEN=$(kubectl -n dev get secret dev-secret -o go-template='{{.data.token}}')
# kubectl config set-credentials dev-user \
    --token=`echo ${TOKEN} | base64 -d` \
    --kubeconfig=dev.conf
```



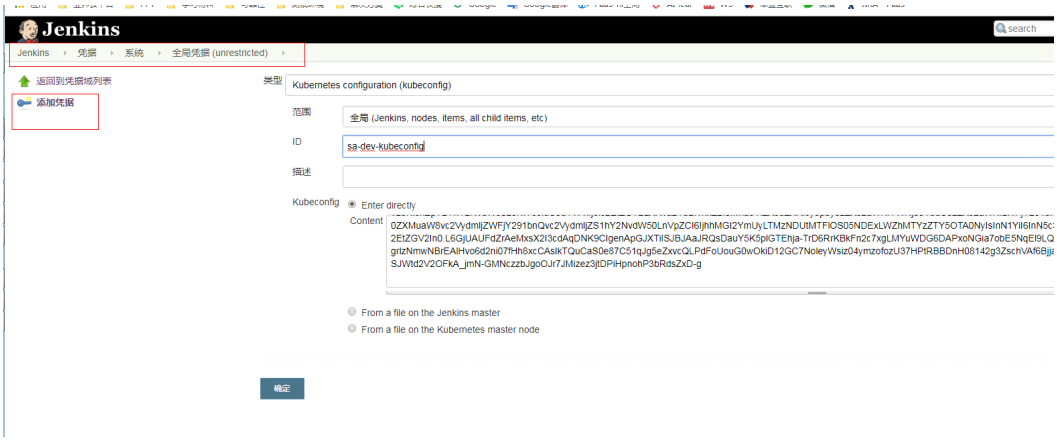
```
# kubectl config set-context default \
   --cluster=cluster \
   --user=dev-user \
   --kubeconfig=dev.conf

# kubectl config use-context default \
   --kubeconfig=dev.conf
```

Verify the configuration.

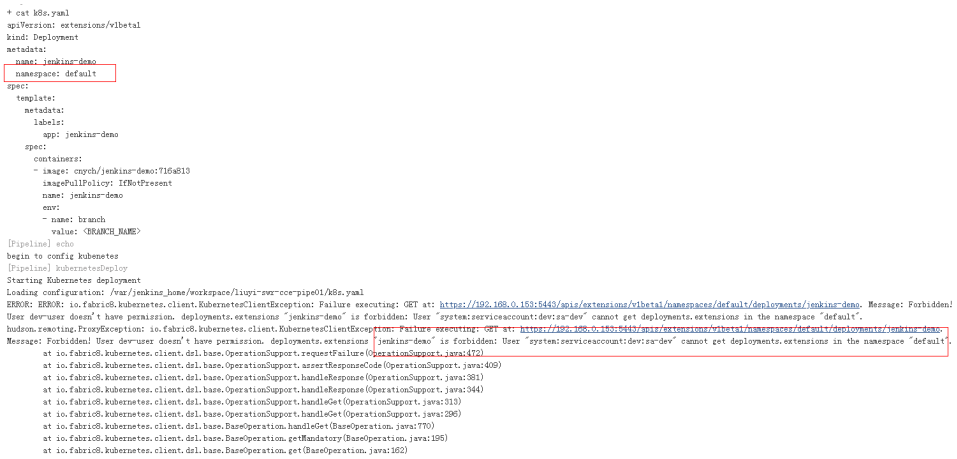
```
# kubectl --kubeconfig=dev.conf get po
Error from server (Forbidden): pods is forbidden: User "system:serviceaccount:dev:dev" cannot list pods in the namespace "default"

# kubectl -n dev --kubeconfig=dev.conf run nginx --image nginx --port 80 --restart=Never
# kubectl -n dev --kubeconfig=dev.conf get po
NAME      READY     STATUS    RESTARTS   AGE
nginx     1/1       Running   0          39s
```

Verify whether the permissions meet the expectation in Jenkins.

Step 1 Add the kubeconfig file with permissions control settings to Jenkins.



Step 2 Start the Jenkins job. In this example, Jenkins fails to be deployed in namespace **default** but is successfully deployed in namespace **dev**.




```
+ cat k8s.yaml
apiVersion: extensions/v1beta1
kind: Deployment
metadata:
  name: jenkins-demo
  namespace: dev
spec:
  template:
    metadata:
      labels:
        app: jenkins-demo
    spec:
      containers:
      - image: swr.ap-southeast-2.myhuaweicloud.com/paas-poc/jenkins-demo:f31618e
        imagePullPolicy: IfNotPresent
        name: jenkins-demo
        env:
        - name: branch
          value: <BRANCH_NAME>
[Pipeline] echo
begin to config kubenetes
[Pipeline] kubernetesDeploy
Starting Kubernetes deployment
Loading configuration: /var/jenkins_home/workspace/liuyi-swr-cce-pipe01/k8s.yaml
Created Deployment: Deployment(apiVersion=extensions/v1beta1, kind=Deployment, metadata=ObjectMeta(annotations=null, clusterName=null, creationTimestamp=2019-02-18T08:05:47Z, deletionGracePeriodSeconds=null,
deletionTimestamp=null, finalizers=[], generateName=null, generation=1, initializers=null, labels={app=jenkins-demo}, name=jenkins-demo, namespace=dev, ownerReferences=[], resourceVersion=582129,
selfLink=/apis/extensions/v1beta1/namespaces/dev/deployments/jenkins-demo, uid=ffdd740a-3353-11e9-9411-fa163e699047, additionalProperties={}), spec=DeploymentSpec(minReadySeconds=null, paused=null,
progressDeadlineSeconds=null, replicas=1, revisionHistoryLimit=null, rollbackTo=null, selector=LabelSelector(matchExpressions=[], matchLabels={app=jenkins-demo}, additionalProperties={}),
strategy=DeploymentStrategy(rollingUpdate=RollingUpdateDeployment(maxSurge=IntOrString(IntVal=1, Kind=null, StrVal=null, additionalProperties={}), maxUnavailable=IntOrString(IntVal=1, Kind=null, StrVal=null,
additionalProperties={}), additionalProperties={}), type=RollingUpdate, additionalProperties={}), template=PodTemplateSpec(metadata=ObjectMeta(annotations=null, clusterName=null, creationTimestamp=null,
deletionGracePeriodSeconds=null, deletionTimestamp=null, finalizers=[], generateName=null, generation=null, initializers=null, labels={app=jenkins-demo}, name=null, namespace=null, ownerReferences=[],
resourceVersion=null, selfLink=null, uid=null, additionalProperties={}), spec=PodSpec(activeDeadlineSeconds=null, affinity=null, automountServiceAccountToken=null, containers=[Container(args=[], command=[], env=
[EnvVar(name=branch, value=<BRANCH_NAME>, valueFrom=null, additionalProperties={})], envFrom=[], image=swr.ap-southeast-2.myhuaweicloud.com/paas-poc/jenkins-demo:f31618e, imagePullPolicy=IfNotPresent, lifecycle=null,
livenessProbe=null, name=jenkins-demo, ports=[], readinessProbe=null, resources=ResourceRequirements(limits=null, requests=null, additionalProperties={}), securityContext=null, stdin=null, stdinOnce=null,
terminationMessagePath=/dev/termination-log, terminationMessagePolicy=File, tty=null, volumeMounts=[], workingDir=null, additionalProperties={})], dnsPolicy=ClusterFirst, hostAliases=[], hostIPC=null,
hostNetwork=null, hostPID=null, hostname=null, imagePullSecrets=[], initContainers=[], nodeName=null, nodeSelector=null, restartPolicy=Always, schedulerName=default-scheduler,
securityContext=PodSecurityContext(fsGroup=null, runAsNonRoot=null, runAsUser=null, seLinuxOptions=null, supplementalGroups=[], additionalProperties={}), serviceAccount=null, serviceAccountName=null, subdomain=null,
terminationGracePeriodSeconds=30, tolerations=[], volumes=[], additionalProperties={}), additionalProperties={}), additionalProperties={}), status=DeploymentStatus(availableReplicas=null, collisionCount=null,
conditions=[], observedGeneration=null, readyReplicas=null, replicas=null, unavailableReplicas=null, updatedReplicas=null, additionalProperties={}), additionalProperties={})
Finished Kubernetes deployment
[Pipeline] echo
hooray, success
```

----End

Scenario 2: Resource-based Permissions Control

Step 1 Generate the service account, role, and binding.

```
# kubectl -n dev create sa sa-test0304

# cat <<EOF > test0304-role.yml
kind: Role
apiVersion: rbac.authorization.k8s.io/v1
metadata:
  namespace: dev
  name: role-test0304
rules:
- apiGroups: ["*"]
  resources: ["deployments"]
  resourceNames: ["tomcat03", "tomcat04"]
  verbs: ["get", "update", "patch"]
EOF
# kubectl create -f test0304-role.yml

# kubectl create rolebinding test0304-bind \
    --role=role-test0304 \
    --serviceaccount=dev:sa-test0304\
    --namespace=dev
```

Step 2 Generate a kubeconfig file.

NOTE

- In clusters earlier than v1.21, a token is obtained by mounting the secret of the service account to a pod. Tokens obtained this way are permanent. This approach is no longer recommended starting from version 1.21. Service accounts will stop auto creating secrets in clusters from version 1.25.

  In clusters of version 1.21 or later, you can use the **TokenRequest** API to **obtain the token** and use the projected volume to mount the token to the pod. Such tokens are valid for a fixed period. When the mounting pod is deleted, the token automatically becomes invalid. For details, see **Service Account Token Security Improvement**.

- If you need a token that never expires, you can also **manually manage secrets for service accounts**. Although a permanent service account token can be manually created, you are advised to use a short-lived token by calling the **TokenRequest** API for higher security.

Because the cluster version used in this case is v1.25, the ServiceAccount will not have a secret created automatically. This example shows how to manually create a secret named **test-secret** and associate it with the ServiceAccount named **sa-test0304**.

```
# kubectl apply -f - <<EOF
apiVersion: v1
kind: Secret
metadata:
  namespace: dev
  name: test-secret
  annotations:
    kubernetes.io/service-account.name: sa-test0304
type: kubernetes.io/service-account-token
EOF
```

Check whether **test-secret** has been created. If **test-secret** is present in secrets of the **dev** namespace, then it has been created.

```
# kubectl get secrets -n dev
NAME                TYPE                                  DATA       AGE
default-secret      kubernetes.io/dockerconfigjson        1          2d22h
dev-secret          kubernetes.io/service-account-token   3          4h14m
paas.elb            cfe/secure-opaque                     1          2d22h
test-secret         kubernetes.io/service-account-token   3          25m
```

Generate a kubeconfig file using **test-secret**.

```
# API_SERVER=" https://192.168.0.153:5443"
# CA_CERT=$(kubectl -n dev get secret test-secret -o yaml | awk '/ca.crt:/{print $2}')
# cat <<EOF > test0304.conf
apiVersion: v1
kind: Config
clusters:
- cluster:
    certificate-authority-data: $CA_CERT
    server: $API_SERVER
  name: cluster
EOF

# TOKEN=$(kubectl -n dev get secret test-secret -o go-template='{{.data.token}}')
# kubectl config set-credentials test0304-user \
    --token=`echo ${TOKEN} | base64 -d` \
    --kubeconfig=test0304.conf

# kubectl config set-context default \
    --cluster=cluster \
    --user=test0304-user \
    --kubeconfig=test0304.conf

# kubectl config use-context default \
    --kubeconfig=test0304.conf
```

Step 3 Verify that Jenkins is running as expected.

In the pipeline script, update the Deployments of tomcat03, tomcat04, and tomcat05 in sequence.

```
      try {
        kubernetesDeploy(
            kubeconfigId: "test0304",
            configs: "test03.yaml")
        println "hooray, success"
       } catch (e) {
           println "oh no! Deployment failed! "
           println e
       }
       echo "test04"
```



```
try {
 kubernetesDeploy(
     kubeconfigId: "test0304",
     configs: "test04.yaml")
 println "hooray, success"
} catch (e) {
    println "oh no! Deployment failed! "
    println e
}
echo "test05"
try {
 kubernetesDeploy(
     kubeconfigId: "test0304",
     configs: "test05.yaml")
 println "hooray, success"
} catch (e) {
    println "oh no! Deployment failed! "
    println e
}
```

The following shows examples of the running results.

Figure 4-14 test03

Figure 4-15 test04

```
test04
[Pipeline] kubernetesDeploy
Starting Kubernetes deployment
Loading configuration: /var/jenkins_home/workspace/liuyi-swr-cce-pipe01/test04.yaml
Applied Deployment: Deployment(apiVersion=extensions/v1beta1, kind=Deployment, metadata=Obje
deletionTimestamp=null, finalizers=[], generateName=null, generation=3, initializers=null, l
selfLink=/apis/extensions/v1beta1/namespaces/dev/deployments/tomcat04, uid=06af3b14-3356-11e
progressDeadlineSeconds=null, replicas=1, revisionHistoryLimit=null, rollbackTo=null, select
strategy=DeploymentStrategy(rollingUpdate=RollingUpdateDeployment(maxSurge=IntOrString(IntVa
additionalProperties={}), additionalProperties={}), type=RollingUpdate, additionalProperties
deletionGracePeriodSeconds=null, deletionTimestamp=null, finalizers=[], generateName=null, g
resourceVersion=null, selfLink=null, uid=null, additionalProperties={}), spec=PodSpec(active
[EnvVar(name=branch, value=<BRANCH_NAME>, valueFrom=null, additionalProperties={})], envFrom
livenessProbe=null, name=tomcat04, ports=[], readinessProbe=null, resources=ResourceRequirem
terminationMessagePath=/dev/termination-log, terminationMessagePolicy=File, tty=null, volume
hostNetwork=null, hostPID=null, hostname=null, imagePullSecrets=[], initContainers=[], nodeN
securityContext=PodSecurityContext(fsGroup=null, runAsNonRoot=null, runAsUser=null, seLinuxO
terminationGracePeriodSeconds=30, tolerations=[], volumes=[], additionalProperties={}), addi
conditions=[DeploymentCondition(lastTransitionTime=2019-02-18T08:56:55Z, lastUpdateTime=2019
type=Available, additionalProperties={}), DeploymentCondition(lastTransitionTime=2019-02-18T
reason=ReplicaSetUpdated, status=True, type=Progressing, additionalProperties={})], observed
additionalProperties={})
Finished Kubernetes deployment
[Pipeline] echo
hooray, success
[Pipeline] echo
test05
[Pipeline] kubernetesDeploy
Starting Kubernetes deployment
Loading configuration: /var/jenkins_home/workspace/liuyi-swr-cce-pipe01/test05.yaml
ERROR: ERROR: io.fabric8.kubernetes.client.KubernetesClientException: Failure executing: GET
test0304-user doesn't have permission. deployments.extensions "tomcat05" is forbidden: User
hudson.remoting.ProxyException: io.fabric8.kubernetes.client.KubernetesClientException: Fail
Forbidden! User test0304-user doesn't have permission. deployments.extensions "tomcat05" is
        at io.fabric8.kubernetes.client.dsl.base.OperationSupport.requestFailure(OperationSu
        at io.fabric8.kubernetes.client.dsl.base.OperationSupport.assertResponseCode(Operati
        at io.fabric8.kubernetes.client.dsl.base.OperationSupport.handleResponse(OperationSu
        at io.fabric8.kubernetes.client.dsl.base.OperationSupport.handleResponse(OperationSu
```

----End

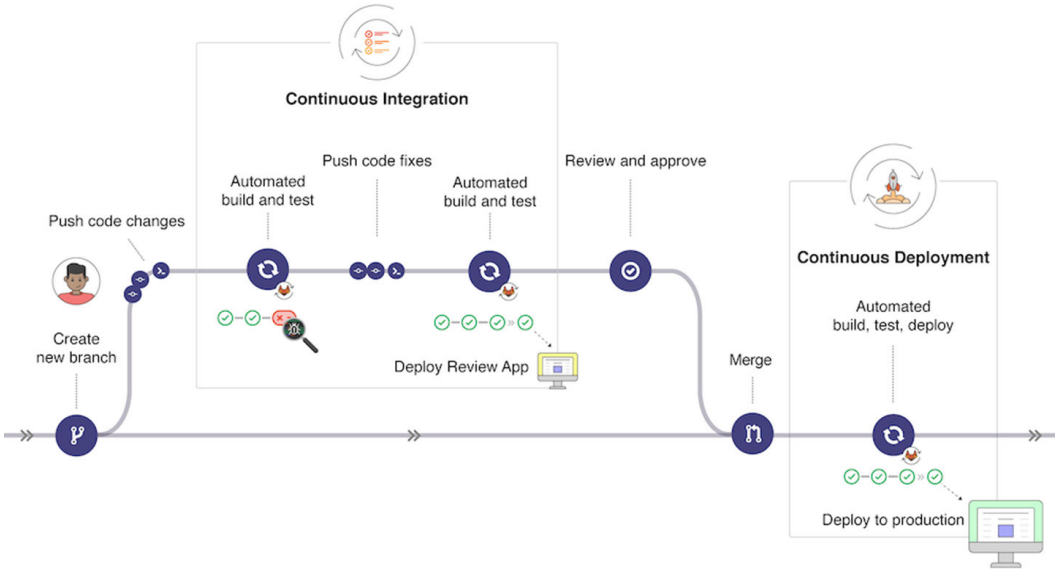
4.2 Interconnecting GitLab with SWR and CCE for CI/CD

Background

GitLab is an open-source version management system developed with Ruby on Rails for Git project repository management. It supports web-based access to public and private projects. Similar to GitHub, GitLab allows you to browse source code, manage bugs and comments, and control team member access to repositories. You will find it very easy to view committed versions and file history database. Team members can communicate with each other using the built-in chat program (Wall).

GitLab provides powerful CI/CD functions and is widely used in software development.

Figure 4-16 GitLab CI/CD process

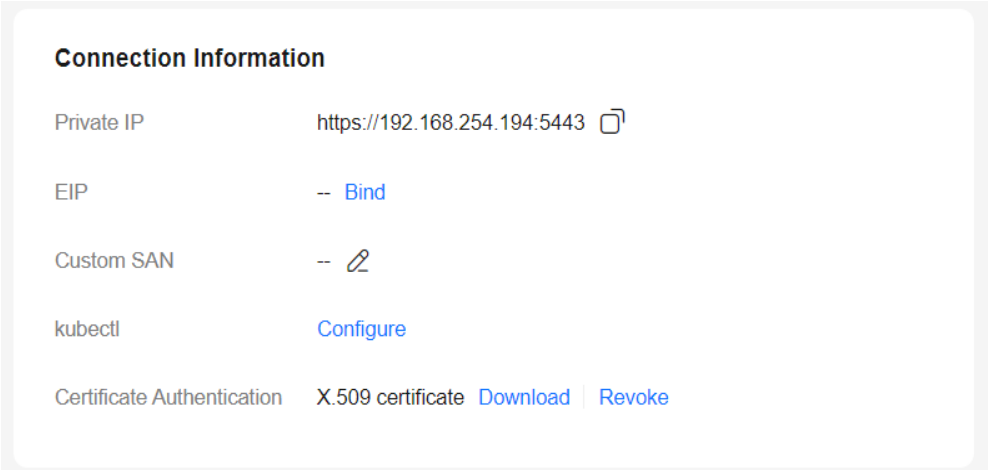


This section describes how to interconnect GitLab with SWR and CCE for CI/CD.

Preparations

1. Create a CCE cluster and a node and bind an EIP to the node for downloading an image during GitLab Runner installation.
2. Download and configure kubectl to connect to the cluster.

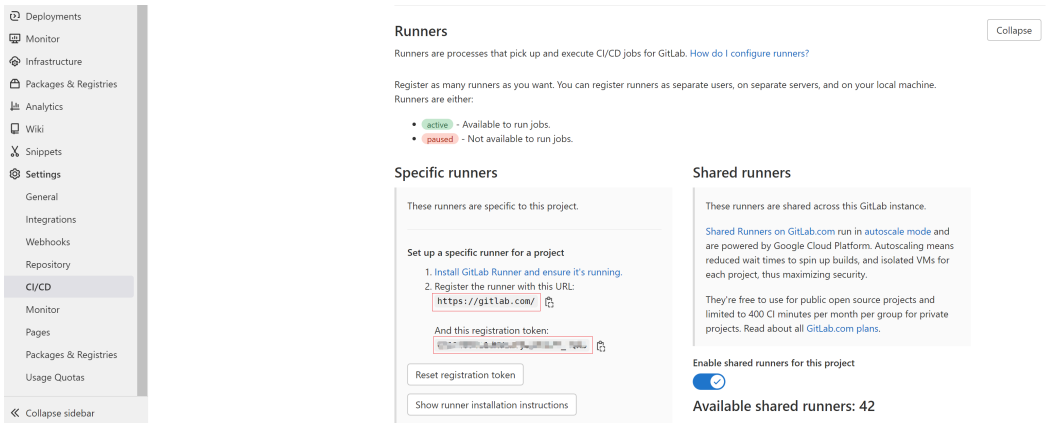
   Log in to the CCE console and click the cluster name to access the cluster console. In the navigation pane, choose **Overview**, locate the **Connection Information** area, click **Configure** next to **kubectl**, and configure kubectl as instructed.

3. **Install Helm 3**.

Installing GitLab Runner

Log in to **GitLab**, choose **Settings** > **CI/CD** in the project view, click **Expand** next to **Runners**, and search for the GitLab Runner registration URL and token.



Create the **values.yaml** file and fill in the following information:

```
# Registration URL
gitlabUrl: https://gitlab.com/
# Registration token
runnerRegistrationToken: "******"
rbac:
  create: true
runners:
  privileged: true
```

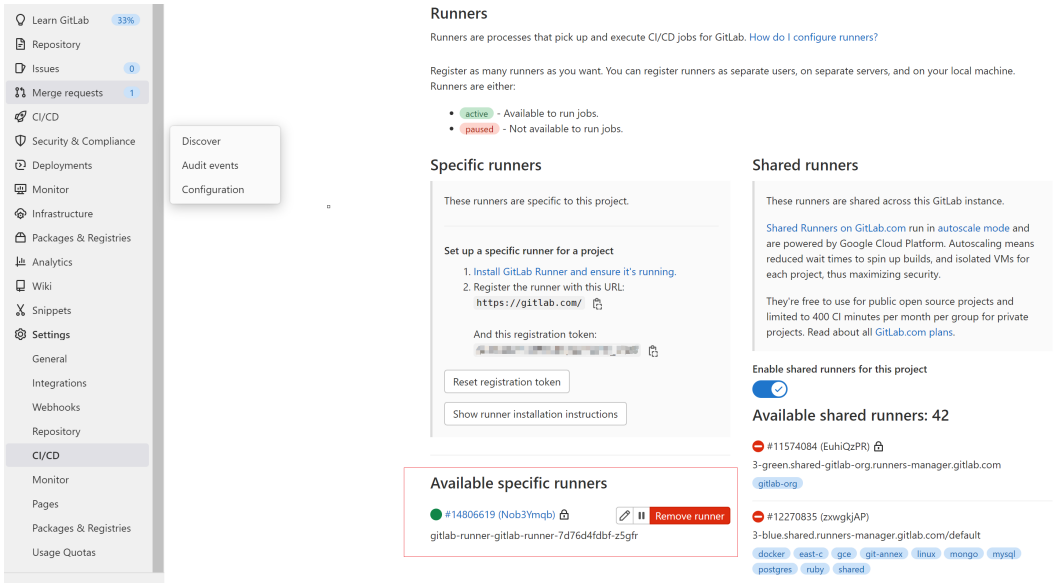
Create a GitLab namespace.

```
kubectl create namespace gitlab
```

Install GitLab Runner using Helm.

```
helm repo add gitlab https://charts.gitlab.io
helm install --namespace gitlab gitlab-runner -f values.yaml gitlab/gitlab-runner --version=0.43.1
```

After the installation, you can obtain the gitlab-runner workload on the CCE console and view the connection information in GitLab later.



Creating an Application

Place the application to be created in the GitLab project repository. This section takes Nginx modification as an example. For details, visit **https://gitlab.com/c8147/cidemo/-/tree/main**.

The following files are included:

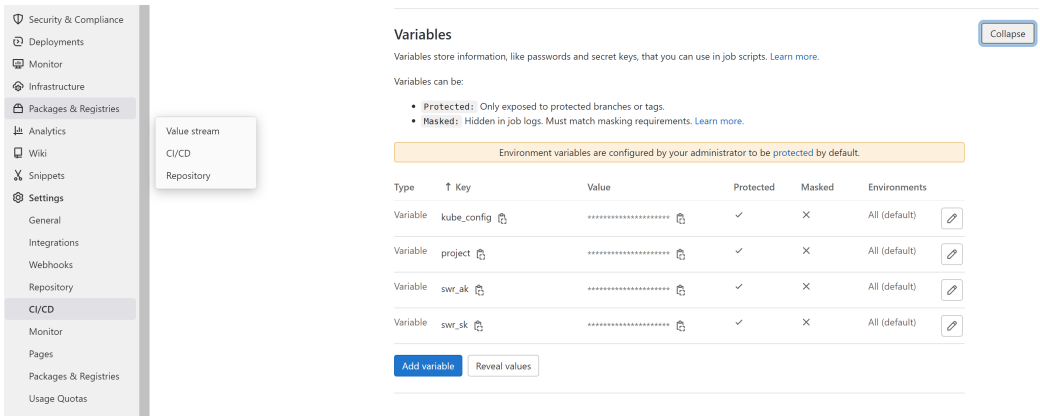
- **.gitlab-ci.yml**: Gitlab CI file, which will be described in detail in **Creating a Pipeline**.
- **Dockerfile**: used to build Docker images.
- **index.html**: used to replace the index page of Nginx.
- **k8s.yaml**: used to deploy the Nginx app. A Deployment named **nginx-test** and a Service named **nginx-test** will be created.

The preceding files are only examples. You can replace or modify them accordingly.

Configuring Global Variables

When using pipelines, build an image, upload it to SWR, and run kubectl commands to deploy the image in the cluster. Before performing these operations, you must log in to SWR and obtain the credential for connecting to the cluster. You can define the information as variables in GitLab.

Log in to **GitLab**, choose **Settings** > **CI/CD** in the project view, and click **Expand** next to **Variables** to add variables.



- **kube_config**

  kubeconfig.json file used for kubectl command authentication. Run the following command on the host where kubectl is configured to convert the file to the Base64 format:

  echo $(cat ~/.kube/config | base64) | tr -d " "

  The command output is the content of **kubeconfig.json**.

- **project**: project name.

  Log in to the management console, hover the cursor on your username in the upper right corner, and choose **My Credentials**. In the **Projects** area on the **API Credentials** page, check the name of the project in your current region.

- **swr_ak**: access key.

Log in to the management console, hover the cursor on your username in the upper right corner, and choose **My Credentials**. In the navigation pane, choose **Access Keys**. Click **Create Access Key**, enter the description, and click **OK**. In the displayed **Information** dialog box, click **Download**. After the certificate is downloaded, obtain the AK and SK information from the **credentials** file.

- **swr_sk**: secret key for logging in to SWR.

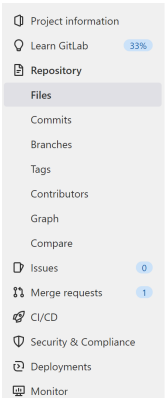
  Run the following command to obtain the key pair. Replace *$AK* and *$SK* with the AK and SK obtained in the preceding steps.

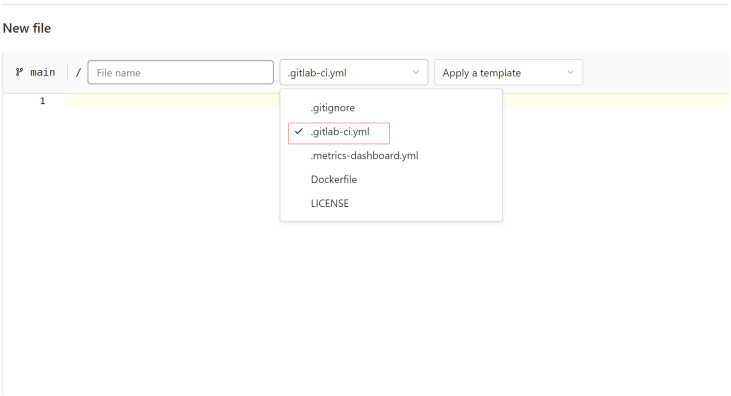
  printf "*$AK*" | openssl dgst -binary -sha256 -hmac "*$SK*" | od -An -vtx1 | sed 's/[\n]//g' | sed 'N;s/\n//'

  The command output displays the login key pair.

Creating a Pipeline

Log in to **Gitlab** and add the **.gitlab-ci.yml** file to **Repository**.





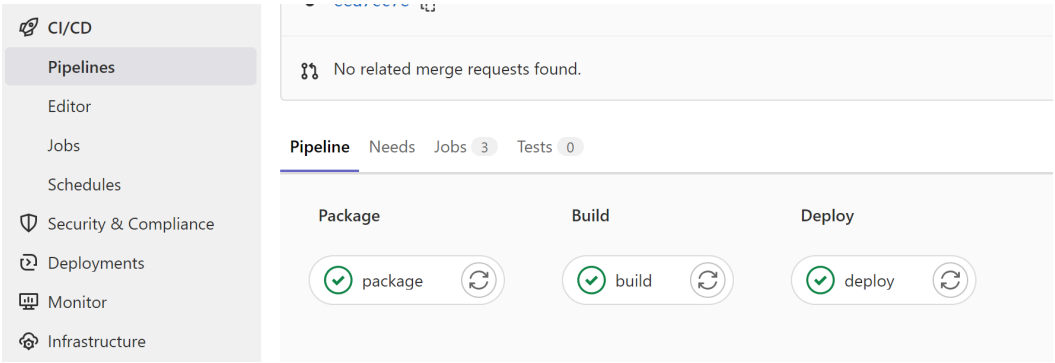
The content is as follows:

```
# Define pipeline stages, including package, build, and deploy.
stages:
  - package
  - build
  - deploy
# If no image is specified in each stage, the default image docker:latest is used.
image: swr.ap-southeast-3.myhuaweicloud.com/container/docker:latest
# In the package stage, only printing is performed.
package:
  stage: package
  script:
    - echo "package"
# In the build stage, the Docker-in-Docker mode is used.
build:
  stage: build
  # Define environment variables for the build stage.
  variables:
    DOCKER_HOST: tcp://docker:2375
  # Define the image for running Docker-in-Docker.
  services:
    - docker:18.09-dind
  script:
    - echo "build"
    # Log in to SWR.
    - docker login -u $project@$swr_ak -p $swr_sk swr.ap-southeast-3.myhuaweicloud.com
    # Build an image. k8s-dev is the organization name in SWR. Replace it to the actual name.
    - docker build -t swr.ap-southeast-3.myhuaweicloud.com/k8s-dev/nginx:$CI_PIPELINE_ID .
    # Push the image to SWR.
```



```
  - docker push swr.ap-southeast-3.myhuaweicloud.com/k8s-dev/nginx:$CI_PIPELINE_ID
deploy:
  # Use the kubectl image.
  image:
    name: swr.ap-southeast-3.myhuaweicloud.com/container/kubectl:latest
    entrypoint: [""]
  stage: deploy
  script:
    # Configure the kubeconfig file.
    - mkdir -p $HOME/.kube
    - export KUBECONFIG=$HOME/.kube/config
    - echo $kube_config |base64 -d > $KUBECONFIG
    # Replace the image in the k8s.yaml file.
    - sed -i "s/<IMAGE_NAME>/swr.ap-southeast-3.myhuaweicloud.com\/k8s-dev\/nginx:$CI_PIPELINE_ID/g"
k8s.yaml
    - cat k8s.yaml
    # Deploy an application.
    - kubectl apply -f k8s.yaml
```

After the **.gitlab-ci.yml** file is saved, the pipeline is started immediately. You can view the pipeline execution status in GitLab.



Verifying Deployment

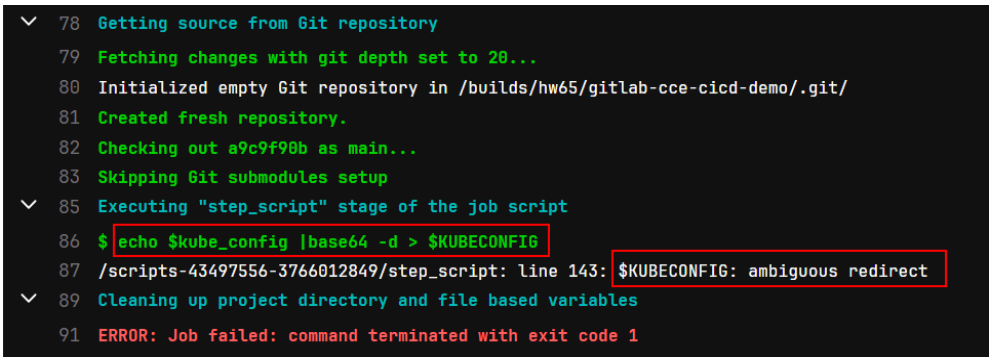
After the pipeline is deployed, locate the **nginx-test** Service on the CCE console, query its access address, and run the **curl** command to access the Service.

```
# curl xxx.xxx.xxx.xxx:31111
Hello Gitlab!
```

If the preceding information is displayed, the deployment is correct.

Common Issues

- If the following problem occurs during the deployment:



  Or


```
$ kubectl apply -f k8s.yaml
E0215 08:03:55.297105      19 memcache.go:255] couldn't get resource list for proxy.exporter.k8s.io/v1beta1: Got empty response for: proxy.exporter.k8s.io/v1beta1
Error from server (Forbidden): error when retrieving current configuration of:
Resource: "apps/v1, Resource=deployments", GroupVersionKind: "apps/v1, Kind=Deployment"
Name: "nginx-test", Namespace: "gitlab"
from server for: "k8s.yaml": deployments.apps "nginx-test" is forbidden: User "system:serviceaccount:gitlab:default" cannot get resource "deployments" in API group "apps" in the namespace "gitlab"
Error from server (Forbidden): error when retrieving current configuration of:
Resource: "/v1, Resource=services", GroupVersionKind: "/v1, Kind=Service"
Name: "nginx-test", Namespace: "gitlab"
from server for: "k8s.yaml": services "nginx-test" is forbidden: User "system:serviceaccount:gitlab:default" cannot get resource "services" in API group "" in the namespace "gitlab"
Cleaning up project directory and file based variables
00:01
ERROR: Job failed: command terminated with exit code 1
```

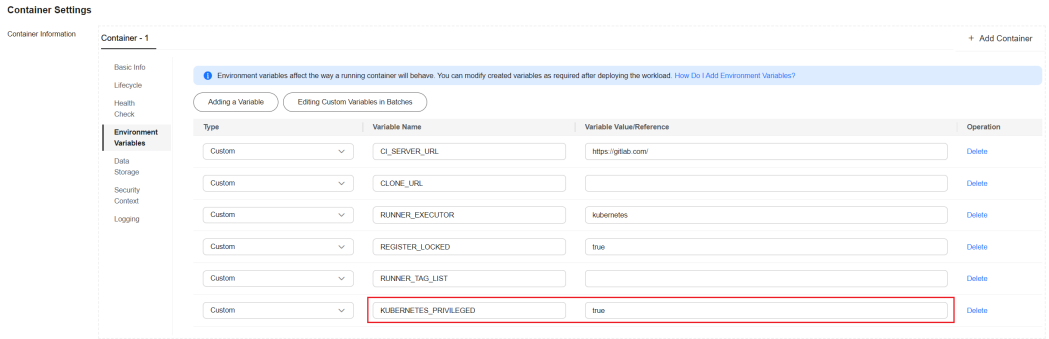
Check whether the following commands are missing in the **.gitlab-ci.yml** file. If yes, add them to the **.gitlab-ci.yml** file.

```
...
 script:
   # Configure the kubeconfig file.
   - mkdir -p $HOME/.kube
   - export KUBECONFIG=$HOME/.kube/config
   - echo $kube_config |base64 -d > $KUBECONFIG
   # Replace the image in the k8s.yaml file.
...
```

- If Docker cannot be executed, information similar to the following will display.

```
Configure a credential helper to remove this warning. See
https://docs.docker.com/engine/reference/commandline/login/#credentials-store
Login Succeeded
$ docker build -t swr.[redacted] com/wpf-test/nginx:$CI_PIPELINE_ID .
Cannot connect to the Docker daemon at tcp://docker:2375. Is the docker daemon running?
Cleaning up project directory and file based variables
00:00
ERROR: Job failed: command terminated with exit code 1
```

The **privileged: true** parameter fails to be transferred during GitLab Runner installation. As a result, you do not have the permissions to run the Docker command. To resolve this issue, find GitLab Runner in the workload list on the CCE console, add the environment variable **KUBERNETES_PRIVILEGED**, and set its value to **true**.

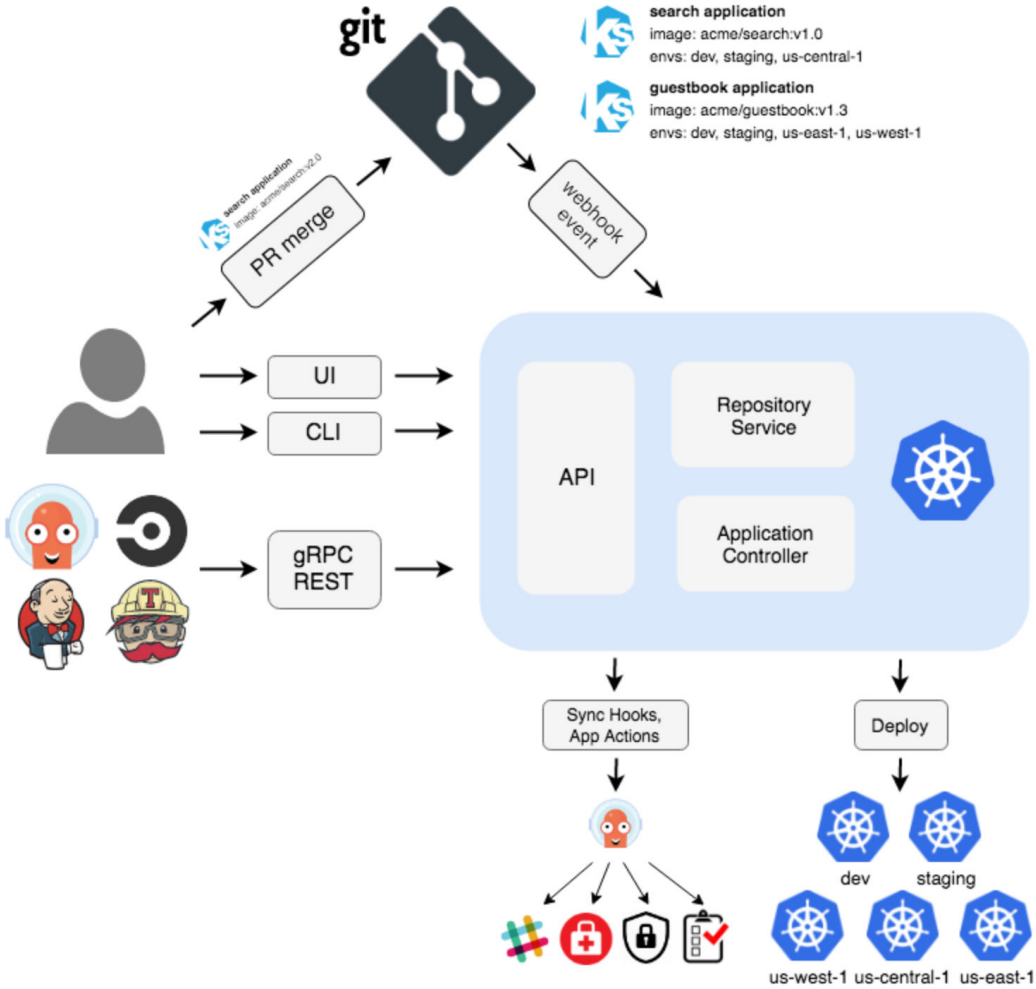


4.3 Continuous Delivery Using Argo CD

Background

ArgoCD is a declarative, GitOps continuous delivery tool for Kubernetes. Argo CD automates the deployment of applications to Kubernetes.

Figure 4-17 Argo CD workflow



This section describes how to interconnect ArgoCD with CCE to perform continuous deployment.

Preparations

1. Create a CCE cluster and a node and bind an EIP to the node for downloading an image during Argo CD installation.
2. Create an ECS, bind an EIP to the ECS, and download and configure kubectl to connect to the cluster. For details, see **Connecting to a Cluster Using kubectl**.

3. Prepare an application in the Git repository. This section uses the Nginx sample application in the **https://gitlab.com/c8147/examples.git** repository.

Installing Argo CD

Step 1 Install the Argo CD server in the cluster.

```
# kubectl create namespace argocd
# kubectl apply -n argocd -f https://raw.githubusercontent.com/argoproj/argo-cd/v2.4.0/manifests/install.yaml
```

Check whether the installation is successful. If all pods in the **argocd** namespace are in the **Running** status, the installation is successful.

```
# kubectl get pod -A
NAMESPACE     NAME                                                READY   STATUS    RESTARTS   AGE
argocd        argocd-application-controller-0                     1/1     Running   0          8m32s
argocd        argocd-applicationset-controller-789457b498-6n6l5   1/1     Running   0          8m32s
argocd        argocd-dex-server-748bddb496-bxj2c                  1/1     Running   0          8m32s
argocd        argocd-notifications-controller-8668ffdd75-q7wdb    1/1     Running   0          8m32s
argocd        argocd-redis-55d64cd8bf-g85np                       1/1     Running   0          8m32s
argocd        argocd-repo-server-778d695657-skprm                 1/1     Running   0          8m32s
argocd        argocd-server-59c9ccff4c-vd9ww                      1/1     Running   0          8m32s
```

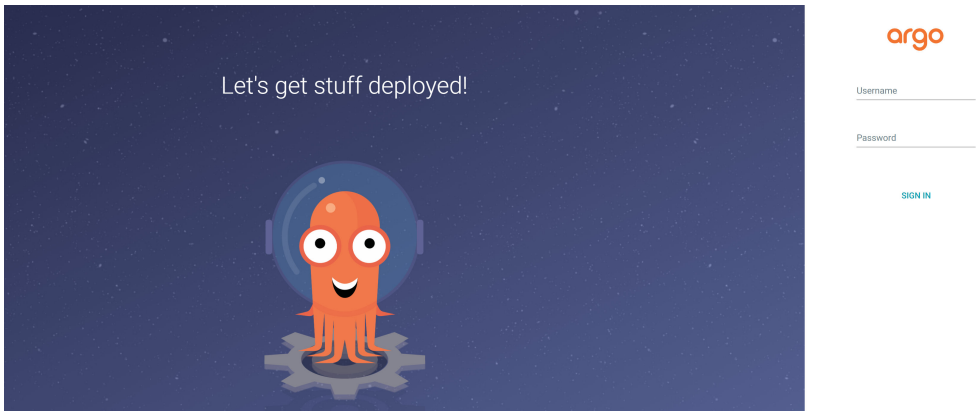
Run the following commands to change the Service type of **argocd-server** to **NodePort**:

```
# kubectl patch svc argocd-server -n argocd -p '{"spec": {"type": "NodePort"}}'
service/argocd-server patched
```

Check the result.

```
# kubectl -n argocd get svc
NAME                                  TYPE        CLUSTER-IP       EXTERNAL-IP   PORT(S)                      AGE
argocd-applicationset-controller      ClusterIP   10.247.237.53    <none>        7000/TCP,8080/TCP            18m
argocd-dex-server                     ClusterIP   10.247.164.111   <none>        5556/TCP,5557/TCP,5558/TCP   18m
argocd-metrics                        ClusterIP   10.247.138.98    <none>        8082/TCP                     18m
argocd-notifications-controller-metrics   ClusterIP   10.247.239.85    <none>        9001/TCP                     18m
argocd-redis                          ClusterIP   10.247.220.90    <none>        6379/TCP                     18m
argocd-repo-server                    ClusterIP   10.247.1.142     <none>        8081/TCP,8084/TCP            18m
argocd-server                         NodePort    10.247.57.16     <none>        80:30118/TCP,443:31221/TCP   18m
argocd-server-metrics                 ClusterIP   10.247.206.190   <none>        8083/TCP                     18m
```

To access Argo CD using the **argocd-server** Service, use ***Node IP:Port number***. In this example, the port number is **31221**.



The login username is **admin**, and the password can be obtained by running the following command:

```
# kubectl -n argocd get secret argocd-initial-admin-secret -o jsonpath="{.data.password}" | base64 -d;echo
```

Step 2 Install the Argo CD client on the ECS.

```
# wget https://github.com/argoproj/argo-cd/releases/download/v2.4.0/argocd-linux-amd64
# cp argocd-linux-amd64 /usr/local/bin/argocd
# chmod +x /usr/local/bin/argocd
```

Run the following commands. If the following information is displayed, the installation is successful.

```
# argocd version
argocd: v2.4.0+91aefab
  BuildDate: 2022-06-10T17:44:14Z
  GitCommit: 91aefabc5b213a258ddcfe04b8e69bb4a2dd2566
  GitTreeState: clean
  GoVersion: go1.18.3
  Compiler: gc
  Platform: linux/amd64
FATA[0000] Argo CD server address unspecified
```

----End

Deploying an Application Using Argo CD

Step 1 Add a CCE cluster to Argo CD.

1. Log in to an ECS.
2. Check the kubectl context configuration.

   ```
   # kubectl config get-contexts
   CURRENT   NAME       CLUSTER          AUTHINFO   NAMESPACE
   *         internal   internalCluster   user
   ```

3. Log in to the Argo CD server. The username is **admin**. You can obtain the server IP address and password from **Step 1**. If the ECS and the cluster are in the same VPC, the node IP address can be a private IP address.

   ```
   argocd login <Node IP address:Port number> --username admin --password <password>
   ```

   Information similar to the following is displayed:

   ```
   # argocd login 192.168.0.52:31221 --username admin --password ******
   WARNING: server certificate had error: x509: cannot validate certificate for 192.168.0.52 because it doesn't contain any IP SANs. Proceed insecurely (y/n)? y
   'admin:login' logged in successfully
   Context '192.168.0.52:31221' updated
   ```

4. Add a CCE cluster.

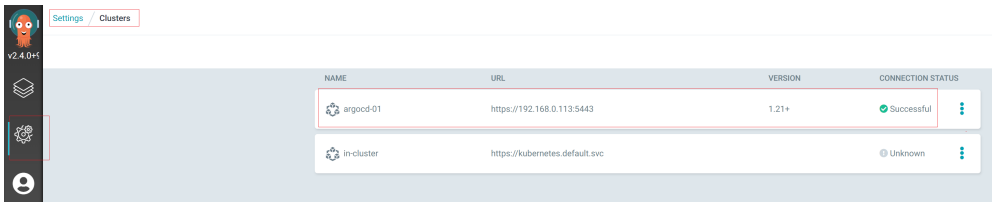
   ```
   # argocd cluster add internal --kubeconfig /root/.kube/config --name argocd-01
   ```

   In the preceding command, ***internal*** is the context name queried in **Step 1.2**, ***/root/.kube/config*** is the path of the kubectl configuration file, and ***argocd-01*** is the cluster name defined in Argo CD.

   Information similar to the following is displayed:

   ```
   WARNING: This will create a service account `argocd-manager` on the cluster referenced by context `internal` with full cluster level privileges. Do you want to continue [y/N]? y
   INFO[0002] ServiceAccount "argocd-manager" already exists in namespace "kube-system"
   INFO[0002] ClusterRole "argocd-manager-role" updated
   INFO[0002] ClusterRoleBinding "argocd-manager-role-binding" updated
   Cluster "https://192.168.0.113:5443"" added
   ```

   Log in to the Argo CD page. You can see that the connection is successful.



Step 2 Connect to the Git repository.

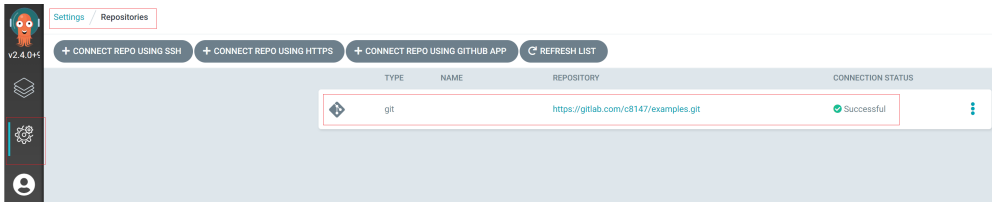
```
# argocd repo add https://gitlab.com/c8147/examples.git --username <username>  --password <password>
```

In the preceding command, ***https://gitlab.com/c8147/examples.git*** indicates the repository address, and ***<username>*** and ***<password>*** indicate the repository login username and password. Replace them with the actual values.

Information similar to the following is displayed:

```
Repository 'https://gitlab.com/c8147/cidemo.git' added
```

Log in to the Argo CD page. You can see that the cluster has been added.



Step 3 Add an application to Argo CD.

```
# argocd app create nginx --repo https://gitlab.com/c8147/examples.git  --path nginx --dest-server https://192.168.0.113:5443 --dest-namespace default
```

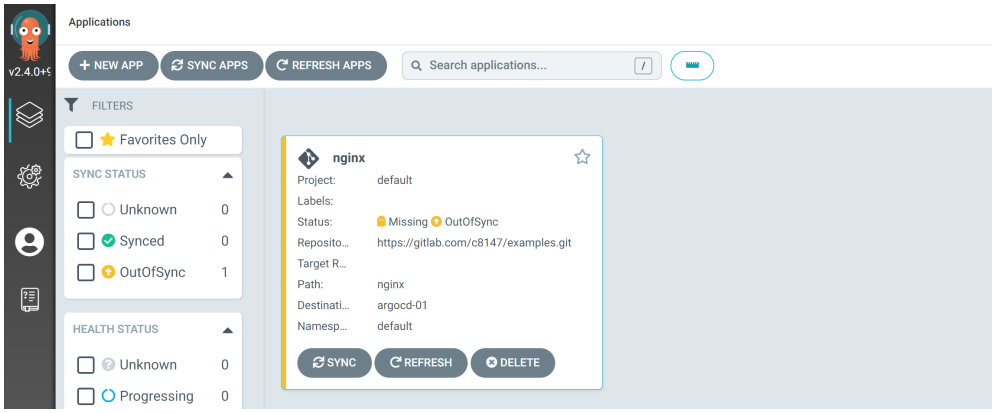
https://gitlab.com/c8147/examples.git indicates the repository address, ***nginx*** indicates the repository path, ***https://192.168.0.113:5443*** indicates the address of the cluster to be deployed, and ***default*** indicates the namespace.

In this example, the nginx directory in the GitLab repository contains a YAML file of the Nginx application. The file includes a Deployment and a Service.

After the application is created, you can view its details.

```
# argocd app list
NAME  CLUSTER                         NAMESPACE  PROJECT  STATUS     HEALTH   SYNCPOLICY  CONDITIONS  REPO                                PATH  TARGET
nginx  https://192.168.0.113:5443  default    default  OutOfSync  Missing  <none>      <none>      https://gitlab.com/c8147/examples.git  nginx
```

Log in to the Argo CD page. You can see that the application has been added.



Step 4 Synchronize the application.

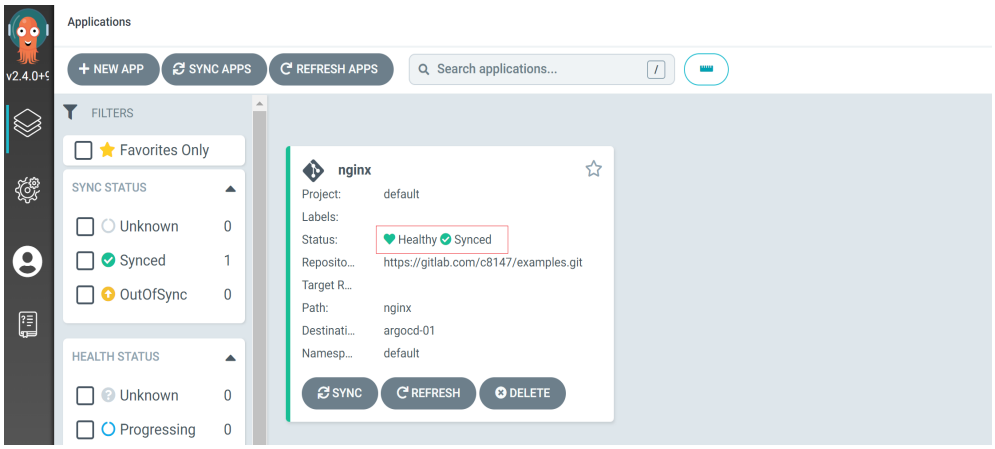
Synchronize the application and deploy it on a specified cluster. Run the following commands:

```
# argocd app sync nginx
TIMESTAMP                  GROUP        KIND   NAMESPACE                  NAME    STATUS    HEALTH
HOOK  MESSAGE
2022-10-24T12:15:10+08:00            Service     default                nginx  OutOfSync  Missing
2022-10-24T12:15:10+08:00   apps  Deployment     default                nginx  OutOfSync  Missing
2022-10-24T12:15:10+08:00            Service     default                nginx    Synced   Healthy
2022-10-24T12:15:10+08:00            Service     default                nginx    Synced   Healthy              service/
nginx created
2022-10-24T12:15:10+08:00   apps  Deployment     default                nginx  OutOfSync  Missing
deployment.apps/nginx created
2022-10-24T12:15:10+08:00   apps  Deployment     default                nginx    Synced   Progressing
deployment.apps/nginx created

Name:               nginx
Project:            default
Server:             https://192.168.0.113:5443
Namespace:          default
URL:                https://192.168.0.178:32459/applications/nginx
Repo:               https://gitlab.com/c8147/examples.git
Target:
Path:               nginx
SyncWindow:         Sync Allowed
Sync Policy:        <none>
Sync Status:        Synced to  (dd15906)
Health Status:      Progressing

Operation:          Sync
Sync Revision:      dd1590679856bd9288036847bdc4a5556c169267
Phase:              Succeeded
Start:              2022-10-24 12:15:10 +0800 CST
Finished:           2022-10-24 12:15:10 +0800 CST
Duration:           0s
Message:            successfully synced (all tasks run)

GROUP  KIND        NAMESPACE  NAME   STATUS  HEALTH       HOOK  MESSAGE
       Service     default    nginx  Synced  Healthy            service/nginx created
apps   Deployment  default    nginx  Synced  Progressing        deployment.apps/nginx created
```

You can see that an Nginx workload and a Service are deployed in a CCE cluster.

```
# kubectl get deployment
NAME    READY   UP-TO-DATE   AVAILABLE   AGE
nginx   1/1     1            1           2m47s
# kubectl get svc
NAME         TYPE        CLUSTER-IP      EXTERNAL-IP   PORT(S)    AGE
kubernetes   ClusterIP   10.247.0.1      <none>        443/TCP    5h12m
nginx        ClusterIP   10.247.177.24   <none>        80/TCP     2m52s
```

Log in to the Argo CD page. You can see that the application status has changed to **Synced**.



----End

Using Argo Rollouts for Grayscale Release

Argo Rollouts is a Kubernetes controller that provides advanced deployment capabilities such as blue-green, grayscale (canary) release, and progressive delivery.

Step 1 Install an argo-rollouts server in the cluster.

```
# kubectl create namespace argo-rollouts
# kubectl apply -f https://github.com/argoproj/argo-rollouts/releases/download/v1.2.2/install.yaml -n argo-rollouts
```

NOTE

If the application is deployed in multiple clusters, install the argo-rollouts server in each target cluster.

Step 2 Install the kubectl add-on of argo-rollouts on the ECS.

```
# curl -LO https://github.com/argoproj/argo-rollouts/releases/download/v1.2.2/kubectl-argo-rollouts-linux-amd64
# chmod +x ./kubectl-argo-rollouts-linux-amd64
# sudo mv ./kubectl-argo-rollouts-linux-amd64 /usr/local/bin/kubectl-argo-rollouts
```

Run the following commands to check whether the add-on has been installed:

```
# kubectl argo rollouts version
kubectl-argo-rollouts: v1.2.2+22aff27
  BuildDate: 2022-07-26T17:24:43Z
  GitCommit: 22aff273bf95646e0cd02555fbe7d2da0f903316
  GitTreeState: clean
  GoVersion: go1.17.6
  Compiler: gc
  Platform: linux/amd64
```

Step 3 Prepare two sample Nginx application images whose versions are v1 and v2, respectively. The welcome pages are displayed as "**nginx:v1!**" and "**nginx:v2!**", respectively.

Create a Dockerfile. The content of the Dockerfile for v1 is as follows. For v2, replace **nginx:v1!** with **nginx:v2!**.

```
FROM nginx:latest
RUN echo '<h1>nginx:v1!</h1>' > /usr/share/nginx/html/index.html
```

Create a v1 image.

```
docker build -t nginx:v1 .
```


Log in to SWR and push the image to SWR. For details, see **Uploading an Image Through a Container Engine Client**. During the push, **container** indicates the organization name in SWR. Set it as required.

```
docker login -u {region}@xxx -p xxx swr.{region}.myhuaweicloud.com
docker tag nginx:v1 swr.cn-east-3.myhuaweicloud.com/container/nginx:v1
docker push swr.cn-east-3.myhuaweicloud.com/container/nginx:v1
```

Create a v2 image and push it to SWR in the same way.

Step 4 Deploy an Argo Rollouts controller. In this example, the controller first shifts 20% of all service traffic to the new version. Then, manually increase the traffic proportion. After that, the controller automatically and gradually increases traffic until the release is complete.

Create a file named **rollout-canary.yaml**:

```
apiVersion: argoproj.io/v1alpha1
kind: Rollout
metadata:
  name: rollout-canary  # Custom Rollout name
spec:
  replicas: 5  # Five replicas
  strategy:  # Upgrade policy
    canary:   # Grayscale (canary) release
      steps:  # Release pace (duration can be set for each phase)
      - setWeight: 20 # Traffic weight
      - pause: {}  # If this field is not specified, the release is paused.
      - setWeight: 40
      - pause: {duration: 10}  # Pause duration, in seconds.
      - setWeight: 60
      - pause: {duration: 10}
      - setWeight: 80
      - pause: {duration: 10}
  revisionHistoryLimit: 2
  selector:
    matchLabels:
      app: rollout-canary
  template:
    metadata:
      labels:
        app: rollout-canary
    spec:
      containers:
      - name: rollout-canary
        image: swr.cn-east-3.myhuaweicloud.com/container/nginx:v1  # The pushed image, whose version is
v1.
        ports:
        - name: http
          containerPort: 80
          protocol: TCP
        resources:
          requests:
            memory: 32Mi
            cpu: 5m
      imagePullSecrets:
        - name: default-secret
---
apiVersion: v1
kind: Service
metadata:
  name: rollout-canary
spec:
  type: NodePort
  ports:
  - port: 80
    targetPort: 80
    nodePort: 31270  # The custom node port number
```



```
selector:
  app: rollout-canary
```

Run the following command to create the preceding two resource objects:

```
kubectl apply -f rollout-canary.yaml
```

NOTE

The Argo Rollouts controller does not trigger upgrade during initial creation and the configured release policy does not take effect. Only the number of replicas increases to 100% immediately.

Step 5 Argo Rollouts visualizes the rollout process and related resource objects to display real-time changes. You can run the **get rollout --watch** command to observe the deployment process, for example:

```
kubectl argo rollouts get rollout rollout-canary --watch
```

In the preceding command, ***rollout-canary*** indicates the custom Rollout name.

```
NAME                                      KIND        STATUS     AGE  INFO
⟳ rollout-canary                          Rollout     ✓ Healthy  8s
└──# revision:1
   └──⧉ rollout-canary-d66dc64d           ReplicaSet  ✓ Healthy  8s   stable
      ├──□ rollout-canary-d66dc64d-bw6sm  Pod         ✓ Running  8s   ready:1/1
      ├──□ rollout-canary-d66dc64d-h89kl  Pod         ✓ Running  8s   ready:1/1
      ├──□ rollout-canary-d66dc64d-kwwnm  Pod         ✓ Running  8s   ready:1/1
      ├──□ rollout-canary-d66dc64d-r6zw4  Pod         ✓ Running  8s   ready:1/1
      └──□ rollout-canary-d66dc64d-rbsr6  Pod         ✓ Running  8s   ready:1/1
```

Step 6 After the creation is complete, you can access the Nginx application using ***Node EIP:Port number***. The port number is specified in the Service resource in the **rollout-canary.yaml file**. In this example, the port number is **31270**.

Step 7 Use the v2 image to update the application.

```
kubectl argo rollouts set image rollout-canary rollout-canary=swr.cn-east-3.myhuaweicloud.com/container/nginx:v2
```

The controller will update the application according to the update policy. In this example, a 20% traffic weight is set in the first step, and the release is paused until the user cancels or continues. You can run the following command to view the detailed process. The release is paused.

```
kubectl argo rollouts get rollout rollout-canary --watch
```

You can view that only one of the five replicas runs the new version, that is, the weight of 20% defined in **setWeight: 20**.

```
NAME                                      KIND        STATUS     AGE  INFO
⟳ rollout-canary                          Rollout     ॥ Paused   49s
├──# revision:2
│  └──⧉ rollout-canary-8644685965         ReplicaSet  ✓ Healthy  9s   canary
│     └──□ rollout-canary-8644685965-9mvvw Pod         ✓ Running  9s   ready:1/1
└──# revision:1
   └──⧉ rollout-canary-d66dc64d           ReplicaSet  ✓ Healthy  49s  stable
      ├──□ rollout-canary-d66dc64d-h89kl  Pod         ✓ Running  49s  ready:1/1
      ├──□ rollout-canary-d66dc64d-kwwnm  Pod         ✓ Running  49s  ready:1/1
      ├──□ rollout-canary-d66dc64d-r6zw4  Pod         ✓ Running  49s  ready:1/1
      └──□ rollout-canary-d66dc64d-rbsr6  Pod         ✓ Running  49s  ready:1/1
```

If you run the following command for multiple times, 20% of the response results are the response of v2.


```
for i in {1..10}; do curl <Node EIP:Port number>; done;
```

Verification result:

```
<h1>nginx:v2!</h1>
<h1>nginx:v1!</h1>
<h1>nginx:v1!</h1>
<h1>nginx:v1!</h1>
<h1>nginx:v1!</h1>
<h1>nginx:v1!</h1>
<h1>nginx:v1!</h1>
<h1>nginx:v1!</h1>
<h1>nginx:v2!</h1>
<h1>nginx:v1!</h1>
```

Step 8 Manually update the version.

```
kubectl argo rollouts promote rollout-canary
```

In this example, the remaining steps are fully automated until the release is complete. Run the following command to view the detailed process. The controller gradually switches all traffic to the new version.

```
kubectl argo rollouts get rollout rollout-canary --watch
```

```
NAME                                       KIND        STATUS        AGE    INFO
⟳ rollout-canary                           Rollout     ✓ Healthy     2m16s
├──# revision:2
│  └──⧉ rollout-canary-8644685965          ReplicaSet  ✓ Healthy     96s    stable
│     ├──□ rollout-canary-8644685965-9mvvw  Pod         ✓ Running     96s    ready:1/1
│     ├──□ rollout-canary-8644685965-z9nbw  Pod         ✓ Running     48s    ready:1/1
│     ├──□ rollout-canary-8644685965-jplvs  Pod         ✓ Running     37s    ready:1/1
│     ├──□ rollout-canary-8644685965-724jn  Pod         ✓ Running     27s    ready:1/1
│     └──□ rollout-canary-8644685965-frblf  Pod         ✓ Running     17s    ready:1/1
└──# revision:1
   └──⧉ rollout-canary-d66dc64d            ReplicaSet  • ScaledDown  2m16s
```

Step 9 You can run the following command to use more Argo Rollouts functions, such as terminating or rolling back a release:

```
kubectl argo rollouts --help
```

----End

4.4 Implementing Separate DevOps Processes for Multiple Clusters Using Jenkins and GitLab

4.4.1 Solution Overview

DevOps is a set of processes, methods, and systems that promote close communication, efficient collaboration, and integration between development (applications or software engineering), technical operations, and quality assurance (QA) departments. By using automatic software delivery and architecture change processes, DevOps enables faster, more frequent, and more reliable planning, development, build, tests, releases, deployment, and maintenance, resulting in stable and reliable development outcomes. As microservices and middle-end architectures continue to emerge, DevOps becomes increasingly crucial.

Solution Architecture

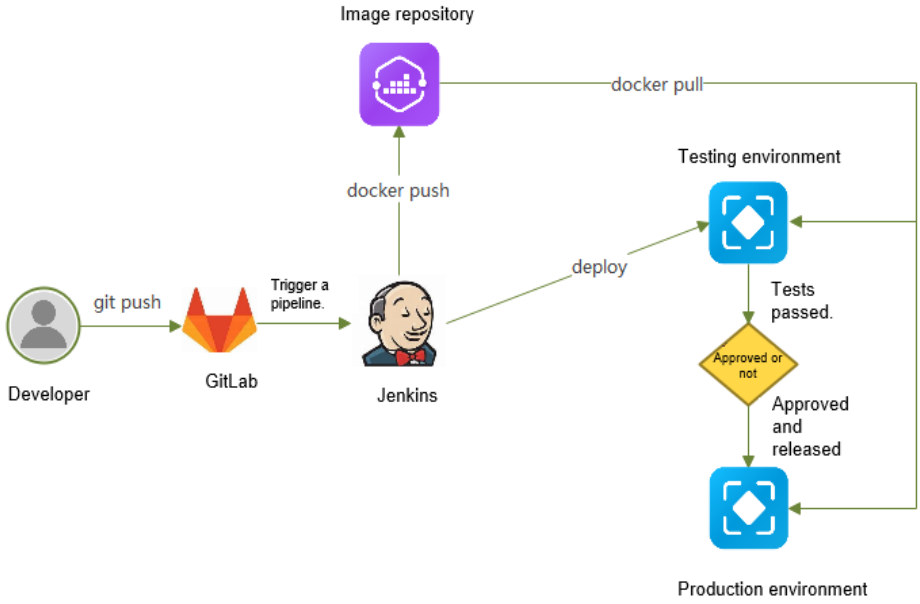
This solution uses GitLab and Jenkins to automate the building and continuous deployment of containerized applications. GitLab handles source code

management and versioning, while Jenkins is responsible for building and deploying the containerized applications. To maintain high isolation between the production and testing environments, two separate Kubernetes clusters are used, one for each environment.

The following shows an example of the complete process, starting from source code compilation and image building, to application testing, production, and rollout:

1. Create a Git repository in GitLab and associate it with Jenkins.
2. Create a build job in Jenkins and allow it to use the Git repository of GitLab.
3. In the build job, configure the compiler and build parameters so that the source code can be obtained from the Git repository and compiled.
4. Push the compiled image to the SWR image repository.
5. Deploy the image in a Kubernetes cluster in the testing environment.
6. After the image passes the test and is approved, deploy it in a Kubernetes cluster in the production environment.

Figure 4-18 Architecture



Solution Highlights

- The entire process, from code submission to deployment and rollout, is automated, resulting in a significant improvement in delivery efficiency.
- Containerized applications are ready to use out-of-the-box, and they can be reused at a low cost.
- To ensure that the testing and production environments operate independently and do not interfere with each other, multiple Kubernetes clusters are isolated.

4.4.2 Resource Planning

In this example, you need to create a VPC, an ECS, a CCE cluster, and a VPC peering connection. For details about the resource planning, see **Table 4-6**.

NOTE

The following resource planning details are only examples for your reference. You need to plan resources based on actual service requirements.

Table 4-6 Resource and cost planning

Resource	Description
VPC	In this example, there are three VPCs, including the VPC where the ECS resides and the VPC where the testing cluster and production cluster reside. These VPCs are located in the same region, and the subnet CIDR blocks of these VPCs do not overlap. • vpc-X: 192.168.0.0/16 (VPC where the ECS with GitLab and Jenkins installed resides) • vpc-A: 172.16.0.0/16 (VPC to which the testing cluster resides) • vpc-B: 172.17.0.0/16 (VPC where the production cluster resides)
ECS	In this example, there is one ECS located in vpc-X (with CIDR block of 192.168.0.0/16). • Node flavor: 4 vCPUs | 16 GiB • OS: Huawei Cloud EulerOS 2.0 • EIP: An EIP is automatically created for the node to access the public network and pull images.
CCE cluster	In this example, there are two CCE clusters, including the testing and production clusters. The following lists some key parameter configurations. (You can configure other parameters as required or use their default values.) • Cluster type: CCE Turbo cluster • VPC: The testing cluster is located in vpc-A (172.16.0.0/16), and the production cluster is located in vpc-B (172.17.0.0/16). • Actual number of nodes: 1 per cluster • Node configurations: – Node flavor: 4 vCPUs | 16 GiB – OS: Huawei Cloud EulerOS 2.0 – EIP: An EIP is automatically created for the node to access the public network and pull images.

Resource	Description
VPC peering connection	In this example, there are two VPC peering connections. The network connection requirements are as follows: • peer-XA: connects vpc-X to vpc-A. • peer-XB: connects vpc-X to vpc-B.

4.4.3 Procedure

4.4.3.1 Setting Up the Jenkins and GitLab Environments

Prerequisites

- A new VPC has been created. In this example, the VPC is named **vpc-X** and the CIDR block is **192.168.0.0/16**.
- An ECS in **vpc-X** (with CIDR block of **192.168.0.0/16**) has been created. The recommended flavors for this ECS are 4 vCPUs and 16 GiB, and it runs Huawei Cloud EulerOS 2.0. An EIP has been bound to the ECS to pull images from the Internet.

Installing Docker of a Specified Version

Step 1 Log in to the ECS.

Step 2 Quickly install Docker of the latest version on the device running Huawei Cloud EulerOS 2.0. You can also manually install Docker. For details, see **Docker Engine installation**.

```
dnf install docker
```

Step 3 Check whether Docker is installed.

```
docker info
```

```
[root@devops-ecs ~]# docker info
Client: Docker Engine - Community
 Version:    25.0.3
 Context:    default
 Debug Mode: false
 Plugins:
  buildx: Docker Buildx (Docker Inc.)
    Version:  v0.12.1
```

----End

Installing and Configuring GitLab

Step 1 Pull the GitLab image.

```
docker pull gitlab/gitlab-ce
```

Step 2 Run the container.

```
docker run -d -p 443:443 -p 80:80 -p 222:22 --name gitlab --restart always -v /home/gitlab/config:/etc/gitlab -v /home/gitlab/logs:/var/log/gitlab -v /home/gitlab/data:/var/opt/gitlab gitlab/gitlab-ce
```

Step 3 Check the container status.

```
docker ps | grep gitlab
```


Step 4 Configure **gitlab.rb** (with the node path of **/home/gitlab/config/gitlab.rb**). GitLab generates a project URL based on the container's host name (that is, the container ID) when a project is created. However, a fixed URL is required for the GitLab server. To achieve this, you must configure **gitlab.rb**.

1. Run the **vi** command on the node to open **/home/gitlab/config/gitlab.rb**.
   ```
   vi /home/gitlab/config/gitlab.rb
   ```
   Add the following content to it:
   ```
   external_url 'http://**.**.**.**' //External IP address of the node, for example, EIP
   gitlab_rails['gitlab_ssh_host'] = '**.**.**.**' //External IP address of the node, for example, EIP
   gitlab_rails['gitlab_shell_ssh_port'] = 222 //This port is mapped when the container is started. (222->22)
   ```
2. Save the changes.

Step 5 Restart the container.

```
docker restart gitlab
```

Step 6 Use a browser to access **ECS EIP:80** and log in to the GitLab service.

The default username is **root**, and the initial login password is stored in the **/etc/gitlab/initial_root_password** directory of the GitLab container.

You can run the following command to obtain the password:

```
docker exec gitlab cat /etc/gitlab/initial_root_password
```

----End

Installing and Configuring Jenkins

Step 1 Pull the Jenkins image.

```
docker pull jenkins/jenkins:lts
```

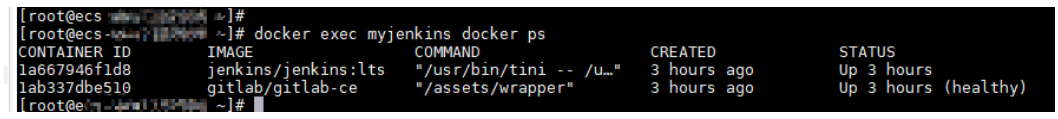
Step 2 Run the Jenkins container.

To execute commands like **docker build** within the container, the container must have the capability of docker in docker (dind). This requires mounting **docker.sock** and **docker** to the container.

```
docker run -d -p 8000:8080 -p 50000:50000 \
 -v /var/jenkins_home:/var/jenkins_home \
 -v /var/run/docker.sock:/var/run/docker.sock \
 -v /usr/bin/docker:/usr/bin/docker \
 --name myjenkins --privileged=true -u root jenkins/jenkins:lts
```

Step 3 Test whether the docker command can be executed in the Jenkins container.

```
docker exec myjenkins docker ps
```



CAUTION

If the error message "docker: error while loading shared libraries: libltdl.so.7: cannot open shared object file: No such file or directory" is displayed, run the following command to address this issue:

```
docker exec myjenkins sh -c "apt-get update && apt-get install -y libltdl7"
```

Step 4 Use a browser to access **ECS EIP:8000** and log in to the Jenkins service.

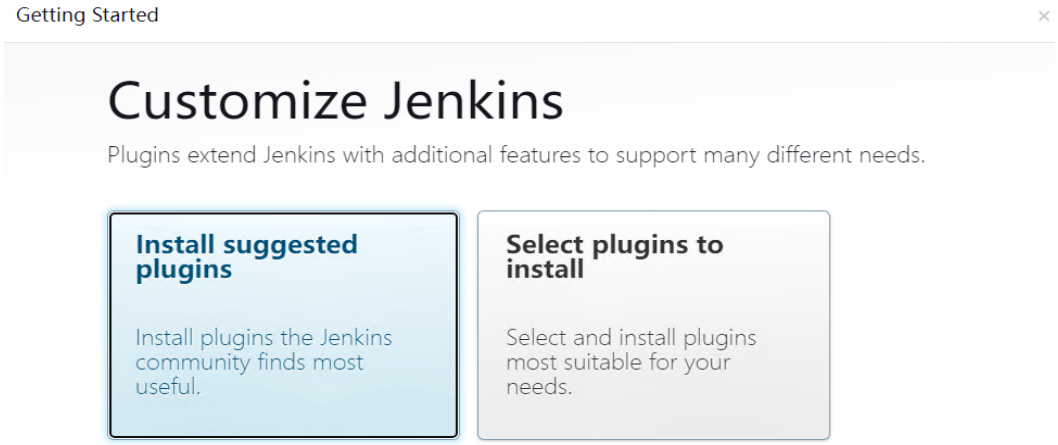
The default username is **root**, and the initial login password is stored in **the /var/jenkins_home/secrets/initialAdminPassword** directory of the container.

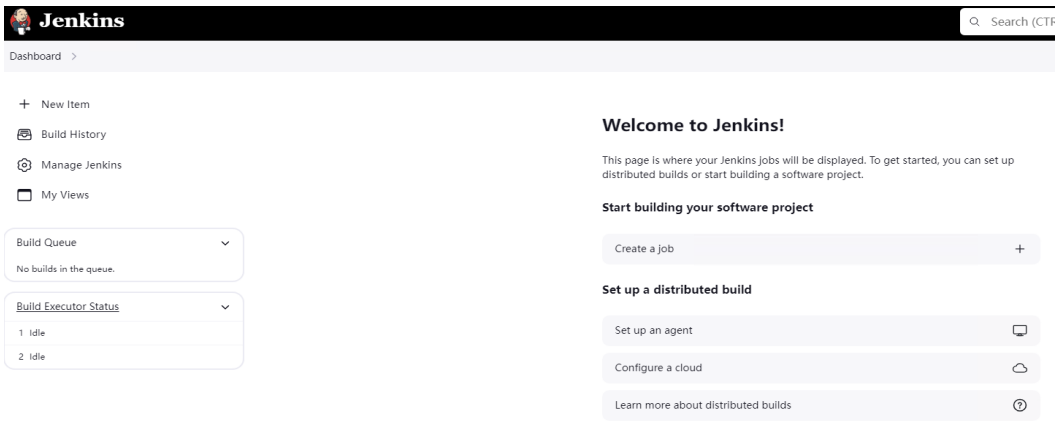
You can run the following command to obtain the password:

```
docker exec myjenkins cat /var/jenkins_home/secrets/initialAdminPassword
```

Step 5 Install the recommended plugins.

After the initial configuration is complete, the Jenkins page is displayed.





Step 6 Install the kubectl command line tool.

1. Download kubectl to the local PC.

   It is recommended that kubectl be of the same version as the cluster to be used. For details, see **kubectl**.

   ```
   wget https://dl.k8s.io/release/v*.*.*/bin/linux/amd64/kubectl  // v*.*.* specifies the cluster version.
   ```

2. Copy kubectl to the Jenkins container.

   ```
   docker cp kubectl myjenkins:/usr/bin/
   docker exec myjenkins chmod +x /usr/bin/kubectl
   ```

Step 7 Configure Jenkins to obtain GitLab code without a password.

1. Obtain the SSH public key.

   ```
   docker exec -it myjenkins ssh-keygen -t rsa
   ```

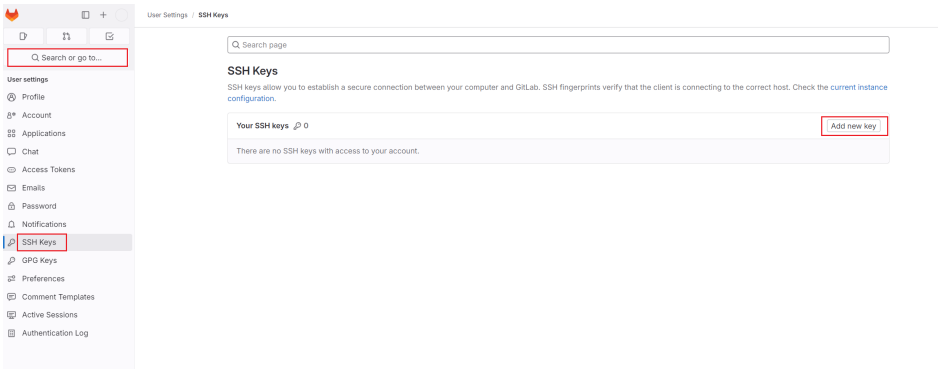
   Press **Enter** to skip configuring other parameters.

   You do not have to adjust the settings for parameters that are already set to their default values.

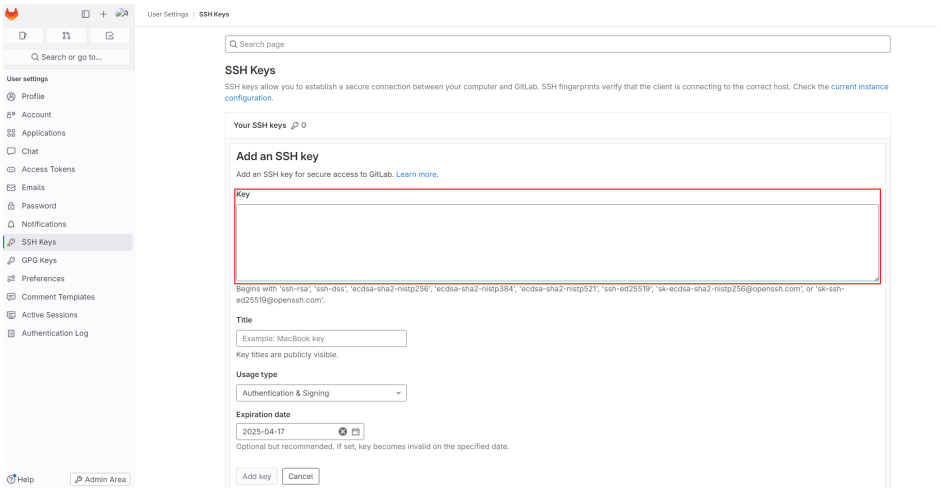
   Check the generated public key.

   ```
   docker exec myjenkins cat /root/.ssh/id_rsa.pub
   ```

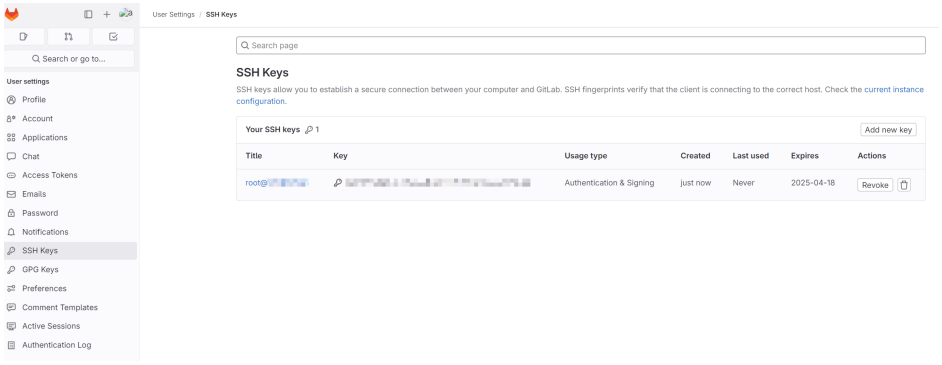
2. Search for **SSH** in GitLab and add a new key.

3. Enter an SSH public key.

4. Save the SSH key.



----End

4.4.3.2 Configuring Cluster Environments

Prerequisites

Two new VPCs have been created, and their CIDR blocks do not overlap. In this example, the VPC is named **vpc-A** and the CIDR block is 172.16.0.0/16. The other VPC is named **vpc-B** and the CIDR block is 172.17.0.0/16.

Creating a Cluster in the Testing Environment

Step 1 Log in to the CCE console and click **Buy Cluster** in the upper right corner on the **Clusters** page.

Step 2 Configure the cluster. The following lists some key parameter configurations. You can configure other parameters as required or use their default values. For details, see **Buying a CCE Standard/Turbo Cluster**.

- **Type**: **CCE Turbo Cluster**
- **Cluster Version**: Select the latest version.
- **VPC**: Select **vpc-A** with the CIDR block of 172.16.0.0/16.

Step 3 Configure other parameters, complete the cluster creation, and wait until the cluster is running.

Step 4 In the navigation pane, choose **Nodes**, click the **Nodes** tab, and click **Create Node** in the upper right corner.

Step 5 Configure the node. The following lists some key parameter configurations. You can configure other parameters as required or use their default values. For details, see **Creating a Node**.

- **Specifications**: Select a flavor with 4 vCPUs and 16 GiB of memory.
- **OS**: **Huawei Cloud EulerOS 2.0**
- **EIP**: Select **Auto create** and bind an EIP to the node. The EIP can be used to pull public network images and perform other operations.

Step 6 Confirm the specifications and create the node.

One node can meet the basic requirements in this practice.

----End

Creating a Cluster in the Production Environment

Step 1 Log in to the CCE console and click **Buy Cluster** in the upper right corner on the **Clusters** page.

Step 2 Configure the cluster. The following lists some key parameter configurations. You can configure other parameters as required or use their default values. For details, see **Buying a CCE Standard/Turbo Cluster**.

- **Type**: **CCE Turbo Cluster**
- **Cluster Version**: Select the latest version.
- **VPC**: Select **vpc-B** with the CIDR block of 172.17.0.0/16.

Step 3 Configure other parameters, complete the cluster creation, and wait until the cluster is running.

Step 4 In the navigation pane, choose **Nodes**, click the **Nodes** tab, and click **Create Node** in the upper right corner.

Step 5 Configure the node pool. The following lists some key parameter configurations. You can configure other parameters as required or use their default values. For details, see **Creating a Node**.

- **Specifications**: Select a flavor with 4 vCPUs and 16 GiB of memory.
- **OS**: **Huawei Cloud EulerOS 2.0**
- **EIP**: Select **Auto create** and bind an EIP to the node. The EIP can be used to pull public network images and perform other operations.

Step 6 Confirm the specifications and create the node. One node can meet the basic requirements in this practice.

----End

Creating VPC Peering Connections

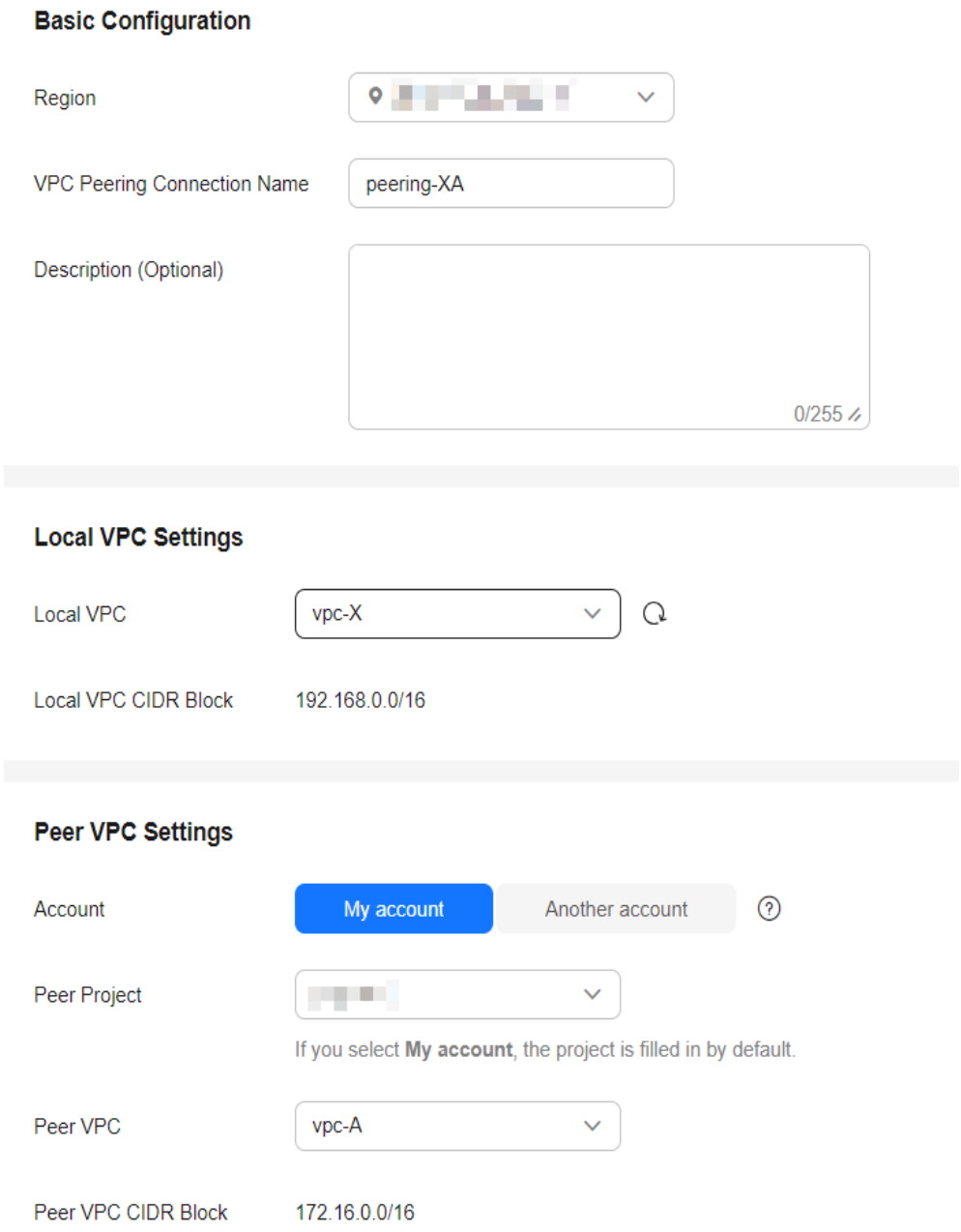
To enable Jenkins to access the API servers of the testing and production clusters, VPC peering connections need to be created since they are located in different VPCs.

Step 1 Log in to the VPC console. In the navigation pane, choose **Virtual Private Cloud** > **VPC Peering Connections**.

Step 2 Enable the network between the Jenkins server and the testing cluster.

1. In the upper right corner, click **Create VPC Peering Connection**. Configure the parameters following instructions.
   - **VPC Peering Connection Name**: **peering-XA**
   - **Local VPC**: **vpc-X** where the Jenkins server resides
   - **Peer VPC**: **vpc-A** where the testing cluster resides

Figure 4-19 Creating a VPC peering connection

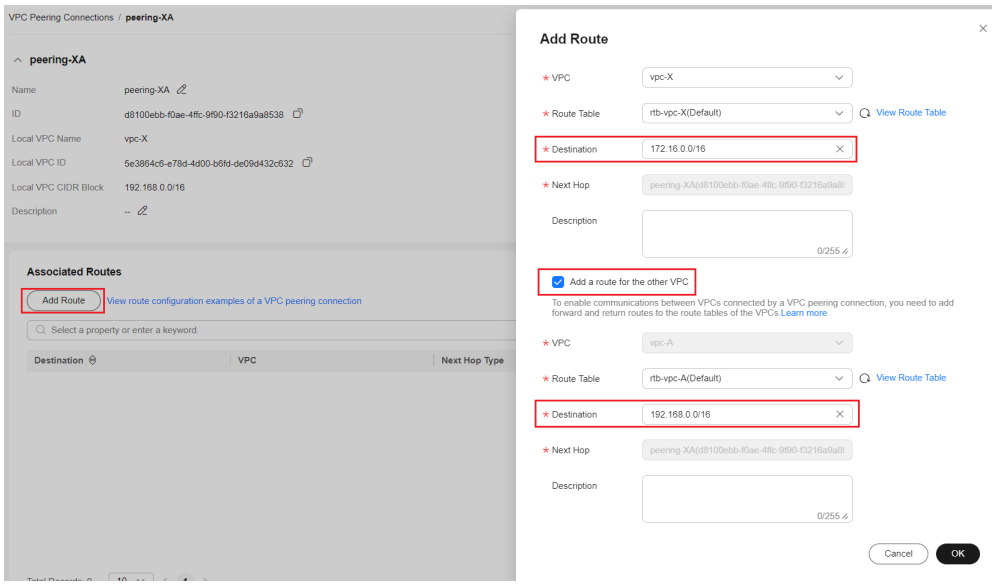


2. Click **Create Now**.
3. Click the name of the created VPC peering connection and add routes.

   Click **Add Route** and add the CIDR block of vpc-A (172.16.0.0/16) to the route table of vpc-X.

   Select **Add a route for the other VPC** and add the CIDR block of vpc-X (192.168.0.0/16) to the route table of vpc-A.

Figure 4-20 Adding a route



4. Click **OK**.

Step 3 Repeat the preceding steps to enable the networking between the Jenkins server and the production cluster.

1. In the upper right corner, click **Create VPC Peering Connection**. Configure the parameters following instructions.
   - **VPC Peering Connection Name**: **peering-XB**
   - **Local VPC**: **vpc-X** where the Jenkins server belongs
   - **Peer VPC**: **vpc-B** where the testing cluster resides
2. Click **OK**.
3. Click the name of the created VPC peering connection and add routes.

   Click **Add Route** and add the CIDR block of vpc-B (172.17.0.0/16) to the route table of vpc-X.

   Select **Add a route for the other VPC** and add the CIDR block of vpc-X (192.168.0.0/16) to the route table of vpc-B.
4. Click **OK**.

----End

Interconnecting with SWR

This solution uses SoftWare Repository for Container (SWR) to store container images built using Jenkins.

Step 1 Log in to the SWR console.

Step 2 Create an organization to manage images. For details, see **Organization Management**.

Step 3 Obtain the long-term valid **docker login** login command. For details, see **Obtaining a Long-Term Valid Login Command**.

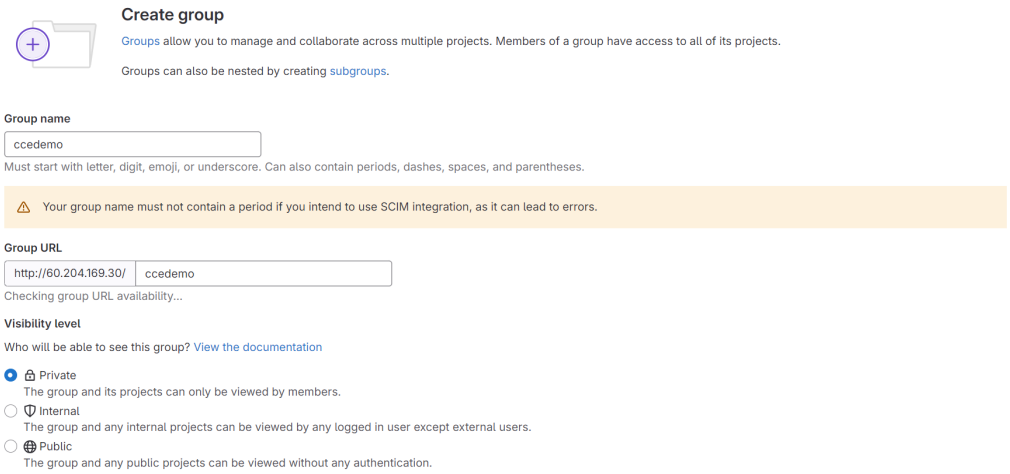
This login command will be used when images are uploaded through pipelines. For details, see **Implementing Continuous Integration and Deployment**.

----End

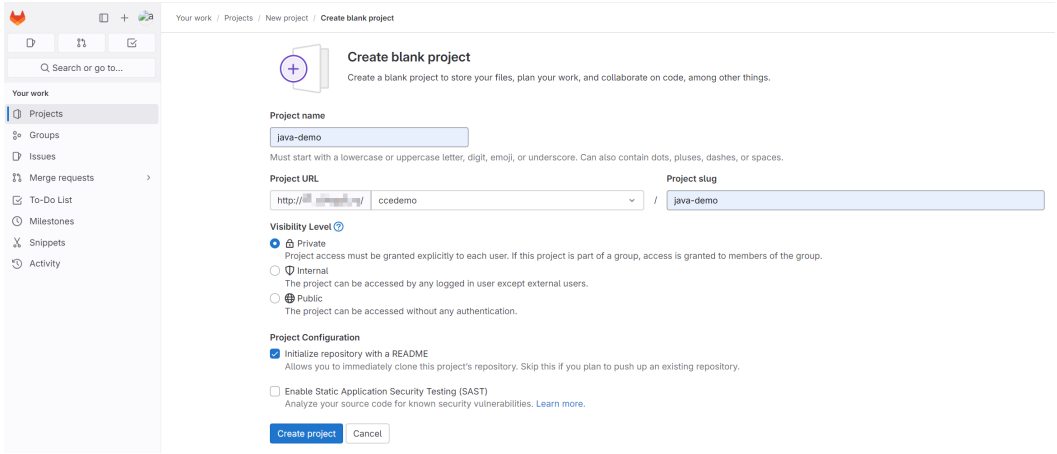
4.4.3.3 Configuring a GitLab Project

Step 1 Obtain the source code and save it to the local. A **Java example** is used.

Step 2 Create the **ccedemo** group on GitLab.



Step 3 Add the **java-demo** project to the **ccedemo** group.



Step 4 Upload the project code to the local GitLab repository.

```
cd ~/java-demo-main   //Change the directory address as needed.
git init
git remote add origin http://**.**.**.**/ccedemo/java-demo.git  // Project URL of java-demo in step 3
git config --global user.name "Administrator"
git config --global user.email "admin@example.com"
git add .
git commit -m "Initial commit"
git push -u origin main
```

Enter the user name **root** and its password. (If the default password is not changed, obtain it by referring to **Step 6**.)

----End

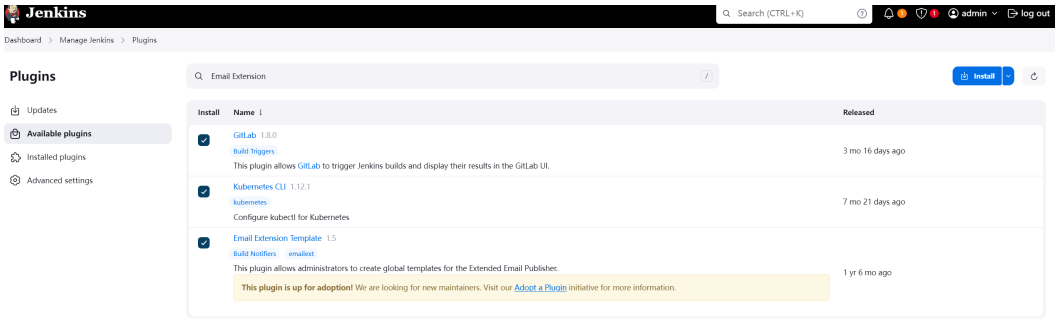
4.4.3.4 Implementing Continuous Integration and Deployment

To implement this solution, Jenkins must be triggered for compilation and packaging via a code push event. Once the request is approved via email, the application can be deployed in a Kubernetes cluster.

Installing Jenkins Plugins

In addition to the default plugins installed during Jenkins installation, you also need to install the GitLab, Kubernetes CLI, and Email Extension Template plugins. For details, see the **Jenkins official documentation**.

On the Jenkins dashboard page, click **Manage Jenkins** on the left and choose **System Configuration** > **Manage Plugins**. On the **Available** tab, search for **GitLab**, **Kubernetes CLI**, and **Email Extension Template**, and install them.

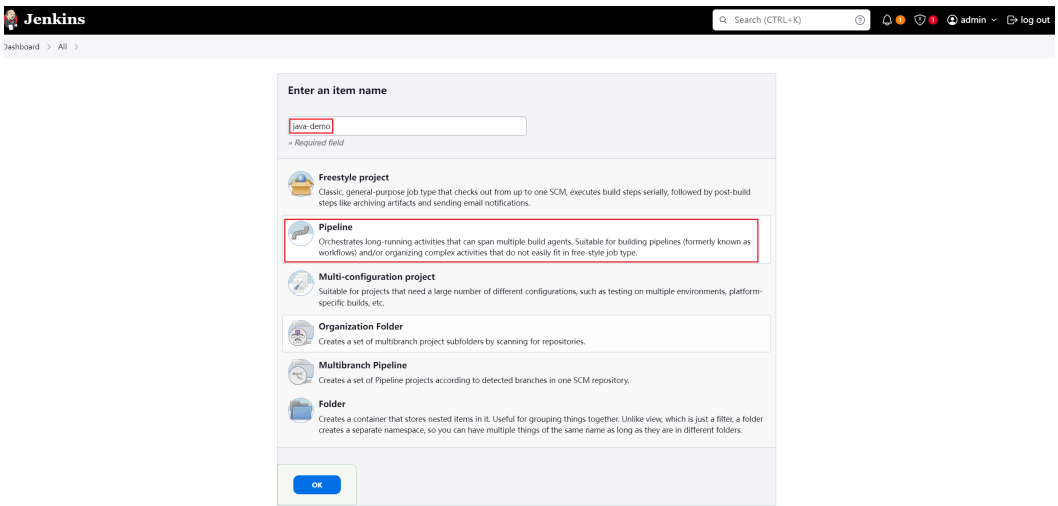


The versions of the preceding plugins may change over time.

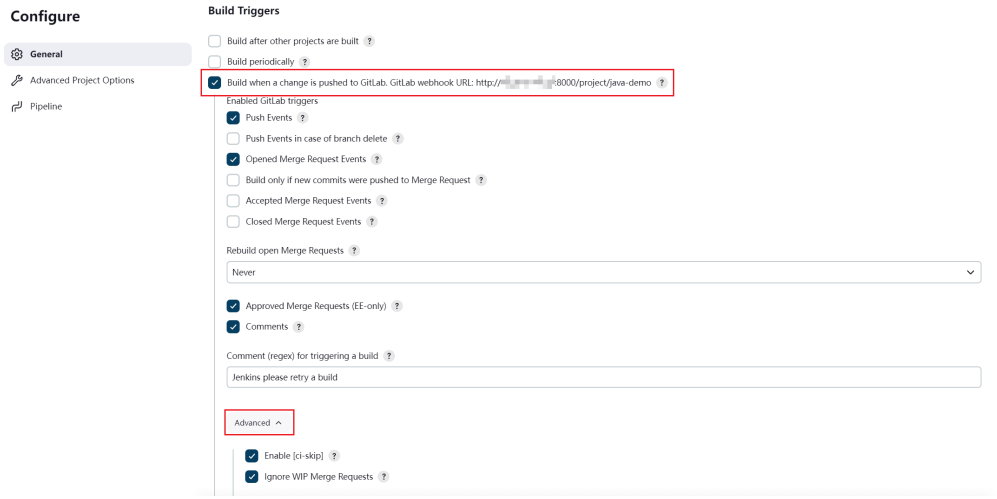
Configuring GitLab Hooks

Once you push your code, GitLab will notify Jenkins of the event using webhooks. To ensure this process runs smoothly, you must first configure GitLab hooks.

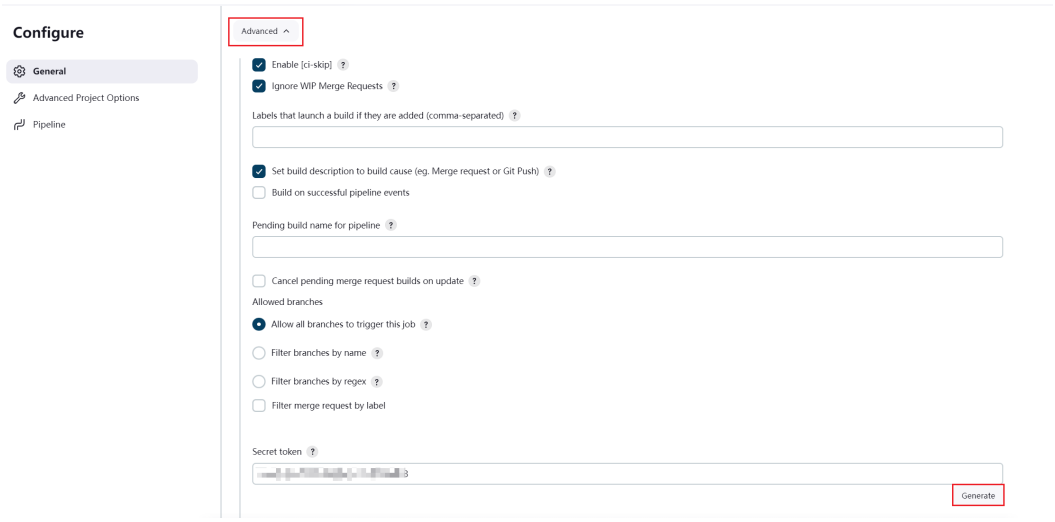
Step 1 Log in to Jenkins, click **New Item**, and create a pipeline.



Step 2 Copy the URL and click **Advanced**.

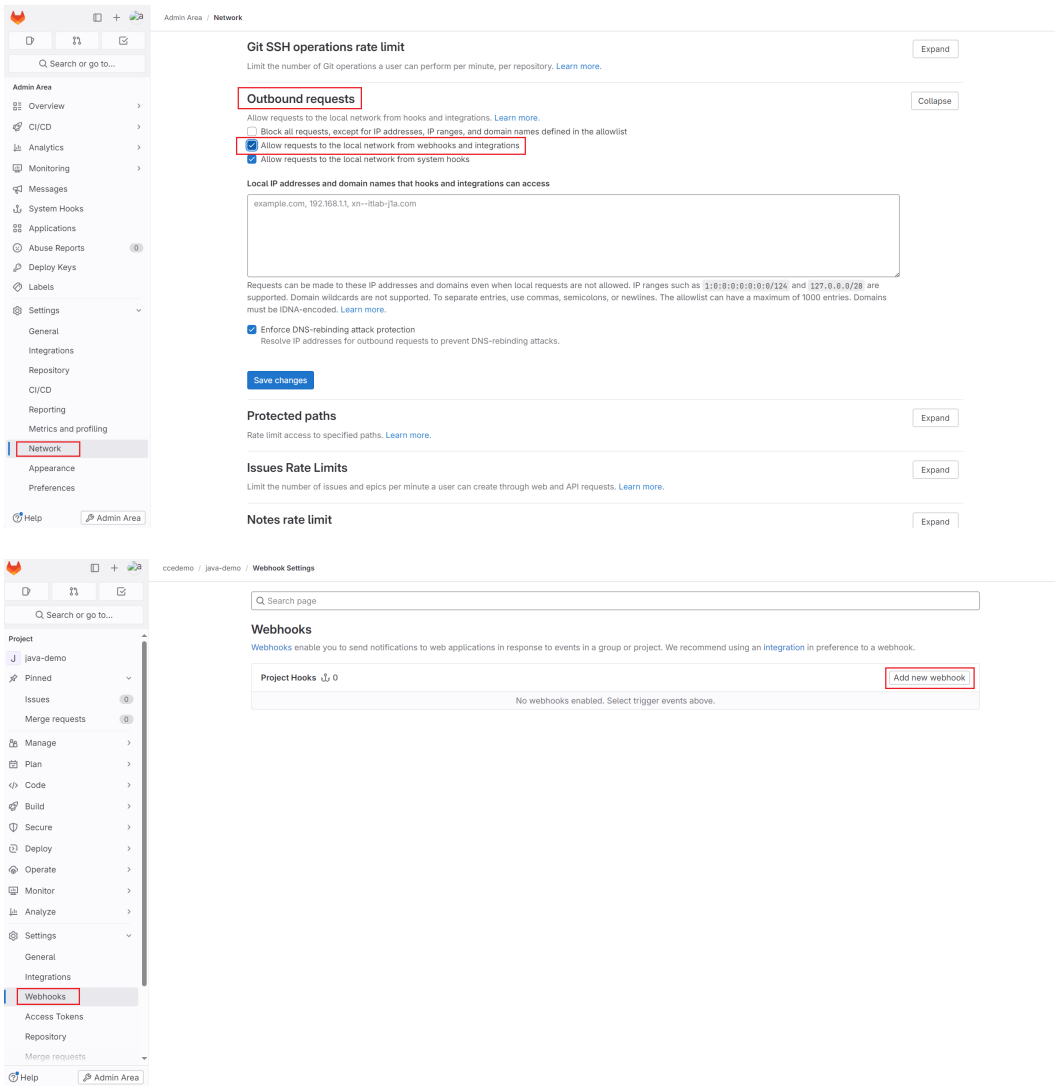


Step 3 Click **Generate** to generate a token, record it, retain the default values for other parameters, and save the changes.

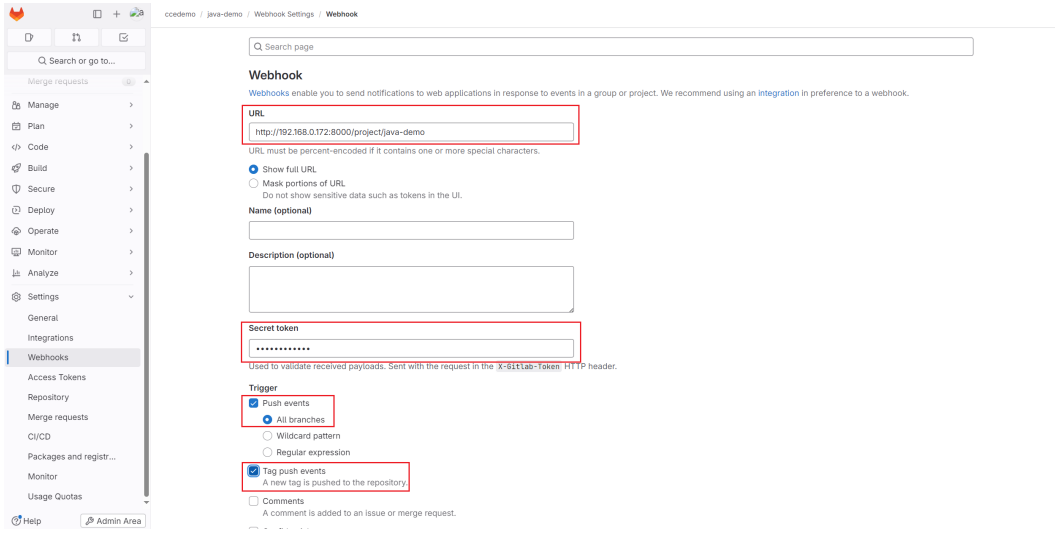


Step 4 Log in to GitLab and enable webhooks.

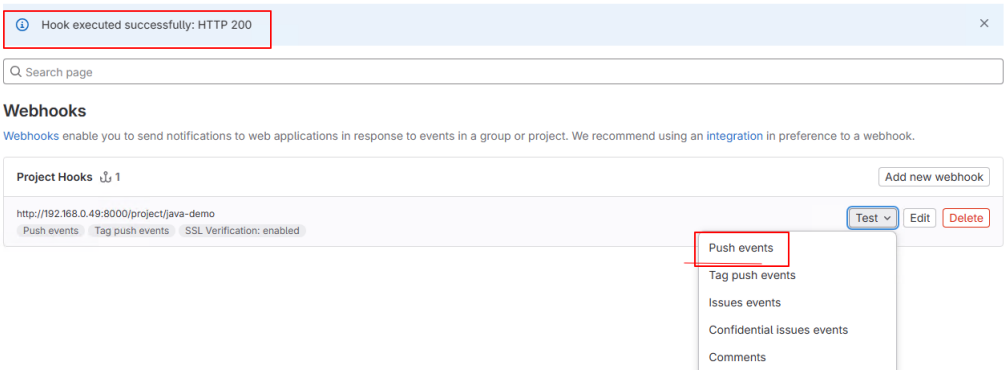
Allow requests to local network. To enhance security, GitLab 10.6 and later versions prohibit webhook requests from being sent to the local network.



Step 5 Log in to the **java-demo** project on GitLab, choose **Settings** > **Webhooks**, and enter the values recorded in Jenkins in **URL** and **Secret token**.



Step 6 At the bottom of the page, confirm that the webhook is added and perform tests.

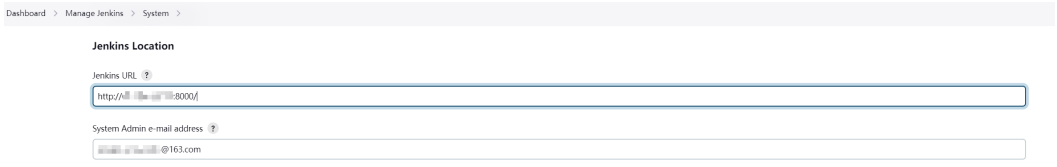


----End

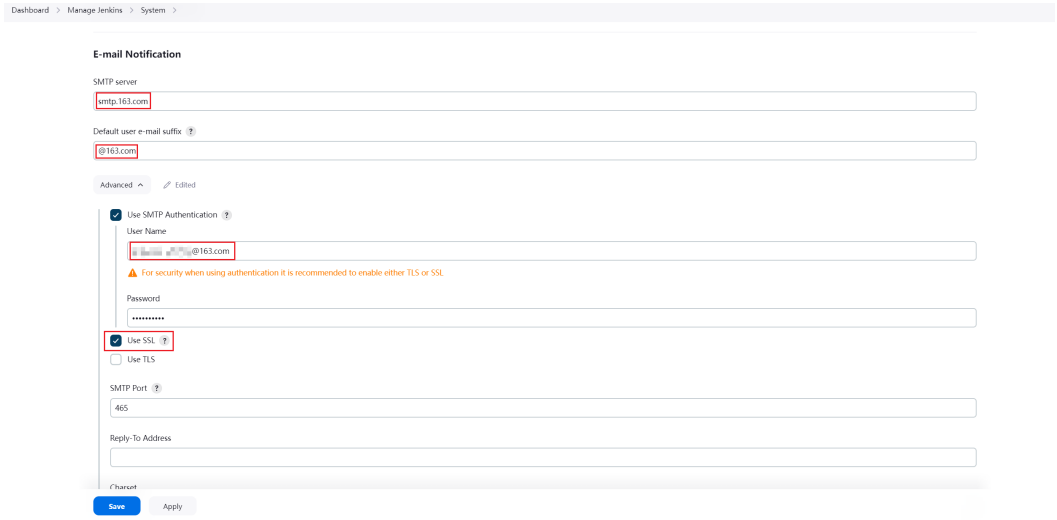
Configuring Email Notifications

Jenkins often uses email for message notifications and approvals. This solution also employs email as the approval method.

Step 1 On the **Manage Jenkins** page, select **System**.



Step 2 Configure basic mailbox information and enter the email address of the administrator.



NOTICE

The password is not the email password but the email authorization code.

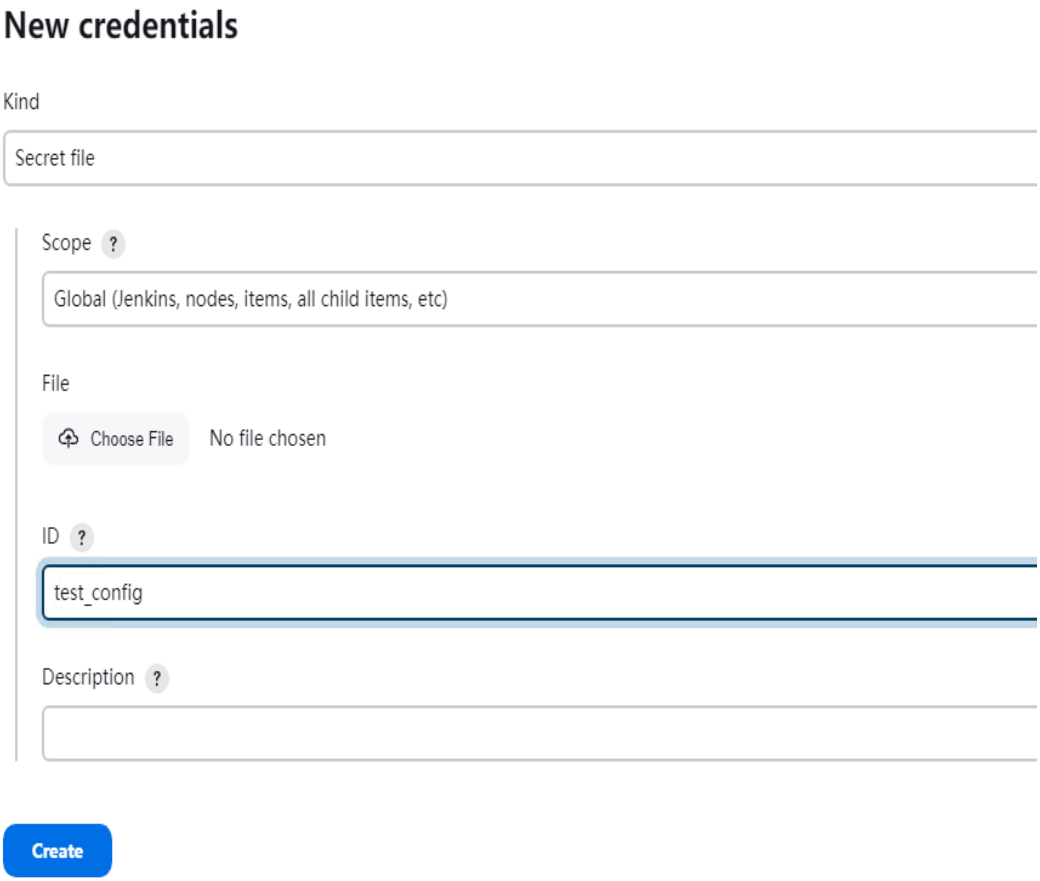
----End

Configuring a Credential

Accessing Kubernetes clusters through HTTPS is crucial for maintaining security. To achieve this, you must configure the credentials for accessing the clusters on Jenkins.

Step 1 Obtain the kubeconfig configuration of the Kubernetes cluster client. For details, see **Connecting to a Cluster Using kubectl**.

Step 2 Log in to Jenkins, click **Manage Jenkins**, choose **Manage Credentials** under **Security**, and create a cluster credential using the secret file.



Step 3 Repeat the preceding steps to create an access credential for the production cluster.

----End

Writing Pipeline Scripts

Pipeline is a workflow framework that operates within Jenkins. It links tasks that would typically run independently on one or more nodes, allowing for the orchestration and visualization of complex processes that cannot be completed by a single task. As the primary feature of Jenkins 2.*X*, it enables Jenkins to transition from CI to CD and DevOps. Consequently, the writing of pipeline scripts is crucial to the successful implementation of the entire solution.

The following shows the concepts of pipeline scripts:

- Node

  A node is a machine which is part of the Jenkins environment and is capable of executing a pipeline.

- Stage

  A stage block defines a group of specific tasks to be executed in different stages such as the build, test, and deploy stages through the entire pipeline.

- Step

  A step is a single task in a stage, such as running a test or deploying code. It tells Jenkins what to do at a specific time, for example, to execute the **shell** command. (For more Jenkins pipeline syntax, see the **Jenkins official documentation**.)

Step 1 Go to the Jenkins pipeline and click **Configuration** in the navigation pane.

Step 2 Configure the pipeline scripts. The following pipeline scripts are for reference only. You can customize the scripts based on your service requirements.

Some parameters in the example need to be changed:

- **git_url**: specifies the SSH address of the code repository in GitLab. You need to replace it with the actual value.
- **swr_login**: The login command is the command obtained in **Step 3**.
- **swr_region**: specifies the region of SWR. You need to specify the region as needed.
- **organization**: specifies the actual organization name in SWR.
- **build_name**: specifies the name of the created image.
- **credential**: specifies the testing cluster credential added to Jenkins. You need to enter the credential ID. To deploy the service in another cluster, add the access credential of the cluster to Jenkins again. For details, see **cluster access credential configurations**.
- **prod_credential**: specifies the production cluster credential added to Jenkins. You need to enter the credential ID. To deploy the service in another cluster, add the access credential of the cluster to Jenkins again. For details, see **cluster access credential configurations**.
- **test_apiserver**: specifies the API server address of the testing cluster. For details, see **Connecting to a Cluster Using kubectl**. You have to ensure that the address can be accessed from the Jenkins cluster.
- **prod_apiserver**: specifies the API server address of the production cluster. For details, see **Connecting to a Cluster Using kubectl**. You have to ensure that the address can be accessed from the Jenkins cluster.
- **test_email**: specifies the email address of the test personnel.
- **admin_email**: specifies the email address of the approver.

```
#!groovy
//Define the code repository address.
def git_url = 'ssh://git@xxxx:222/ccedemo/java-demo.git'
//Define the SWR login command.
def swr_login = 'docker login -u cn-north-4@xxxx -p xxxxxx swr.cn-north-4.myhuaweicloud.com'
//Define the SWR region.
def swr_region = 'cn-north-4'
// Specify the name of an SWR organization to which images are pushed.
def organization = 'testapp'
//Define the image name.
```



```
def build_name = 'demo01'
//Certificate ID of the testing cluster
def test_credential = 'test_config'
//Certificate ID of the production cluster
def prod_credential = 'prod_config'
//API server address of the testing cluster. You have to ensure that the address can be accessed from the Jenkins cluster.
def test_apiserver = 'https://xxx:5443'
//API server address of the production cluster. You have to ensure that the address can be accessed from the Jenkins cluster.
def prod_apiserver = 'https://xxxx:5443'
// Email addresses
def test_email="xxxxx@xx.com"
def admin_email="xxxx@xx.com"

pipeline{
agent any
stages{
    stage('Git code'){
        steps{
            echo "1. Git code"
            git url: git_url
            script {
                // Specify the return value of git rev-parse --short HEAD as the commit ID, which is then used as the image tag.
                build_tag = sh(returnStdout: true, script: 'git rev-parse --short HEAD').trim()
                image_url = "swr.${swr_region}.myhuaweicloud.com/${organization}/${build_name}:${build_tag}"
                }
            }
    }
    stage('Build') {
        steps{
            echo "2. Build Docker Image Stage and Push Image"
            sh "docker build -t  ${image_url} ."
            sh swr_login
            sh "docker push ${image_url}"
            // Replace the image URL with that in the Kubernetes resource file.
            sh  "sed -i 's+demo01:v1+${image_url}+g' ./demo01.yaml"
        }
    }
    stage('Deploy Test Enviroment') {
        steps{
            // Configure the testing environment certificate.
            echo "3. Deploy Test Enviroment"
            script {
                try {
                    withKubeConfig([credentialsId: test_credential, serverUrl: test_apiserver]) {
                        sh 'kubectl apply -f ./demo01.yaml'
                        //The YAML file is stored in the code repository. It is only used as an example here, so you need to replace it as required.
                    }
                    println "deploy success"
                    // Send an email to the test personnel.
                    mail subject: "[Please Test] The application has been deployed in the test environment. Please start the test.",
                    body: """After the test is passed, <a href="${BUILD_URL}input">click the link and use the account to log in to the system. The test is successful.</h3>""",
                    charset: 'utf-8',
                    mimeType: 'text/html',
                    to: "$test_email"
                } catch (e) {
                    RUN_FLAG = false
                    println "deploy failed!"
                    println e
                }
            }
        }
    }
```

```
    stage('Test'){
        // Wait for the test personnel to make confirmation.
        input{
            message "Test Passed or Not"
            submitter "admin"
        }
        steps{
            script{
                println "4. Test Passed"
                // Send an email to the administrator.
                mail subject: "[Please Approve] Release to the production environment",
                body: """The test is passed, <a href="${BUILD_URL}input">click the link and use the account to log in to the system for approval.</h3>""",
                charset: 'utf-8',
                mimeType: 'text/html',
                to: "$test_email"
            }
        }
    }
    stage('Approve'){
        input{
            message "Release to Production Environment or Not"
            submitter "admin"
        }
        steps{
            script{
                println "5. Approved and release it to the production environment."
            }
        }
    }
    stage('Deploy Produce Enviroment'){
        steps{
            echo "6. Deploy Produce Enviroment"
            script {
                try {
                    withKubeConfig([credentialsId: prod_credential, serverUrl: prod_apiserver]) {
                        sh 'kubectl apply -f ./demo01.yaml'
                        //The YAML file is stored in the code repository. It is only used as an example here, so you need to replace it as required.
                    }
                    println "deploy success"
                } catch (e) {
                    println "deploy failed!"
                    println e
                }
            }
        }
    }
}
```

Step 3 Save the changes to complete the configurations of the entire project.

----End

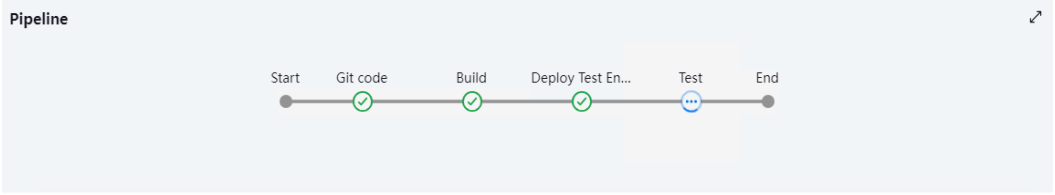
Configuring Continuous Build and Deployment

Step 1 Modify the local code and submit it to trigger compilation.

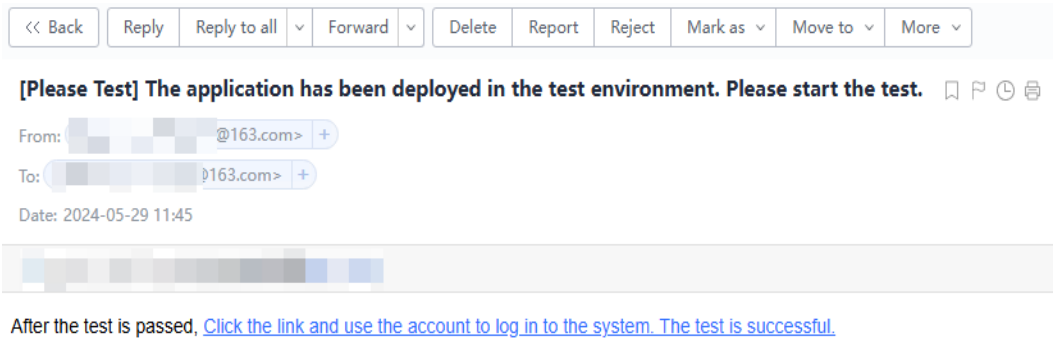
```
git add . && git commit -m "add template" && git push
```

Step 2 Go back to the Jenkins page.

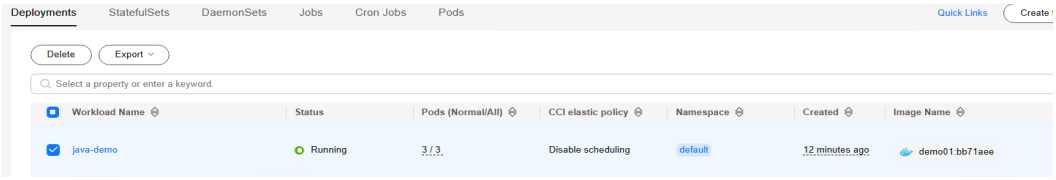
You can see that the project has automatically triggered compilation and building.



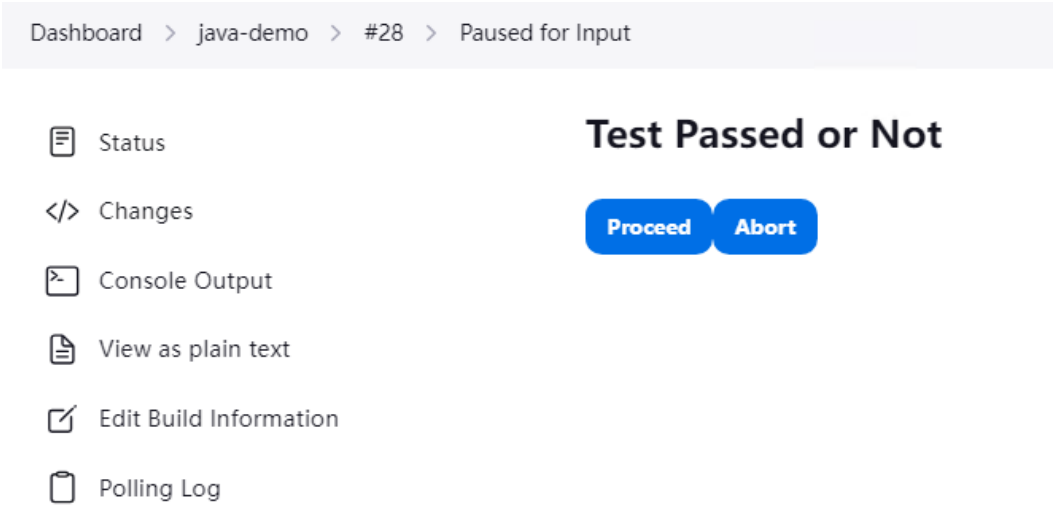
Step 3 Wait a few minutes for the email notification confirming the test.



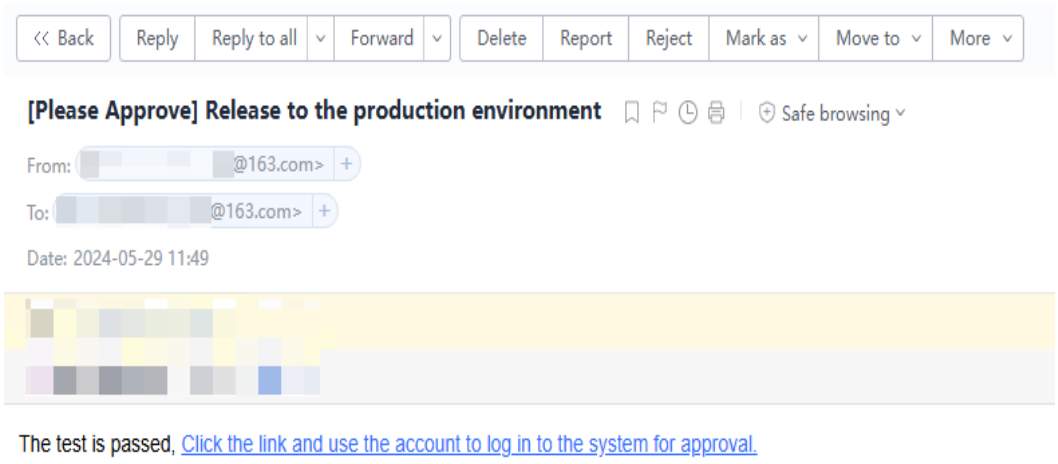
Step 4 Log in to the testing cluster and verify that the **java-demo** workload has been created.



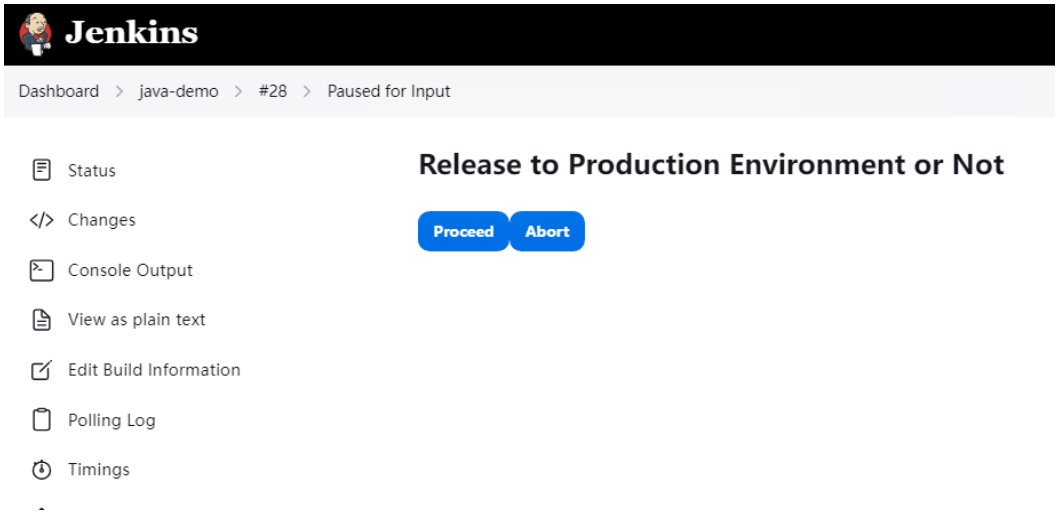
Step 5 Click the link in the email to confirm the test. (In this example, the upgrade test is considered to pass.)



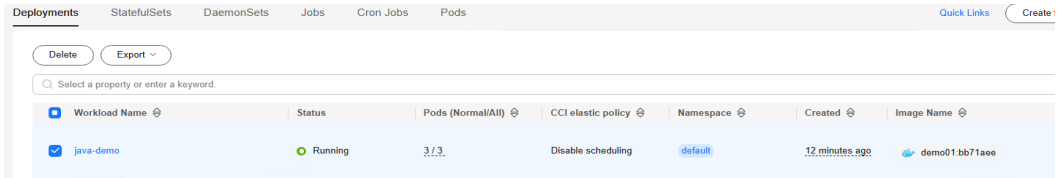
Step 6 (For the approver) Receive an email requesting approval.



Step 7 (For the approver) Determine that the service can be deployed in the production environment, click the link, and agree to the request.



Step 8 Access the production cluster console and verify that the java-demo workload has been created and released in the production environment.



----End

5 Disaster Recovery

5.1 Recommended Configurations for HA CCE Clusters

This section describes the recommended configurations for a Kubernetes cluster in which applications can run stably and reliably.

Item	Description	Recommended Operations
Master node	CCE is a hosted Kubernetes cluster service. You do not need to perform O&M on the master nodes. You can configure your cluster specifications to improve the stability and reliability.	• **Deploying the Master Nodes in Different AZs** • **Selecting a Network Model** • **Selecting a Service Forwarding Mode** • **Configuring Quotas and Limits for the Cloud Service Resources and Resources in a Cluster** • **Monitoring Metrics of the Master Nodes**
Worker node	In a Kubernetes cluster, the data plane consists of worker nodes that can run containerized applications and transmit network traffic. When using CCE, perform O&M on worker nodes by yourself. To achieve HA, ensure the worker nodes' scalability and repairability and pay attention to the running statuses of the worker nodes' key components.	• **Partitioning Data Disks Attached to a Node** • **Running npd** • **Configuring the DNS Cache** • **Properly Deploying CoreDNS**

Item	Description	Recommended Operations
Application	If you want your applications to be always available, especially during peak hours, run them in a scalable and elastic manner and pay attention to their running statuses.	• Running Multiple Pods • Configuring Resource Quotas for a Workload • Deploying an Application in Multiple AZs • Deploying the System Add-ons in Multiple AZs • Configuring Auto Scaling • Viewing Logs, Monitoring Metrics, and Adding Alarm Rules

Deploying the Master Nodes in Different AZs

Multiple regions are provided for you to deploy your services, and there are different availability zones (AZs) in each region. An AZ is a collection of one or more physical data centers with independent cooling, fire extinguishing, moisture-proof, and electricity facilities in each AZ. AZs within a region are connected using high-speed optical fibers. This allows you to build cross-AZ HA systems.

When creating a cluster, enable the HA mode of the cluster and configure the distribution mode of the master nodes. The master nodes are randomly deployed in different AZs. This ensures a higher disaster recovery (DR) capability of the cluster.

You can also customize the distribution mode. The following two modes are supported:

- **Random**: Master nodes are deployed in different AZs for DR.
- **Custom**: Master nodes are deployed in specific AZs.
  - **Host**: Master nodes are deployed on different hosts in the same AZ.
  - **Custom**: Master nodes are deployed in the AZ you specify.

Figure 5-1 Configuring an HA cluster

Selecting a Network Model

- Network model: CCE supports VPC network, Cloud Native 2.0 network, and container tunnel network models for your clusters. Different models have different performance and functions. For details, see **Network Models**.
- VPC network: To enable your applications to access other cloud services like RDS, create related services in the same VPC network as your cluster which runs these applications. This is because services using different VPC networks are isolated from each other. If you have created instances, use **VPC peering connections** to enable communications between VPCs.
- Container CIDR block: Do not configure a small container CIDR block. Otherwise, the number of supported nodes will be limited.
  - For a cluster using a VPC network, if the subnet mask of the container CIDR block is /16, there are 256 x 256 IP addresses available. If the maximum number of pods reserved on each node is 128, the maximum number of nodes supported is 512.
  - For a cluster using a container tunnel network, if the subnet mask of the container CIDR block is /16, there are 256 x 256 IP addresses assigned to your cluster. The container CIDR block allocates 16 IP addresses to the nodes at a time by default. The maximum number of nodes supported by your cluster is 4096 (65536/16=4096).
  - For a cluster using a Cloud Native 2.0 network, the container CIDR block is the VPC subnet, and the number of containers can be created depends on the size of the selected subnet.
- Service CIDR block: The service CIDR block determines the upper limit of Service resources in your cluster. Evaluate your actual needs and then configure the CIDR block. A created CIDR block cannot be modified. Do not configure an excessively small one.

For details, see **Planning CIDR Blocks for a Cluster**.

Selecting a Service Forwarding Mode

kube-proxy is a key component of a Kubernetes cluster. It is responsible for load balancing and forwarding between a Service and its backend pod. When using clusters, consider the potential performance problems of the forwarding mode.

CCE supports the iptables and IPVS forwarding modes.

- IPVS allows higher throughput and faster forwarding. It applies to scenarios where the cluster scale is large or the number of Services is large.
- iptables is the traditional kube-proxy mode. This mode applies to the scenario where the number of Services is small or there are a large number of short concurrent connections on the client. When there are more than 1000 Services in the cluster, network delay may occur.

Configuring Quotas and Limits for the Cloud Service Resources and Resources in a Cluster

CCE allows you to configure resource quotas and limits for your cloud service resources and resources in your clusters. This prevents excessive use of resources. When creating your applications for CCE clusters, consider these limits and

periodically review them. This will avoid scaling failures caused by insufficient quotas during application running.

- Configuring resource quotas for cloud services: Cloud services like ECS, EVS, VPC, ELB, and SWR are also used to run the CCE clusters. If the existing resource quotas cannot meet your requirements, submit a service ticket to increase the quotas.
- Configuring resource quotas for a cluster: You are allowed to configure the namespace-level resource quotas to limit the number of objects of a certain type created in a namespace and the total computing resources like CPU and memory consumed by the objects. For details, see **Configuring Resource Quotas**.

Monitoring Metrics of the Master Nodes

Monitoring metrics of the master nodes allows you to check the master nodes' performance and efficiently identify problems occurred on them. The master nodes which are not running properly may lower application reliability.

CCE can monitor kube-apiserver, kube-controller, kube-scheduler, and etcd-server on master nodes. You need to install the **Cloud Native Cluster Monitoring** add-on. With grafana, you can use the **Kubernetes monitoring overview dashboard** to monitor metrics of Kubernetes API server requests and latency and etcd latency.

If an on-premises Prometheus instance is used, you can manually add monitoring metrics. For details, see **Monitoring Metrics of Master Node Components Using Prometheus**.

Partitioning Data Disks Attached to a Node

By default, the first data disk of a worker node is for storing the container runtime and kubelet components. The remaining capacity of this data disk affects image download and container startup and running. For details, see **Space Allocation of a Data Disk**.

The default space of this date disk is 100 GiB. You can adjust the space as required. Images, system logs, and application logs are stored on data disks. Therefore, you need to evaluate the number of pods to be deployed on each node, the size of logs, images, and temporary data of each pod, as well as some reserved space for the system. For details, see **Selecting a Data Disk for the Node**.

Running npd

A failure in a worker node may affect the availability of the applications. **CCE Node Problem Detector** is used to monitor node exceptions. It helps you detect and handle latent exceptions in a timely manner. You can also customize the check items, including target node, check period, and triggering threshold. For details, see **Configuring Node Fault Detection Policies**.

Configuring the DNS Cache

When the number of DNS requests in a cluster increases, the load of CoreDNS increases and the following issues may occur:

- Increased delay: CoreDNS needs to process more requests, which may slow down the DNS query and affect service performance.
- Increased resource usage: To ensure DNS performance, CoreDNS requires higher specifications.

To minimize the impact of DNS delay, deploy NodeLocal DNSCache in the cluster to improve the networking stability and performance. NodeLocal DNSCache runs a DNS cache proxy on cluster nodes. All pods with DNS configurations use the DNS cache proxy running on nodes instead of the CoreDNS service for domain name resolution. This reduces CoreDNS' load and improves the cluster DNS performance.

You can install the **NodeLocal DNSCache** add-on. For details, see **Using NodeLocal DNSCache to Improve DNS Performance**.

Properly Deploying CoreDNS

Deploy the CoreDNS instances in different AZs and nodes to mitigate the single-node or single-AZ faults.

Ensure that the CPU and memory of the node where CoreDNS is running are not fully used. Otherwise, the Queries per second (QPS) and response of domain name resolution will be affected.

For details about how to properly configure CoreDNS, see **Configuring CoreDNS**.

Running Multiple Pods

If your application runs in one pod, the application will be unavailable if the pod is abnormal. Use Deployments or other types of replicas to deploy your applications. Each time a pod fails or is terminated, the controller automatically restarts a new pod that has the same specifications as the original one to ensure that a specified number of pods are always running in the cluster.

When creating a workload, set the number of instances to a value greater than 2. If an instance is faulty, the remaining instances still run until Kubernetes automatically creates another pod to compensate for the loss. You can also use HPA and CA (**Using HPA and CA for Auto Scaling of Workloads and Nodes**) to automatically scale in or out the workloads as required.

Using Containers to Isolate Processes

Containers provide process-level isolation. Each container has its own file system, network, and resource allocation. This prevents interference between different processes and avoids attacks and data leakage from malicious processes. Using containers to isolate processes can improve the reliability, security, and portability of applications.

If several processes work together, create multiple containers in a pod so that they can share the same network, PV, and other resources. Taking the init container as an example. The init containers run before the main containers are started to complete some initialization tasks like configuring environment variables, loading databases or data stores, and pulling Git repositories.

Note that multiple containers in a pod share the lifecycle of this pod. Therefore, if one container is abnormal, the entire pod will be restarted.

Configuring Resource Quotas for a Workload

Configure and adjust resource requests and limits for all workloads.

If too many pods are scheduled to one node, the node will be overloaded and unable to provide services.

To avoid this problem, when deploying a pod, specify the resource request and limit required by the pod. Kubernetes then selects a node with enough idle resources for this pod. In the following example, the Nginx pod requires 1-core CPU and 1024 MiB memory. The actual usage cannot exceed 2-core CPU and 4096 MiB memory.

Kubernetes statically schedules resources. The remaining resources on each node are calculated as follows: Remaining resources on a node = Total resources on the node – Allocated resources (not resources in use). If you manually run a resource-consuming process, Kubernetes cannot detect it.

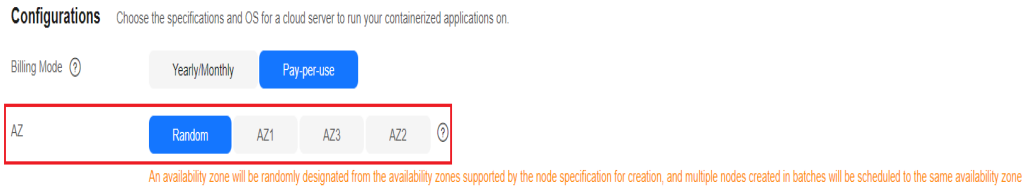
Additionally, the resource usage must be claimed for all pods. For a pod that does not claim the resource usage, after it is scheduled to a node, Kubernetes does not deduct the resources used by this pod from the node on which it is running. Other pods may still be scheduled to this node.

Deploying an Application in Multiple AZs

You can run pods on nodes in multiple AZs to prevent an application from being affected by faults of a single AZ.

When creating a node, manually specify an AZ for the node.

Figure 5-2 Specifying an AZ of a node



During application deployment, configure anti-affinity policies for pods so that the scheduler can schedule pods across multiple AZs. For details, see **Implementing High Availability for Applications in CCE**. The following is an example:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: web-server
  labels:
    app: web-server
spec:
  replicas: 4
  selector:
    matchLabels:
      app: web-server
  template:
    metadata:
      labels:
        app: web-server
```



```
  spec:
    containers:
    - name: web-app
      image: nginx
    imagePullSecrets:
    - name: default-secret
    affinity:
      podAntiAffinity:  # Workload anti-affinity
        preferredDuringSchedulingIgnoredDuringExecution:  # Indicates that the rule is met as much as possible. Otherwise, scheduling cannot be performed when the number of pods exceeds the number of AZs.
        - podAffinityTerm:
            labelSelector:  # Pod label matching rule. Configure anti-affinity policies between pods and their own labels.
              matchExpressions:
              - key: app
                operator: In
                values:
                - web-server
            topologyKey: topology.kubernetes.io/zone  # Topology domain of the AZ where the node is located
          weight: 100
```

You can also use **Pod Topology Spread Constraints** to deploy pods in multiple AZs.

Deploying the System Add-ons in Multiple AZs

The Deployment pods of CCE system add-ons like CoreDNS and Everest can be deployed in multiple AZs, the same way as deploying an application. This function can satisfy different user requirements.

Table 5-1 Deployment description

Mode	Configuration Description	Usage Description	Recommended Configuration Scenario
Preferred	Add-on pods will have labels with the key **topology.kubernetes.io/zone** for soft anti-affinity deployment, and the anti-affinity type is **preferredDuring-SchedulingIgnored-DuringExecution**.	Add-on pods will be preferentially scheduled to nodes in different AZs. If resources in some AZs are insufficient, some add-on pods may be scheduled to the same AZ which has enough resources.	No mandatory requirements for multi-AZ DR

Mode	Configuration Description	Usage Description	Recommended Configuration Scenario
Required	Add-on pods will have labels with the key **topology.kubernetes.io/zone** for hard anti-affinity deployment, and the anti-affinity type is **requiredDuringSchedulingIgnoredDuringExecution**.	A maximum of one pod of the same add-on can be deployed in each AZ. The number of running pods cannot exceed the number of AZs in the cluster. If the node where the add-on pod runs is faulty, pods running on the faulty node cannot be automatically migrated to other nodes in the same AZ.	Changing number of AZs (This mode is used to prevent all pods from being scheduled to the node in the current AZ in advance.)
Equivalent mode	Add-on pods will have labels with the key **topology.kubernetes.io/zone** for configuring topology spread constraints. The pod difference between different topology domains cannot exceed 1 for add-on pods to be evenly distributed in different AZs.	The effect of this mode is between that of the preferred mode and that of the required mode. In the equivalent mode, add-on pods can be deployed in different AZs. Additionally, multiple pods can be deployed in a single AZ when there are more pods than AZs. To use this mode, you need to plan node resources in each AZ in advance to ensure that each AZ has enough node resources for deploying pods. (If there are more than one add-on pods in a single AZ, the nodes to which the add-on pods can be scheduled in each AZ should be one more than the actual add-on pods in the current AZ.) This ensures successful deployment of add-on pods although node resources in some AZ are insufficient and smooth scheduling of add-on pods during update.	Scenarios have high requirements for DR

Configuring Health Check for a Container

Kubernetes automatically restarts pods that are not running properly. This prevents service interruption caused by exceptions of pods. In some cases, however, even if a pod is running, it does not mean that it can provide services properly. For example, a deadlock may occur in a process in a running pod, but Kubernetes does not automatically restart the pod because it is still running. To solve this problem, configure a liveness probe to check whether the pod is healthy. If the liveness probe detects a problem, Kubernetes will restart the pod.

You can also configure a readiness probe to check whether the pod can provide normal services. After an application container is started, it may take some time for initialization. During this process, the pod on which this container is running cannot provide services to external systems. The Services forward requests to this pod only when the readiness probe detects that the pod is ready. When a pod is faulty, the readiness probe can prevent new traffic from being forwarded to the pod.

The startup probe is used to check whether the application container is started. The startup probe ensures that the containers can start successfully before the liveness probe and readiness probe do their tasks. This ensures that the liveness probe and readiness probe do not affect the startup of containers. Configuring the startup probe ensures that the slow-start containers can be detected by the liveness probe to prevent Kubernetes from terminating them before they are started.

You can configure the preceding probes when creating an application. The following is an example:

```
apiVersion: v1
kind: Pod
metadata:
  labels:
    test: liveness
  name: liveness-http
spec:
  containers:
  - name: liveness
    image: nginx:alpine
    args:
    - /server
    livenessProbe:
      httpGet:
        path: /healthz
        port: 80
        httpHeaders:
        - name: Custom-Header
          value: Awesome
      initialDelaySeconds: 3
      periodSeconds: 3
    readinessProbe:
      exec:
        command:
          - cat
          - /tmp/healthy
      initialDelaySeconds: 5
      periodSeconds: 5
    startupProbe:
      httpGet:
        path: /healthz
        port: 80
      failureThreshold: 30
      periodSeconds: 10
```


For details, see **Configuring Container Health Check**.

Configuring Auto Scaling

Auto scaling can automatically adjust the number of application containers and nodes as required. Containers and nodes can be quickly scaled out or scaled in to save resources and costs.

Typically, two types of auto scaling may occur during peak hours:

- Workload scaling: When deploying applications in pods, you can configure requested resources and resource limits for the pods to prevent unlimited usage of resources during peak hours. However, after the upper limit is reached, an application error may occur. To resolve this issue, scale in the number of pods to share workloads.
- Node scaling: After the number of pods grows, the resource usage of the node may increase to a certain extent. This results in that the added pods cannot be scheduled. To solve this problem, scale in or out nodes based on the resource usage.

For details, see **Using HPA and CA for Auto Scaling of Workloads and Nodes**.

Viewing Logs, Monitoring Metrics, and Adding Alarm Rules

- Logging
  - Control plane logs are reported from the master nodes. CCE supports kube-controller-manager, kube-apiserver, kube-scheduler, and audit logs. For details, see **Collecting Control Plane Component Logs**.
  - Application logs are generated by pods. These logs include logs generated by pods in which the service containers are running and Kubernetes system components like CoreDNS. CCE allows you to configure policies for collecting, managing, and analyzing logs periodically to prevent logs from being over-sized. For details, see **Logging Overview**.
- Monitoring
  - Metrics of the master nodes: Monitoring these metrics enables you to efficiently identify problems occurred on the master nodes. For details, see **Monitoring Metrics of the Master Nodes**.
  - Metrics of the applications: CCE can comprehensively monitor applications in clusters by checking these metrics. In addition to standard metrics, you can configure custom metrics of your applications that comply with their specifications to improve the observability. For details, see **Monitoring Center Overview**.
- Alarm

  You can add alarm rules for metrics to detect cluster faults and generate warnings in a timely manner with the monitoring function. This helps you maintain service stability. For details, see **Customized Alarm Configurations**.

5.2 Implementing High Availability for Applications in CCE

Basic Principles

To achieve high availability for your CCE containers, you can do as follows:

1. Deploy three master nodes for the cluster.
2. Create nodes in different AZs. When nodes are deployed across AZs, you can customize scheduling policies based on your requirements to maximize resource utilization.
3. Create multiple node pools in different AZs and use them for node scaling.
4. Set the number of pods to be greater than 2 when creating a workload.
5. Set pod affinity rules to distribute pods to different AZs and nodes.

Procedure

Assume that there are four nodes in a cluster distributed in different AZs.

```
$ kubectl get node -L topology.kubernetes.io/zone,kubernetes.io/hostname
NAME          STATUS   ROLES    AGE   VERSION                   ZONE     HOSTNAME
192.168.5.112   Ready    <none>   42m   v1.21.7-r0-CCE21.11.1.B007   zone01   192.168.5.112
192.168.5.179   Ready    <none>   42m   v1.21.7-r0-CCE21.11.1.B007   zone01   192.168.5.179
192.168.5.252   Ready    <none>   37m   v1.21.7-r0-CCE21.11.1.B007   zone02   192.168.5.252
192.168.5.8     Ready    <none>   33h   v1.21.7-r0-CCE21.11.1.B007   zone03   192.168.5.8
```

Create workloads according to the following podAntiAffinity rules:

- Pod anti-affinity in an AZ. Configure the parameters as follows:
  - **weight**: A larger weight value indicates a higher priority of scheduling. In this example, set it to **50**.
  - **topologyKey**: includes a default or custom key for the node label that the system uses to denote a topology domain. A topology key determines the scope where the pod should be scheduled to. In this example, set this parameter to **topology.kubernetes.io/zone**, which is the label for identifying the AZ where the node is located.
  - **labelSelector**: Select the label of the workload to realize the anti-affinity between this container and the workload.
- The second one is the pod anti-affinity in the node hostname. Configure the parameters as follows:
  - **weight**: Set it to **50**.
  - **topologyKey**: Set it to **kubernetes.io/hostname**.
  - **labelSelector**: Select the label of the pod, which is anti-affinity with the pod.

```
kind: Deployment
apiVersion: apps/v1
metadata:
  name: nginx
  namespace: default
spec:
  replicas: 2
```



```
  selector:
    matchLabels:
      app: nginx
  template:
    metadata:
      labels:
        app: nginx
    spec:
      containers:
        - name: container-0
          image: nginx:alpine
          resources:
            limits:
              cpu: 250m
              memory: 512Mi
            requests:
              cpu: 250m
              memory: 512Mi
      affinity:
        podAntiAffinity:
          preferredDuringSchedulingIgnoredDuringExecution:
            - weight: 50
              podAffinityTerm:
                labelSelector:                    # Select the label of the workload to realize the anti-affinity between this container and the workload.
                  matchExpressions:
                    - key: app
                      operator: In
                      values:
                        - nginx
                namespaces:
                  - default
                topologyKey: topology.kubernetes.io/zone   # It takes effect in the same AZ.
            - weight: 50
              podAffinityTerm:
                labelSelector:                    # Select the label of the workload to realize the anti-affinity between this container and the workload.
                  matchExpressions:
                    - key: app
                      operator: In
                      values:
                        - nginx
                namespaces:
                  - default
                topologyKey: kubernetes.io/hostname     # It takes effect on the node.
      imagePullSecrets:
        - name: default-secret
```

Create a workload and view the node where the pod is located.

```
$ kubectl get pod -owide
NAME                     READY   STATUS    RESTARTS   AGE   IP           NODE
nginx-6fffd8d664-dpwbk   1/1     Running   0          17s   10.0.0.132   192.168.5.112
nginx-6fffd8d664-qhclc   1/1     Running   0          17s   10.0.1.133   192.168.5.252
```

Increase the number of pods to 3. The pod is scheduled to another node, and the three nodes are in three different AZs.

```
$ kubectl scale --replicas=3 deploy/nginx
deployment.apps/nginx scaled
$ kubectl get pod -owide
NAME                     READY   STATUS    RESTARTS   AGE     IP           NODE
nginx-6fffd8d664-8t7rv   1/1     Running   0          3s      10.0.0.9     192.168.5.8
nginx-6fffd8d664-dpwbk   1/1     Running   0          2m45s   10.0.0.132   192.168.5.112
nginx-6fffd8d664-qhclc   1/1     Running   0          2m45s   10.0.1.133   192.168.5.252
```

Increase the number of pods to 4. The pod is scheduled to the last node. With podAntiAffinity rules, pods can be evenly distributed to AZs and nodes.


```
$ kubectl scale --replicas=4 deploy/nginx
deployment.apps/nginx scaled
$ kubectl get pod -owide
NAME                     READY   STATUS    RESTARTS   AGE     IP           NODE
nginx-6fffd8d664-8t7rv   1/1     Running   0          2m30s   10.0.0.9     192.168.5.8
nginx-6fffd8d664-dpwbk   1/1     Running   0          5m12s   10.0.0.132   192.168.5.112
nginx-6fffd8d664-h796b   1/1     Running   0          78s     10.0.1.5     192.168.5.179
nginx-6fffd8d664-qhclc   1/1     Running   0          5m12s   10.0.1.133   192.168.5.252
```

5.3 Implementing High Availability for Add-ons in CCE

Application Scenarios

CCE offers various add-ons that enhance the cloud native capabilities of clusters. These add-ons include features like container scheduling and elasticity, cloud native observability, container networking, storage, and security. Helm charts are used to deploy these add-ons. Workload pods of the add-ons are deployed on worker nodes within the clusters.

As add-ons have become more popular, their stability and reliability have become essential requirements. By default, CCE implements a policy for add-on deployment where worker nodes have a hard anti-affinity configuration, and AZs have a soft anti-affinity configuration. This section explains how to enhance the CCE add-on scheduling policy, allowing you to customize the deployment policy according to your requirements.

Deployment Solution

An add-on typically runs as Deployments or DaemonSets. By default, DaemonSet pods are deployed on all nodes. To ensure HA of the add-on, there are multiple pods, AZ affinity policies, and specified node scheduling configured for Deployments.

Pod-level HA solution:

- **Increasing the Number of Pods**: Multi-pod deployment can effectively prevent service unavailability caused by a single point of failure (SPOF).

Node-level HA solutions:

- **Deploying the Add-on Pods on Dedicated Nodes**: To prevent resource preemption between service applications and core add-ons, it is best to deploy the core add-on pods on dedicated nodes. This ensures that the add-on resources are isolated and restricted on the node level.
- **Deploying the Add-on in Multiple AZs**: Multi-AZ deployment can effectively prevent service unavailability caused by the failure of a single AZ.

Take the CoreDNS add-on as an example. This add-on is deployed as two pods by default in the preferred mode, and the scheduling policies are hard anti-affinity for nodes and soft anti-affinity for AZs. In this case, two nodes are needed to ensure that all add-on pods in the cluster can run properly, and Deployment pods of the add-on can be preferentially scheduled to nodes in different AZs.

The following sections describe how to further improve the add-on SLA.

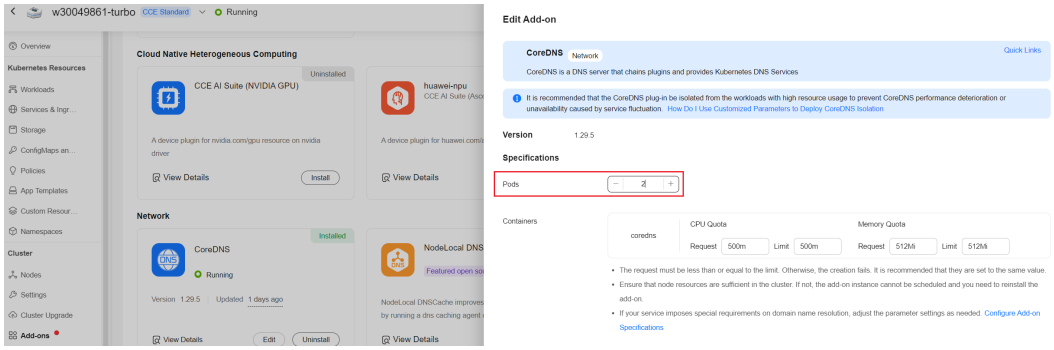
Increasing the Number of Pods

You can adjust the number of CoreDNS pods ensure high performance and HA.

Step 1 Log in to the CCE console and click the cluster name to access the cluster console. In the navigation pane, choose **Add-ons**, locate **CoreDNS** on the right, and click **Edit**.

Step 2 Increase the number of replicas.

Figure 5-3 Changing the pod quantity



Step 3 Click **OK**.

----End

Deploying the Add-on Pods on Dedicated Nodes

You can adjust the node affinity policy of CoreDNS and make the CoreDNS pods run on dedicated nodes. This can prevent the CoreDNS resources from being preempted by service applications.

A custom policy is used as an example.

Step 1 Log in to the CCE console and click the cluster name to access the cluster console. In the navigation pane, choose **Nodes**.

Step 2 Click the **Nodes** tab, select the node dedicated for CoreDNS, and click **Labels and Taints** above the node list.

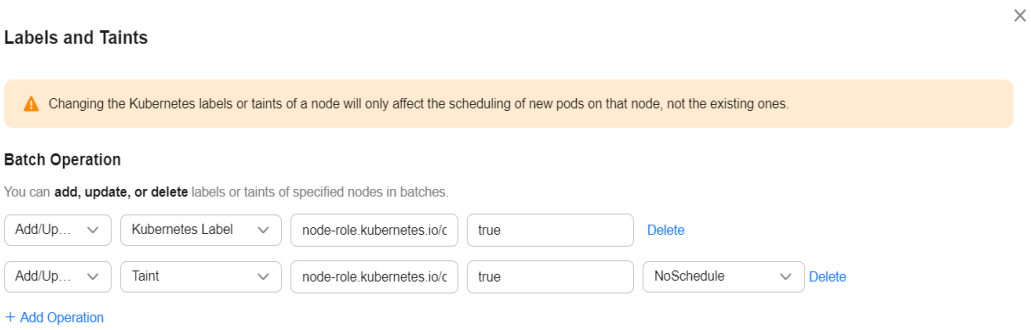
Add the following labels:

- Key: **node-role.kubernetes.io/coredns**
- Value: **true**

Add the following taints:

- Key: **node-role.kubernetes.io/coredns**
- Value: **true**
- Effect: **NoSchedule**

Figure 5-4 Adding a label and a taint

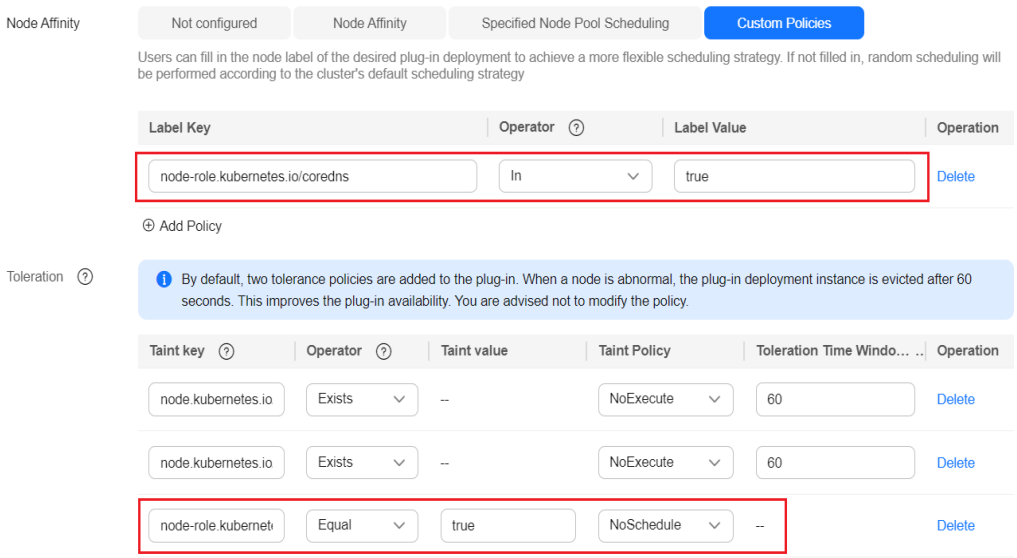


Step 3 In the navigation pane, choose **Add-ons**, locate **CoreDNS**, and click **Edit**.

Step 4 Select Custom Policies for **Node Affinity** and add the preceding node label.

Add tolerations for the preceding taint.

Figure 5-5 Adding a toleration



Step 5 Click **OK**.

----End

Deploying the Add-on in Multiple AZs

By default, the add-on scheduling policy can handle single-node faults. However, if your services require a higher SLA, you can create nodes with different AZ specifications on the node pool page and set the multi-AZ deployment mode of the add-on to the required mode.

Step 1 Log in to the CCE console and click the cluster name to access the cluster console.

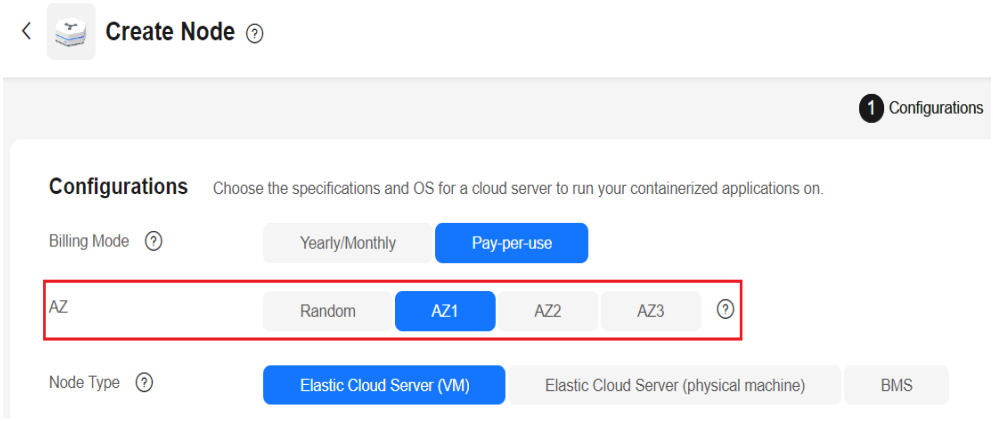
Step 2 Create nodes in different AZs.

To create nodes in different AZs, you can simply repeat these steps. Alternatively, you can create multiple node pools, associate them with different AZ

specifications, and increase the number of nodes in each pool to achieve the same result.

1. In the navigation pane, choose **Nodes**, click the **Nodes** tab, and click **Create Node** in the upper right corner.
2. On the page displayed, select an AZ for the node.

Figure 5-6 Creating a node

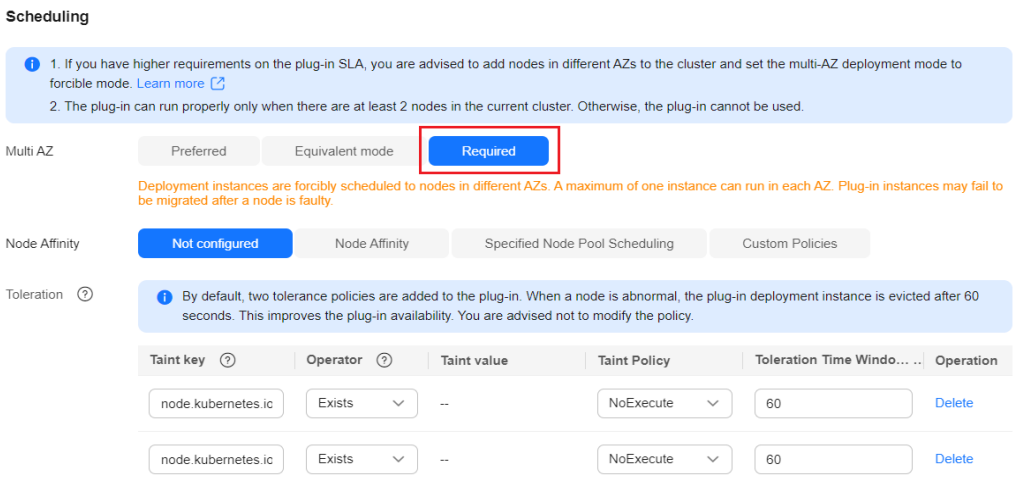


3. Configure other mandatory parameters following instructions to complete the creation.

Step 3 In the navigation pane, choose **Add-ons**. In the right pane, locate **CoreDNS** and click **Edit**.

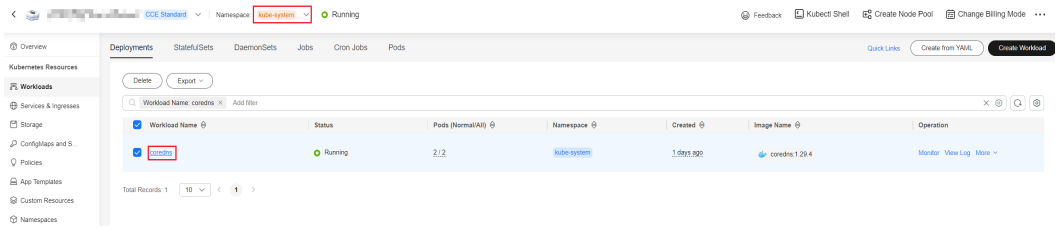
Step 4 In the window that slides out from the right, set **Multi AZ** to **Required** and click **Install**.

Figure 5-7 Changing the multi-AZ deployment mode to the required mode



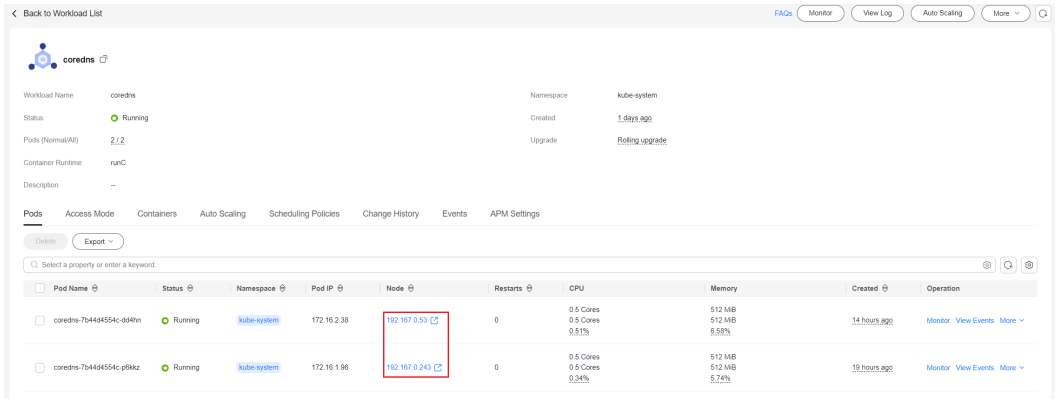
Step 5 Choose **Workload**, click the **Deployments** tab, and view the CoreDNS pods. Select the **kube-system** namespace to view the pod distribution of the add-on.

Figure 5-8 Viewing the deployment and distribution of CoreDNS pods



Step 6 View that the Deployment pods of the add-on has been allocated to nodes in two AZs.

Figure 5-9 Viewing CoreDNS pod distribution



----End

6 Security

6.1 Overview

Based on the shared security responsibility model, CCE safeguards the master nodes in a cluster and CCE components, and provides a series of hierarchical security capabilities at the cluster and container levels. Users are responsible for the security of cluster nodes and comply with the security best practices provided by CCE to perform security configuration and O&M.

CCE Application Scenarios

CCE is a container service built on popular Docker and Kubernetes technologies and offers a wealth of features best suited to enterprises' demand for running container clusters at scale. With unique advantages in system reliability, performance, and compatibility with open-source communities, CCE can suit the diverse needs of enterprises interested in building container clouds.

CCE provides a function list and typical application scenarios. For details about the function list, see **Function Overview**. For details about the application scenarios, see **Application Scenarios**.

Exception Scenarios

You are not advised to use clusters in scenarios that require strong resource isolation. CCE provides tenants with a dedicated, exclusive cluster. Currently, resources such as nodes and networks are not strictly isolated. If no strict security protection measures are available, security risks exist when the cluster is used by multiple external uncontrollable users at the same time. For example, in a development pipeline scenario, when multiple users are allowed to use the pipeline, the service code logic of different users is uncontrollable, and the cluster and services in the cluster may be attacked.

Enabling HSS

Host Security Service (HSS) provides host management, risk prevention, intrusion detection, advanced defense, security operations, and web page anti-tamper functions to comprehensively identify and manage information assets on hosts,

monitor risks on hosts in real time, and prevent unauthorized intrusions. You are advised to enable HSS to protect hosts in CCE clusters. For details about HSS and how to use it, see **HSS**.

6.2 Configuration Suggestions on CCE Cluster Security

For security purposes, you are advised to configure a cluster as follows.

Using the CCE Cluster of the Latest Version

Kubernetes releases a major version in about four months. CCE follows the same frequency as Kubernetes to release major versions. To be specific, a new CCE version is released about three months after a new Kubernetes version is released in the community. For example, Kubernetes v1.19 was released in September 2020 and CCE v1.19 was released in March 2021.

The latest cluster version has known vulnerabilities fixed or provides a more comprehensive security protection mechanism. You are advised to select the latest cluster version when creating a cluster. Before a cluster version is deprecated and removed, upgrade your cluster to a supported version.

Handling Vulnerabilities Released on the Official Website Promptly

CCE releases vulnerabilities irregularly. You need to handle the vulnerabilities in a timely manner. For details, see **Vulnerability Notice**.

Disabling the Automatic Token Mounting Function of the Default Service Account

By default, Kubernetes associates the default service account with every pod, which means that the token is mounted to a container. The container can use this token to pass the authentication by the kube-apiserver and kubelet components. In a cluster with RBAC disabled, the service account who owns the token has the control permissions for the entire cluster. In a cluster with RBAC enabled, the permissions of the service account who owns the token depends on the roles associated by the administrator. The service account's token is generally used by workloads that need to access kube-apiserver, such as coredns, autoscaler, and prometheus. For workloads that do not need to access kube-apiserver, you are advised to disable the automatic association between the service account and token.

Two methods are available:

- Method 1: Set the **automountServiceAccountToken** field of the service account to **false**. After the configuration is complete, newly created workloads will not be associated with the default service account by default. Configure this field for each namespace as required.

  ```
  apiVersion: v1
  kind: ServiceAccount
  metadata:
    name: default
  automountServiceAccountToken: false
  ...
  ```

  When a workload needs to be associated with a service account, explicitly set **automountServiceAccountToken** to **true** in the YAML file of the workload.


```
...
spec:
  template:
    spec:
      serviceAccountName: default
      automountServiceAccountToken: true
      ...
```

- Method 2: Explicitly disable the function of automatically associating service accounts with workloads.

```
...
spec:
  template:
    spec:
      automountServiceAccountToken: false
      ...
```

Configuring Proper Cluster Access Permissions for Users

CCE allows you to create multiple IAM users. Your account can create different user groups, assign different access permissions to different user groups, and add users to the user groups with corresponding permissions when creating IAM users. In this way, users can control permissions on different regions and assign read-only permissions. Your account can also assign namespace-level permissions for users or user groups. To ensure security, it is advised that minimum user access permissions are assigned.

If you need to create multiple IAM users, configure the permissions of the IAM users and namespaces properly.

- For details about how to configure cluster permissions, see **Cluster Permissions (IAM-based)**.
- For details about how to configure namespace permissions, see **Namespace Permissions (Kubernetes RBAC-based)**.

Configuring Resource Quotas for Cluster Namespaces

CCE provides resource quota management, which allows users to limit the total amount of resources that can be allocated to each namespace. These resources include CPU, memory, storage volumes, pods, Services, Deployments, and StatefulSets. Proper configuration can prevent excessive resources created in a namespace from affecting the stability of the entire cluster.

For details, see **Setting a Resource Quota**.

Configuring LimitRange for Containers in a Namespace

With resource quotas, cluster administrators can restrict the use and creation of resources by namespace. In a namespace, a pod or container can use the maximum CPU and memory resources defined by the resource quota of the namespace. In this case, a pod or container may monopolize all available resources in the namespace. You are advised to configure LimitRange to restrict resource allocation within the namespace. The LimitRange parameter has the following restrictions:

- Limits the minimum and maximum resource usage of each pod or container in a namespace.

For example, create the maximum and minimum CPU usage limits for a pod in a namespace as follows:

cpu-constraints.yaml

```
apiVersion: v1
kind: LimitRange
metadata:
  name: cpu-min-max-demo-lr
spec:
  limits:
  - max:
      cpu: "800m"
    min:
      cpu: "200m"
    type: Container
```

Then, run **kubectl -n** *<namespace>* **create -f** *cpu-constraints.yaml* to complete the creation. If the default CPU usage is not specified for the container, the platform automatically configures the default CPU usage. That is, the default configuration is automatically added after the container is created.

```
...
spec:
  limits:
  - default:
      cpu: 800m
    defaultRequest:
      cpu: 800m
    max:
      cpu: 800m
    min:
      cpu: 200m
    type: Container
```

- Limits the maximum and minimum storage space that each PersistentVolumeClaim can apply for in a namespace.

  storagelimit.yaml

  ```
  apiVersion: v1
  kind: LimitRange
  metadata:
    name: storagelimit
  spec:
    limits:
    - type: PersistentVolumeClaim
      max:
        storage: 2Gi
      min:
        storage: 1Gi
  ```

  Then, run **kubectl -n** *<namespace>* **create -f** *storagelimit.yaml* to complete the creation.

Configuring Network Isolation in a Cluster

- Container tunnel network

  If networks need to be isolated between namespaces in a cluster or between workloads in the same namespace, you can configure network policies to isolate the networks. For details, see **Network Policies**.

- Cloud Native 2.0 network

  In the Cloud Native Network 2.0 model, you can configure security groups to isolate networks between pods. For details, see **Binding a Security Group to a Workload Using a Security Group Policy**.

- VPC network

  Network isolation is not supported.

Enabling the Webhook Authentication Mode with kubelet

NOTICE

CCE clusters of v1.15.6-r1 or earlier are involved, whereas versions later than v1.15.6-r1 are not.

Upgrade the CCE cluster version to 1.13 or 1.15 and enable the RBAC capability for the cluster. If the version is 1.13 or later, no upgrade is required.

When creating a node, you can enable the kubelet authentication mode by injecting the **postinstall** file (by setting the kubelet startup parameter **--authorization-node=Webhook**).

Step 1 Run the following command to create clusterrolebinding:

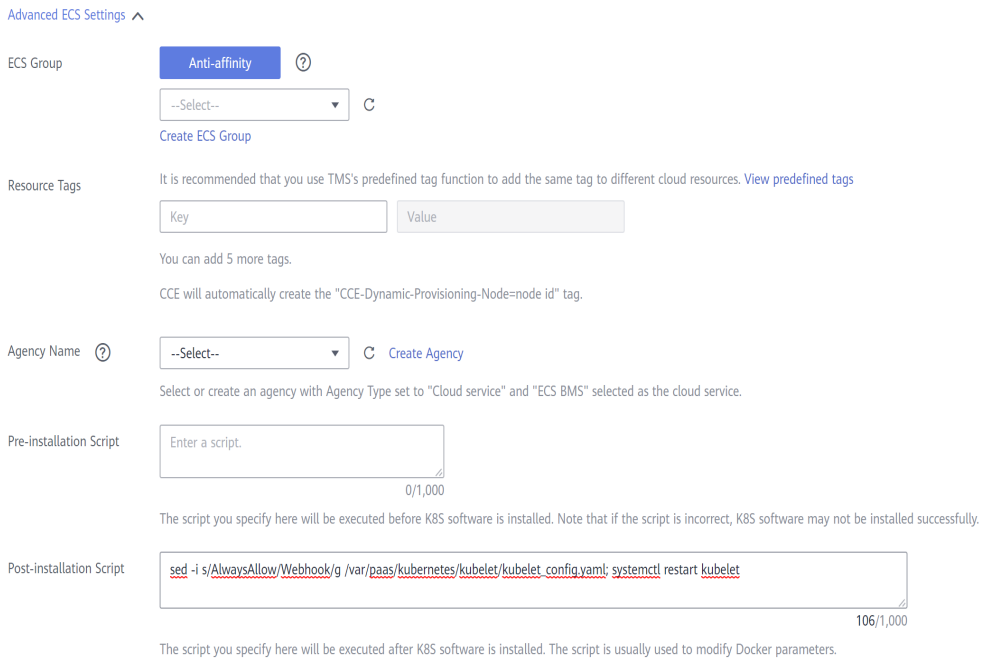
kubectl create clusterrolebinding kube-apiserver-kubelet-admin --clusterrole=system:kubelet-api-admin --user=system:kube-apiserver

Step 2 For an existing node, log in to the node, change **authorization mode** in **/var/paas/kubernetes/kubelet/kubelet_config.yaml** on the node to **Webhook**, and restart kubelet.

sed -i s/AlwaysAllow/Webhook/g /var/paas/kubernetes/kubelet/kubelet_config.yaml; systemctl restart kubelet

Step 3 For a new node, add the following command to the post-installation script to change the kubelet permission mode:

sed -i s/AlwaysAllow/Webhook/g /var/paas/kubernetes/kubelet/kubelet_config.yaml; systemctl restart kubelet



----End

Uninstalling web-terminal After Use

The web-terminal add-on can be used to manage CCE clusters. Keep the login password secure and uninstall the add-on when it is no longer needed.

6.3 Configuration Suggestions on CCE Node Security

Handling Vulnerabilities Released on the Official Website Promptly

Before releasing a new image, fix the node vulnerabilities by referring to **Vulnerability Notice**.

Preventing Nodes from Being Exposed to Public Networks

- Do not bind an EIP to a node unless necessary to reduce the attack surface.
- If an EIP must be used, properly configure the firewall or security group rules to restrict access of unnecessary ports and IP addresses.

You may have configured the **kubeconfig.json** file on a node in your cluster. kubectl can use the certificate and private key in this file to control the entire cluster. You are advised to delete unnecessary files from the **/root/.kube** directory on the node to prevent malicious use.

rm -rf /root/.kube

Hardening VPC Security Group Rules

CCE is a universal container platform. Its default security group rules apply to common scenarios. Based on security requirements, you can harden the security

group rules set for CCE clusters on the **Security Groups** page of **Network Console**.

For details, see **Configuring Cluster Security Group Rules.**

Hardening Nodes on Demand

CCE cluster nodes use the default settings of open source OSs. After a node is created, you need to perform security hardening according to your service requirements.

In CCE, you can perform hardening as follows:

- Use the post-installation script after the node is created. For details, see the description about **Post-installation Script** in **Advanced Settings** when creating a node. This script is user-defined.
- Build custom images in CCE to create worker nodes. For details about the creation process, see **Creating a Custom CCE Node Image**.

Forbidding Containers to Obtain Host Machine Metadata

If a single CCE cluster is shared by multiple users to deploy containers, containers cannot access the management address (169.254.169.254) of OpenStack, preventing containers from obtaining metadata of host machines.

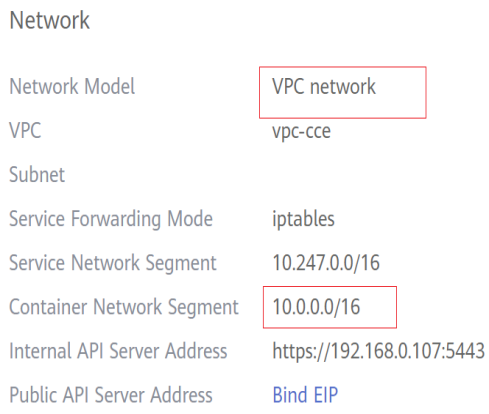
For details about how to restore the metadata, see the "Notes" section in **Obtaining Metadata**.

WARNING

This solution may affect the password change on the ECS console. Therefore, you must verify the solution before rectifying the fault.

Step 1 Obtain the network model and container CIDR of the cluster.

On the **Clusters** page of the CCE console, view the network model and container CIDR of the cluster.



Step 2 Prevent the container from obtaining host metadata.

- VPC network

  a. Log in to each node in the cluster as user **root** and run the following command:
  ```
  iptables -I OUTPUT -s {container_cidr} -d 169.254.169.254 -j REJECT
  ```
  {container_cidr} indicates the container CIDR of the cluster, for example, **10.0.0.0/16**.

  To ensure configuration persistence, write the command to the **/etc/rc.local** script.

  b. Run the following commands in the container to access the **userdata** and **metadata** interfaces of OpenStack and check whether the request is intercepted:
  ```
  curl 169.254.169.254/openstack/latest/meta_data.json
  curl 169.254.169.254/openstack/latest/user_data
  ```

- Container tunnel network

  a. Log in to each node in the cluster as user **root** and run the following command:
  ```
  iptables -I FORWARD -s {container_cidr} -d 169.254.169.254 -j REJECT
  ```
  {container_cidr} indicates the container CIDR of the cluster, for example, **10.0.0.0/16**.

  To ensure configuration persistence, write the command to the **/etc/rc.local** script.

  b. Run the following commands in the container to access the **userdata** and **metadata** interfaces of OpenStack and check whether the request is intercepted:
  ```
  curl 169.254.169.254/openstack/latest/meta_data.json
  curl 169.254.169.254/openstack/latest/user_data
  ```

- CCE Turbo cluster

  No additional configuration is required.

----End

6.4 Configuration Suggestions on CCE Container Runtime Security

Container technology uses Linux namespaces and cgroups to isolate and control resources between containers and nodes. Namespaces provide kernel-level isolation, allowing processes to be restricted from accessing specific sets of resources, such as file systems, networks, processes, and users. Cgroups are a Linux kernel feature that manages and limits the usage of resources, such as CPU, memory, disk, and network, to prevent a single process from consuming too many resources and negatively impacting the overall system performance.

While namespaces and cgroups isolate resources between containers and nodes in an environment, node resources are not visible to containers. However, this isolation does not provide true security isolation because containers share the kernels of their nodes. If a container exhibits malicious behavior or a kernel vulnerability is exploited by attackers, the container may breach resource isolation. This can result in the container escaping and potentially compromising the node and other containers on the node.

To enhance runtime security, there are various mechanisms that can be used to detect and prevent malicious activities in containers. These mechanisms, such as capabilities, seccomp, AppArmor, and SELinux, can be integrated into Kubernetes. By using these mechanisms, container security can be improved and potential threats can be minimized.

Capabilities

Capabilities are a permission mechanism that enables a process to perform certain system operations without requiring full root permissions. This mechanism divides root permissions into smaller, independent permissions known as capabilities. By doing so, the process only obtains the minimum permission set necessary to complete its tasks. This approach enhances system security and helps mitigate potential security risks.

In a containerized environment, you can manage a container's capabilities by configuring its **securityContext**. The following is a configuration example:

```
...
securityContext:
  capabilities:
    add:
    - NET_BIND_SERVICE
    drop:
    -all
```

In this way, you can ensure that the container only has the necessary permissions to complete its tasks. This approach eliminates the risk of security breaches caused by excessive permissions. For more information about how to configure capabilities for a container, see **Set capabilities for a Container**.

Seccomp

Seccomp is a mechanism that filters system calls, limiting the ones that processes can use to decrease the potential attack surface. Linux has many system calls, but not all are needed for containerized applications. By restricting the system calls that containers can execute, you can greatly reduce the risk of attacks on your applications.

Seccomp's main principle is to intercept all system calls and only allow trusted ones to pass. Container runtimes, such as Docker and containerd, come with default seccomp configurations that work for most common workloads.

In Kubernetes clusters, you can configure seccomp policies for containers to use the default security configuration. The following shows how to configure seccomp in different versions of Kubernetes clusters:

- For clusters of versions earlier than Kubernetes 1.19, you can use the following annotations to specify the seccomp configuration:
  ```
  annotations:
    seccomp.security.alpha.kubernetes.io/pod: "runtime/default"
  ```
- For clusters of Kubernetes 1.19 and later versions, you can use **securityContext** to configure seccomp policies.
  ```
  securityContext:
    seccompProfile:
      type: RuntimeDefault
  ```


These configurations use the default seccomp policy, which permits containers to make a limited number of secure system calls. For more configuration options and advanced settings of seccomp, see **Restrict a Container's Syscalls with seccomp**.

AppArmor and SELinux

AppArmor and SELinux are both Mandatory Access Control (MAC) systems that offer a more stringent approach than traditional Discretionary Access Control (DAC) to manage and restrict process permissions. While similar to seccomp in concept, these systems provide more precise access control, including access to file system paths, network ports, and other resources.

AppArmor and SELinux enable administrators to create policies that precisely manage the resources that applications can access. They can limit read and write permissions on specific files or directories, or regulate access to network ports.

Both systems are integrated into Kubernetes, allowing security policies to be applied at the container level.

- For details about how to use AppArmor, see **Restrict a Container's Access to Resources with AppArmor**.
- For SELinux, you can configure **seLinuxOptions** in **securityContext**.

  ```
  ...
  securityContext:
    seLinuxOptions:
      level: "s0:c123,c456"
  ```

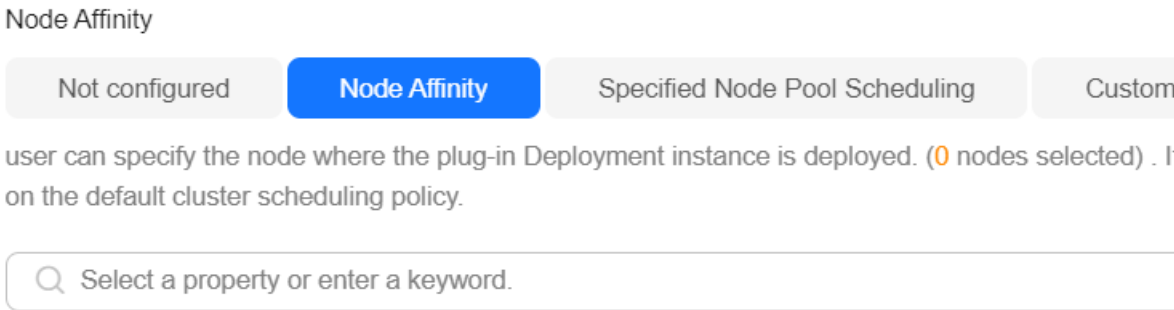
  For details, see **Assign SELinux labels to a Container**.

6.5 Configuration Suggestions on CCE Container Security

Controlling the Pod Scheduling Scope

The nodeSelector or nodeAffinity is used to limit the range of nodes to which applications can be scheduled, preventing the entire cluster from being threatened due to the exceptions of a single application. For details, see **Node Affinity**.

To achieve strong isolation, like in logical multi-tenancy situations, it is important to have system add-ons run on separate nodes or node pools. This helps keep them separated from service pods and reduces the risk of privilege escalation within a cluster. To do this, you can set the node affinity policy to either **Node Affinity** or **Specified Node Pool Scheduling** on the add-on installation page.



Suggestions on Container Security Configuration

- Set the computing resource limits (**request** and **limit**) of a container. This prevents the container from occupying too many resources and affecting the stability of the host and other containers on the same node.
- Unless necessary, do not mount sensitive host directories to containers, such as **/**, **/boot**, **/dev**, **/etc**, **/lib**, **/proc**, **/sys**, and **/usr**.
- Do not run the sshd process in containers unless necessary.
- Unless necessary, it is not recommended that containers and hosts share the network namespace.
- Unless necessary, it is not recommended that containers and hosts share the process namespace.
- Unless necessary, it is not recommended that containers and hosts share the IPC namespace.
- Unless necessary, it is not recommended that containers and hosts share the UTS namespace.
- Unless necessary, do not mount the sock file of Docker to any container.

Container Permission Access Control

When using a containerized application, comply with the minimum privilege principle and properly set securityContext of Deployments or StatefulSets.

- Configure runAsUser to specify a non-root user to run a container.
- Configure privileged to prevent containers being used in scenarios where privilege is not required.
- Configure capabilities to accurately control the privileged access permission of containers.
- Configure allowPrivilegeEscalation to disable privilege escape in scenarios where privilege escalation is not required for container processes.
- Configure seccomp to restrict the container syscalls. For details, see **Restrict a Container's Syscalls with seccomp** in the official Kubernetes documentation.
- Configure ReadOnlyRootFilesystem to protect the root file system of a container.

  Example YAML for a Deployment:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: security-context-example
  namespace: security-example
spec:
  replicas: 1
  selector:
    matchLabels:
      app: security-context-example
      label: security-context-example
  strategy:
    rollingUpdate:
      maxSurge: 25%
      maxUnavailable: 25%
    type: RollingUpdate
  template:
    metadata:
      annotations:
```



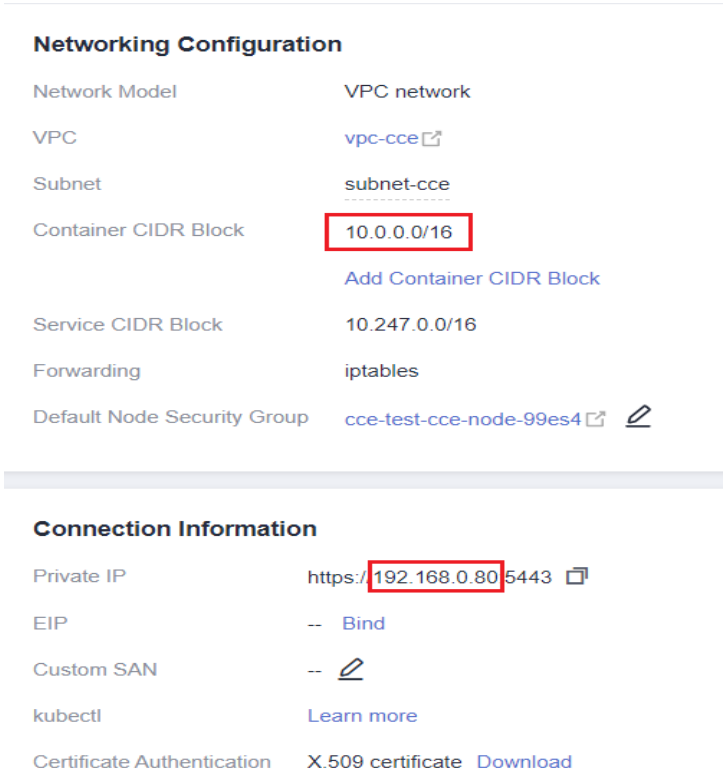
```
    seccomp.security.alpha.kubernetes.io/pod: runtime/default
  labels:
    app: security-context-example
    label: security-context-example
spec:
  containers:
    - image: ...
      imagePullPolicy: Always
      name: security-context-example
      securityContext:
        allowPrivilegeEscalation: false
        readOnlyRootFilesystem: true
        runAsUser: 1000
        capabilities:
          add:
          - NET_BIND_SERVICE
          drop:
          - all
      volumeMounts:
        - mountPath: /etc/localtime
          name: localtime
          readOnly: true
        - mountPath: /opt/write-file-dir
          name: tmpfs-example-001
  securityContext:
    seccompProfile:
      type: RuntimeDefault
  volumes:
    - hostPath:
        path: /etc/localtime
        type: ""
      name: localtime
    - emptyDir: {}
      name: tmpfs-example-001
```

Restricting the Access of Containers to the Management Plane

If application containers on a node do not need to access Kubernetes, you can perform the following operations to disable containers from accessing kube-apiserver:

Step 1 Query the container CIDR block and private API server address.

On the **Clusters** page of the CCE console, click the name of the cluster to find the information on the details page.



Step 2 Configure access rules.

- CCE cluster: Log in to each node in the cluster as user **root** and run the following command:
  - VPC network:
    ```
    iptables -I OUTPUT -s {container_cidr} -d {Private API server IP} -j REJECT
    ```
  - Container tunnel network:
    ```
    iptables -I FORWARD -s {container_cidr} -d {Private API server IP} -j REJECT
    ```

  {container_cidr} indicates the container CIDR of the cluster, for example, 10.0.0.0/16.

  To ensure configuration persistence, write the command to the **/etc/rc.local** script.
- CCE Turbo cluster: Add an outbound rule to the ENI security group of the cluster.
  a. Log in to the VPC console.
  b. In the navigation pane, choose **Access Control** > **Security Groups**.
  c. Locate the ENI security group corresponding to the cluster and name it in the format of *{Cluster name}*-**cce-eni-***{Random ID}*. Click the security group name and configure rules.
  d. Click the **Outbound Rules** tab and click **Add Rule** to add an outbound rule for the security group.
     - **Priority**: Set it to **1**.
     - **Action**: Select **Deny**, indicating that the access to the destination address is denied.

- **Type**: Select **IPv4**.
- **Protocol & Port**: Enter **5443** based on the port in the intranet API server address.
- **Destination**: Select **IP address** and enter the IP address of the internal API server.

e. Click **OK**.

Step 3 Run the following command in the container to access kube-apiserver and check whether the request is intercepted:

```
curl -k https://{Private API server IP}:5443
```

----End

6.6 Configuration Suggestions on CCE Container Image Security

Container images are the primary defense against external attacks and are crucial for securing applications, systems, and the entire supply chain. If an image is insecure, it can become a vulnerability for attackers to exploit. This can lead to the container escaping to its node, allowing attackers to access sensitive data on the node or use it as a launching pad to gain control over the entire cluster or tenant account. This section describes some recommended configurations to mitigate such risks.

Minimizing a Container Image

To improve container image security, it is recommended that you remove any unnecessary binary files. When using an unknown image from Docker Hub, you are advised to review the image content with a tool like Dive. Dive provides layer-by-layer details of an image, helping to identify potential security risks. For details, see **Dive**.

For improved security, it is recommended that you delete binary files with setuid and setgid permissions, because these can be exploited to elevate permissions. It is also wise to remove shell tools and applications that could be used maliciously, like nc and curl. To locate files with setuid and setgid bits, use the following command:

```
find / -perm /6000 -type f -exec ls -ld {} \;
```

To remove special permissions from the obtained files, add the following command to your container image:

```
RUN find / -xdev -perm /6000 -type f -exec chmod a-s {} \; || true
```

Using Multi-Stage Builds

Multi-stage builds are a great way to create container images efficiently, especially in the CI process. With multi-stage builds, you can perform lint checks on source code or static code analysis during the build process, providing quick feedback to developers. There is no need to wait for the entire build to finish.

Multi-stage builds offer significant security advantages by allowing developers to include only necessary components in container images, excluding build tools and other unnecessary binary files. This approach reduces the attack surface of images and improves overall security.

For more information about the concepts, best practices, and advantages of multi-stage builds, see the **Docker documentation**. This will help you create streamlined and secure container images while optimizing development and deployment processes.

Using SWR

SWR provides easy, secure, reliable management of container images throughout their lifecycles, featuring image push, pull, and deletion.

SWR stands out for its precise permissions management, allowing administrators to customize access permissions for different users with read, edit, and manage levels. This ensures image security and compliance, meeting the needs of team collaboration.

Additionally, SWR offers automatic deployment capabilities. You can set a trigger to automatically deploy updated image versions. When a new image version is released, SWR automatically triggers the application that uses the image in CCE to update it, streamlining CI/CD.

To further enhance SWR's security and flexibility, fine-grained permissions control can be added to IAM users. For details about authorization management, see **User Permissions**.

Scanning an Image Using SWR

With SWR, you can easily scan and secure your images with just a few clicks. Image scanning provides a thorough security check for your private images in repositories. It detects potential vulnerabilities and offers rectification suggestions.

Using an Image Signature and Configuring a Signature Verification Policy

Image signature verification is a security measure that confirms whether a container image has been tampered with after its creation. The image creator can sign the image content, and a user can verify the image's integrity and source by checking the signature.

This verification is crucial in maintaining container image security. By using image signature verification, organizations can guarantee the security and reliability of their containerized applications and safeguard them from potential security risks.

Adding the USER Instruction to a Dockerfile to Run Commands as a Non-root User

Properly configuring user permissions during container build and deployment can greatly enhance container security. This not only helps prevent potential malicious activities, but also aligns with the principle of least privilege (PoLP).

By setting the USER instruction in Dockerfiles, subsequent commands are executed as non-root users, which is a standard security practice.

- Limited permissions: Running a container as a non-root user can also mitigate potential security risks, because attackers cannot gain full control over the node even if the container is attacked.
- Restricted access: Non-root users typically have limited permissions, which restrict their access to and operation capabilities on node resources.

In addition to Dockerfiles, the **securityContext** field in **podSpec** of Kubernetes can be used to configure user and group IDs and enforce security policies during container deployment.

6.7 Configuration Suggestions on CCE Secret Security

Currently, CCE has configured static encryption for secret resources. The secrets created by users will be encrypted and stored in etcd of the CCE cluster. Secrets can be used in two modes: environment variable and file mounting. No matter which mode is used, CCE still transfers the configured data to users. Therefore, it is recommended that:

1. Do not record sensitive information in logs.
2. For the secret that uses the file mounting mode, the default file permission mapped in the container is 0644. Configure stricter permissions for the file. For example:

```
apiversion: v1
kind: Pod
metadata:
  name: mypod
spec:
  containers:
  - name: mypod
    image: redis
    volumeMounts:
    - name: foo
      mountPath: "/etc/foo"
  volumes:
  - name: foo
    secret:
      secretName: mysecret
      defaultMode: 256
```

   In **defaultMode: 256**, **256** is a decimal number, which corresponds to the octal number **0400**.

3. When the file mounting mode is used, configure the secret file name to hide the file in the container.

```
apiVersion: v1
kind: Secret
metadata:
  name: dotfile-secret
data:
  .secret-file: dmFsdWUtMg0KDQo=
---
apiVersion: v1
kind: Pod
metadata:
  name: secret-dotfiles-pod
spec:
  volumes:
  - name: secret-volume
    secret:
      secretName: dotfile-secret
  containers:
  - name: dotfile-test-container
```



```
    image: k8s.gcr.io/busybox
    command:
    - ls
    - "-1"
    - "/etc/secret-volume"
    volumeMounts:
    - name: secret-volume
      readOnly: true
      mountPath: "/etc/secret-volume"
```

In this way, **.secret-file** cannot be seen by running **ls -l** in the **/etc/secret-volume/** directory, but can be viewed by running **ls -al**.

4. Encrypt sensitive information before creating a secret and decrypt the information when using it.

Using a Bound ServiceAccount Token to Access a Cluster

The secret-based ServiceAccount token does not support expiration time or auto update. In addition, after the mounting pod is deleted, the token is still stored in the secret. Token leakage may incur security risks. A bound ServiceAccount token is recommended for CCE clusters of version 1.23 or later. In this mode, the expiration time can be set and is the same as the pod lifecycle, reducing token leakage risks. Example:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: security-token-example
  namespace: security-example
spec:
  replicas: 1
  selector:
    matchLabels:
      app: security-token-example
      label: security-token-example
  template:
    metadata:
      annotations:
        seccomp.security.alpha.kubernetes.io/pod: runtime/default
      labels:
        app: security-token-example
        label: security-token-example
    spec:
      serviceAccountName: test-sa
      containers:
        - image: ...
          imagePullPolicy: Always
          name: security-token-example
      volumes:
        - name: test-projected
          projected:
            defaultMode: 420
            sources:
              - serviceAccountToken:
                  expirationSeconds: 1800
                  path: token
              - configMap:
                  items:
                    - key: ca.crt
                      path: ca.crt
                  name: kube-root-ca.crt
              - downwardAPI:
                  items:
                    - fieldRef:
                        apiVersion: v1
                        fieldPath: metadata.namespace
                      path: namespace
```


For details, see **Managing Service Accounts**.

Using the CCE Secrets Manager for DEW Add-on

The CCE Secrets Manager for DEW add-on (dew-provider) is used to interconnect with DEW. This add-on allows you to mount secrets stored outside a cluster (DEW for storing sensitive information) to pods. In this way, sensitive information can be decoupled from the cluster environment, which prevents information leakage caused by program hardcoding or plaintext configuration. For details, see **CCE Secrets Manager for DEW**.

6.8 Configuration Suggestions on CCE Workload Identity Security

A workload identity enables workloads within a cluster to act as IAM users, granting them access to cloud services without the need for an IAM account's AK and SK. This helps to minimize security risks.

This section describes how to use workload identities in CCE.

Notes and Constraints

The cluster version must be 1.19.16 or later.

Procedure

Step 1 Obtain the public key of the cluster serviceAccountToken from CCE. For details, see **Step 1: Obtain the Public Key for Signature of the CCE Cluster**.

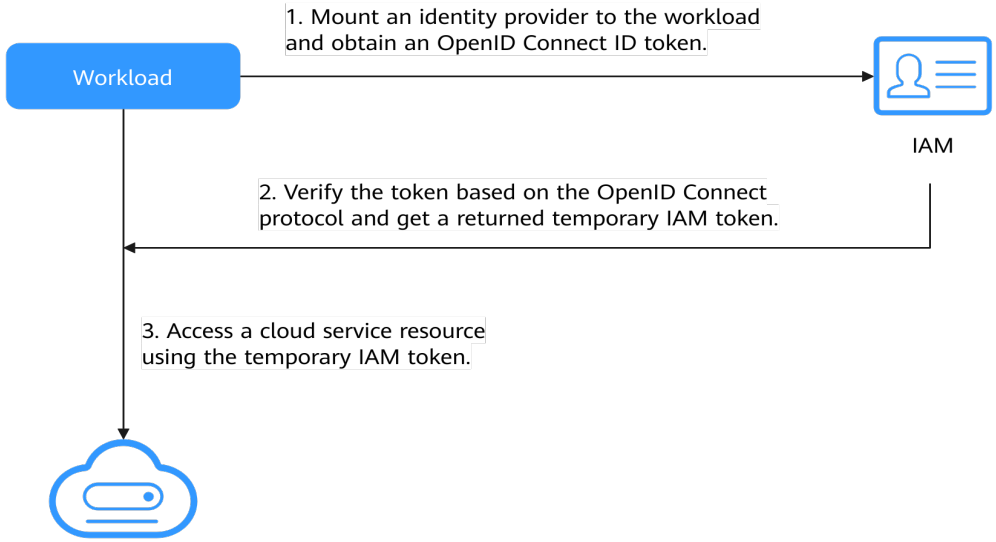
Step 2 Create an identity provider on IAM. For details, see **Step 2: Configure an Identity Provider**.

Step 3 Obtain an IAM token from the workload to simulate an IAM user to access a cloud service. For details, see **Step 3: Use a Workload Identity**.

The procedure is as follows:

1. Deploy the application pod and obtain the OpenID Connect ID token file by mounting the identity provider.
2. Use the mounted OpenID Connect ID token file in programs in the pod to access IAM and obtain a temporary IAM token.
3. Access the cloud service using the IAM token in programs in the pod.

Figure 6-1 Workflow



----End

Step 1: Obtain the Public Key for Signature of the CCE Cluster

Step 1 Use kubectl to access the target cluster.

Step 2 Obtain the public key:

kubectl get --raw /openid/v1/jwks

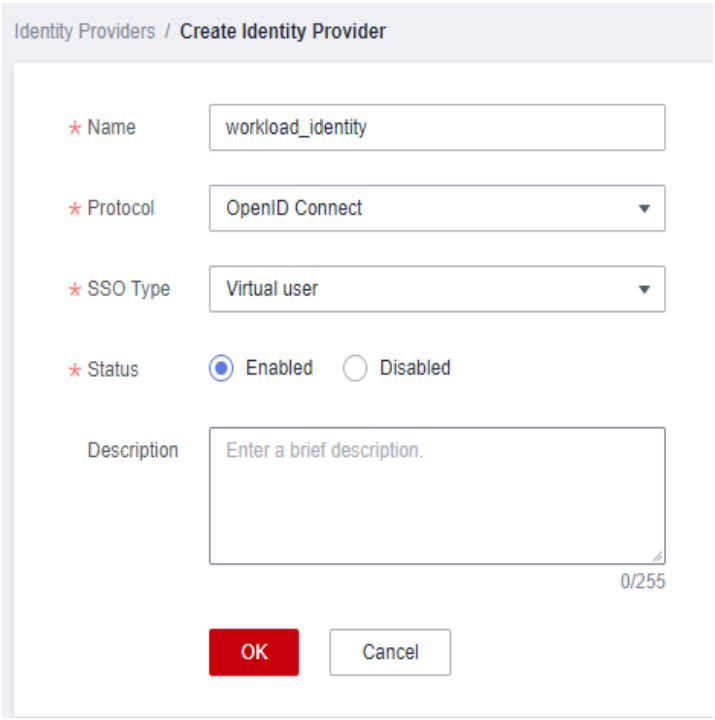
```
# kubectl get --raw /openid/v1/jwks
{"keys":[{"use":"sig","kty":"RSA","kid":"*****","alg":"RS256","n":"*****","e":"AQAB"}]}
```

The returned field is the public key of the cluster.

----End

Step 2: Configure an Identity Provider

Step 1 Log in to the IAM console, choose **Identity Providers** in the navigation pane, and click **Create Identity Provider** in the upper right corner. On the displayed page, set **Protocol** to **OpenID Connect** and **SSO Type** to **Virtual user** and click **OK**.

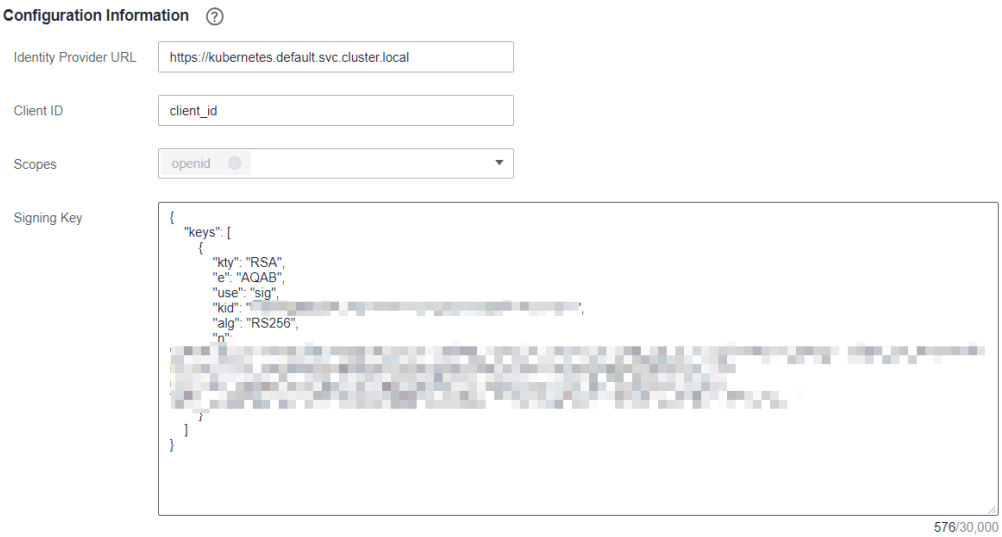


Step 2 In the identity provider list, locate the row containing the new identity provider and click **Modify** in the **Operation** column to modify the identity provider information.

Access Type: Select **Programmatic access**.

Configuration Information

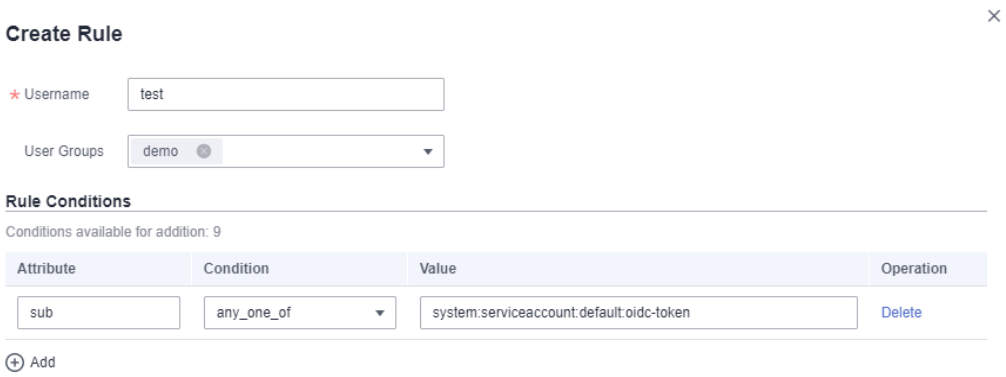
- **Identity Provider URL**: Enter **https://kubernetes.default.svc.cluster.local**.
- **Client ID**: Enter an ID, which will be used when you create a container.
- **Signing Key**: Enter the JWKS of the CCE cluster obtained in **Step 1: Obtain the Public Key for Signature of the CCE Cluster**.



Identity Conversion Rules

An identity conversion rule maps the ServiceAccount of a workload to IAM user.

For example, create a ServiceAccount named **oidc-token** in namespace **default** of the cluster and map it to user group **demo**. If you use the identity provider ID to access cloud services, you have the permissions of the **demo** user group. The attribute must be **sub**. The value format is **system:serviceaccount:*Namespace*:*ServiceAccountName***.



Rules are in the JSON format as follows:

```
[
  {
    "local": [
      {
        "user": {
          "name": "test"
        }
      },
      {
        "group": {
          "name": "demo"
        }
      }
    ],
    "remote": [
      {
        "type": "sub",
        "any_one_of": [
          "system:serviceaccount:default:oidc-token"
        ]
      }
    ]
  }
]
```

Step 3 Click **OK**.

----End

Step 3: Use a Workload Identity

Step 1 Create a ServiceAccount, whose name must be the value of **ServiceAccountName** set in **Step 2: Configure an Identity Provider**.

```
apiVersion: v1
kind: ServiceAccount
metadata:
  name: oidc-token
```


Step 2 Mount the identity provider to the workload and obtain the OpenID Connect ID token file.

An example is as follows:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx
spec:
  replicas: 1
  selector:
    matchLabels:
      app: nginx
      version: v1
  template:
    metadata:
      labels:
        app: nginx
        version: v1
    spec:
      containers:
      - name: container-1
        image: nginx:latest
        volumeMounts:
        - mountPath: "/var/run/secrets/tokens"     # Mount the serviceAccountToken generated by Kubernetes to the /var/run/secrets/tokens/oidc-token file.
          name: oidc-token
      imagePullSecrets:
      - name: default-secret
      serviceAccountName: oidc-token      # Name of the created ServiceAccount
      volumes:
      - name: oidc-token
        projected:
          defaultMode: 420
          sources:
          - serviceAccountToken:
              audience: client_id   # Must be the client ID of the identity provider.
              expirationSeconds: 7200       # Expiry period
              path: oidc-token              # Path name, which can be customized
```

Step 3 After the creation is complete, log in to the container. The content of the **/var/run/secrets/tokens/oidc-token** file is the serviceAccountToken generated by Kubernetes.

NOTE

If the serviceAccountToken is used for more than 24 hours or 80% of its expiry period, kubelet will automatically rotate the serviceAccountToken.

Step 4 Use the OpenID Connect ID token to call the API for **Obtaining a Token with an OpenID Connect ID Token**. The **X-Subject-Token** field in the response header is the IAM token. Then, you can use this token to access cloud services.

The following shows an example:

```
curl -i --location --request POST 'https://{{iam endpoint}}/v3.0/OS-AUTH/id-token/tokens' \
 --header 'X-Idp-Id: workload_identity' \
 --header 'Content-Type: application/json' \
 --data @token_body.json
```

Specifically:

- **{{iam endpoint}}** indicates the endpoint of IAM. For details, see **Regions and Endpoints**.
- **workload_identity** is the identity provider name, which is the same as that configured in **Step 2: Configure an Identity Provider**.

- **token_body.json** is a local file and its content is as follows:

```
{
  "auth" : {
    "id_token" : {
      "id" : "eyJhbGciOiJSU..."
    },
    "scope": {
      "project" : {
        "id" : "46419baef4324...",
        "name" : ******
      }
    }
  }
}
```

  - **$.auth.id_token.id**: The value is the content of the **/var/run/secrets/tokens/oidc-token** file in the container.
  - **$.auth.scope.project.id**: indicates the project ID. For details about how to obtain the project ID, see **Obtaining a Project ID**.
  - **$.auth.scope.project.name**: indicates the project name, for example, **cn-north-4**.

----End

7 Auto Scaling

7.1 Using HPA and CA for Auto Scaling of Workloads and Nodes

Application Scenarios

The best way to handle surging traffic is to automatically adjust the number of machines based on the traffic volume or resource usage, which is called scaling.

When deploying applications in pods, you can configure requested resources and resource limits for the pods to prevent unlimited usage of resources during peak hours. However, after the upper limit is reached, an application error may occur. Pod scaling can effectively resolve this issue. If the resource usage on the node increases to a certain extent, newly added pods cannot be scheduled to this node. In this case, CCE will add nodes accordingly.

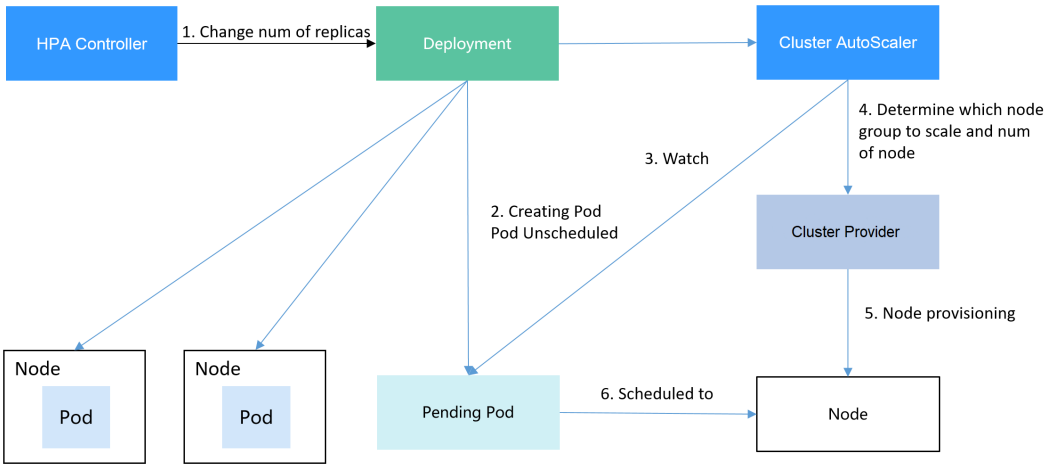
Solution

Two major auto scaling policies are HPA (Horizontal Pod Autoscaling) and CA (Cluster AutoScaling). HPA is for workload auto scaling and CA is for node auto scaling.

HPA and CA work with each other. HPA requires sufficient cluster resources for successful scaling. When the cluster resources are insufficient, CA is needed to add nodes. If HPA reduces workloads, the cluster will have a large number of idle resources. In this case, CA needs to release nodes to avoid resource waste.

As shown in **Figure 7-1**, HPA performs scale-out based on the monitoring metrics. When cluster resources are insufficient, newly created pods are in Pending state. CA then checks these pending pods and selects the most appropriate node pool based on the configured scaling policy to scale out the node pool. For details about how HPA and CA work, see **Workload Scaling Mechanisms** and **Node Scaling Mechanisms**.

Figure 7-1 HPA and CA working flows

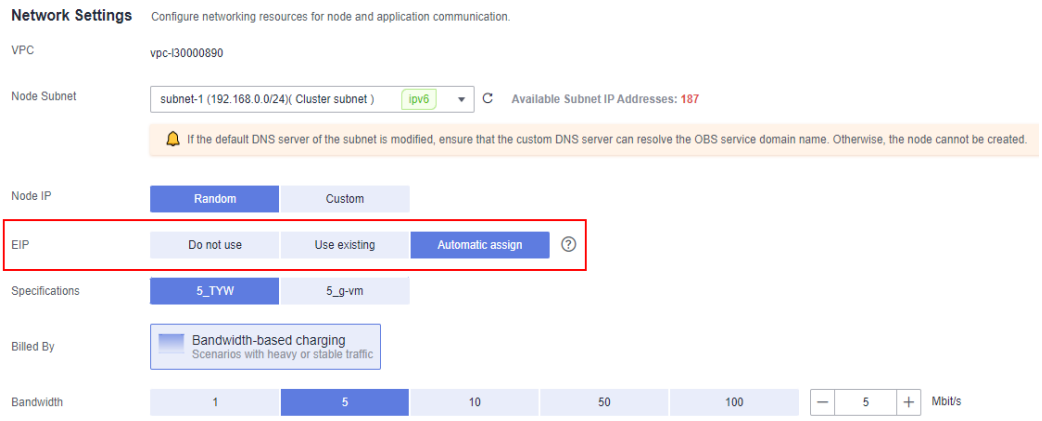


Using HPA and CA enables automatic scaling for most scenarios while also providing monitoring capabilities.

This section uses an example to describe the auto scaling process using HPA and CA policies together.

Preparations

Step 1 Create a cluster with one node. The node should have 2 cores of vCPUs and 4 GiB of memory, or a higher specification, as well as an EIP to allow external access. If no EIP is bound to the node during node creation, you can manually bind one on the ECS console after creating the node.



Step 2 Install add-ons for the cluster.

- autoscaler: node scaling add-on
- metrics-server: an aggregator of resource usage data in a Kubernetes cluster. It can collect measurement data of major Kubernetes resources, such as pods, nodes, containers, and Services.

Step 3 Log in to the cluster node and run a computing-intensive application. When a user sends a request, the result needs to be calculated before being returned to the user.

1. Create a PHP file named **index.php** to calculate the square root of the request for 1,000,000 times before returning **OK!**.
   ```
   vi index.php
   ```
   The file content is as follows:
   ```
   <?php
    $x = 0.0001;
    for ($i = 0; $i <= 1000000; $i++) {
      $x += sqrt($x);
    }
    echo "OK!";
   ?>
   ```
2. Compile a **Dockerfile** file to build an image.
   ```
   vi Dockerfile
   ```
   The content is as follows:
   ```
   FROM php:5-apache
   COPY index.php /var/www/html/index.php
   RUN chmod a+rx index.php
   ```
3. Run the following command to build an image named **hpa-example** with the tag **latest**.
   ```
   docker build -t hpa-example:latest .
   ```
4. (Optional) Log in to the SWR console, choose **Organizations** in the navigation pane, and click **Create Organization** in the upper right corner.

   Skip this step if you already have an organization.
5. In the navigation pane, choose **My Images** and then click **Upload Through Client**. On the page displayed, click **Generate a temporary login command** and click  to copy the command.
6. Run the login command copied in the previous step on the cluster node. If the login is successful, the message "Login Succeeded" is displayed.
7. Tag the hpa-example image.

   docker tag *{Image name 1:Tag 1}|{Image repository address}|{Organization name}|{Image name 2:Tag 2}*

   - *{Image name 1:Tag 1}*: name and tag of the local image to be uploaded.
   - *{Image repository address}*: the domain name at the end of the login command in **login command**. It can be obtained on the SWR console.
   - *{Organization name}*: name of the **created organization**.
   - *{Image name 2:Tag 2}*: desired image name and tag to be displayed on the SWR console.

   The following is an example:

   docker tag hpa-example:latest swr.ap-southeast-1.myhuaweicloud.com/cloud-develop/hpa-example:latest
8. Push the image to the image repository.

   docker push *{Image repository address}|{Organization name}|{Image name 2:Tag 2}*

   The following is an example:

   docker push swr.ap-southeast-1.myhuaweicloud.com/cloud-develop/hpa-example:latest

   The following information will be returned upon a successful push:
   ```
   6d6b9812c8ae: Pushed
   ...
   ```



```
fe4c16cbf7a4: Pushed
latest: digest: sha256:eb7e3bbd*** size: **
```

To view the pushed image, go to the SWR console and refresh the **My Images** page.

----End

Creating a Node Pool and a Node Scaling Policy

Step 1 Log in to the CCE console, access the created cluster, click **Nodes** on the left, click the **Node Pools** tab, and click **Create Node Pool** in the upper right corner.

Step 2 Configure the node pool.

- **Node Type**: Select a node type.
- **Specifications**: 2 vCPUs | 4 GiB

Retain the defaults for other parameters. For details, see **Creating a Node Pool**.

Step 3 Locate the row containing the newly created node pool and click **Auto Scaling** in the upper right corner. For details, see **Creating a Node Scaling Policy**.

If the CCE Cluster Autoscaler add-on is not installed in the cluster, install it first. For details, see **CCE Cluster Autoscaler**.

- **Customize scale-out rules.**: Click **Add Rule**. In the dialog box displayed, configure parameters. If the CPU allocation rate is greater than 70%, a node is added to each associated node pool. A node scaling policy needs to be associated with a node pool. Multiple node pools can be associated. When you need to scale nodes, node with proper specifications will be added or reduced from the node pool based on the minimum waste principle.
- **Nodes**: Modify the node quantity range. The number of nodes in a node pool will always be within the range during auto scaling.
- **Cooldown Period**: a period during which the nodes added in the current node pool cannot be scaled in

Step 4 Click **OK**.

----End

Creating a Workload

Use the hpa-example image to create a Deployment with one replica. The image path is related to the organization uploaded to the SWR repository and needs to be replaced with the actual value.

```
kind: Deployment
apiVersion: apps/v1
metadata:
  name: hpa-example
spec:
  replicas: 1
  selector:
    matchLabels:
      app: hpa-example
  template:
    metadata:
      labels:
        app: hpa-example
    spec:
```



```
    containers:
    - name: container-1
      image: 'hpa-example:latest' # Replace it with the address of the image you uploaded to SWR.
      resources:
        limits:                   # The value of limits must be the same as that of requests to prevent flapping during scaling.
          cpu: 500m
          memory: 200Mi
        requests:
          cpu: 500m
          memory: 200Mi
    imagePullSecrets:
    - name: default-secret
```

Then, create a NodePort Service for the workload so that the workload can be accessed from external networks.

NOTE

To allow external access to NodePort Services, allocate an EIP for the node in the cluster. After the allocation, synchronize node data. For details, see **Synchronizing Data with Cloud Servers**. If the node has already bound with an EIP, you do not need to create one.

Alternatively, you can create a Service with an ELB load balancer for external access. For details, see **Using kubectl to Create a Service (Automatically Creating a Load Balancer)**.

```
kind: Service
apiVersion: v1
metadata:
  name: hpa-example
spec:
  ports:
    - name: cce-service-0
      protocol: TCP
      port: 80
      targetPort: 80
      nodePort: 31144
  selector:
    app: hpa-example
  type: NodePort
```

Creating an HPA Policy

Create an HPA policy. As shown below, the policy is associated with the hpa-example workload, and the target CPU usage is 50%.

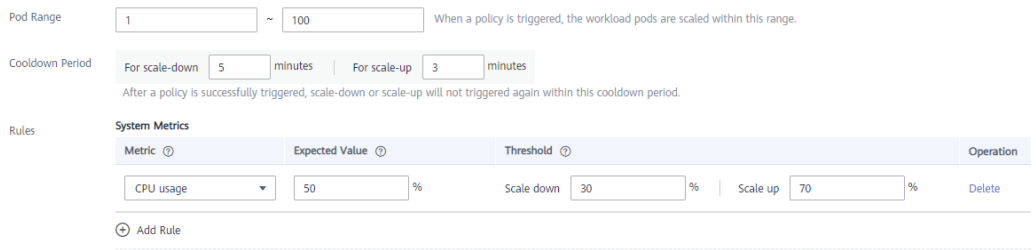
There are two other annotations. One annotation defines the CPU thresholds, indicating that scaling is not performed when the CPU usage is between 30% and 70% to prevent impact caused by slight fluctuation. The other is the scaling time window, indicating that after the policy is successfully executed, a scaling operation will not be triggered again in this cooling interval to prevent impact caused by short-term fluctuation.

```
apiVersion: autoscaling/v2
kind: HorizontalPodAutoscaler
metadata:
  name: hpa-policy
  annotations:
    extendedhpa.metrics: '[{"type":"Resource","name":"cpu","targetType":"Utilization","targetRange":{"low":"30","high":"70"}}]'
    extendedhpa.option: '{"downscaleWindow":"5m","upscaleWindow":"3m"}'
spec:
  scaleTargetRef:
    kind: Deployment
    name: hpa-example
    apiVersion: apps/v1
```



```
minReplicas: 1
maxReplicas: 100
metrics:
  - type: Resource
    resource:
      name: cpu
      target:
        type: Utilization
        averageUtilization: 50
```

Configure the parameters as follows if you are using the console.



Observing the Auto Scaling Process

Step 1 Check the cluster node status. In the following example, there are two nodes.

```
# kubectl get node
NAME          STATUS   ROLES    AGE     VERSION
192.168.0.183   Ready    <none>   2m20s   v1.17.9-r0-CCE21.1.1.3.B001-17.36.8
192.168.0.26    Ready    <none>   55m     v1.17.9-r0-CCE21.1.1.3.B001-17.36.8
```

Check the HPA policy. The CPU usage of the target workload is 0%.

```
# kubectl get hpa hpa-policy
NAME         REFERENCE                TARGETS   MINPODS   MAXPODS   REPLICAS   AGE
hpa-policy   Deployment/hpa-example   0%/50%    1         100       1          4m
```

Step 2 Run the following command to access the workload. In the following command, {ip:port} indicates the access address of the workload, which can be queried on the workload details page.

while true;do wget -q -O- http://*{ip:port}*; done

NOTE

If no EIP is displayed, the cluster node has not been assigned any EIP. Allocate one, bind it to the node, and synchronize node data. For details, see **Synchronizing Data with Cloud Servers**.

Observe the scaling process of the workload.

```
# kubectl get hpa hpa-policy --watch
NAME         REFERENCE                TARGETS     MINPODS   MAXPODS   REPLICAS   AGE
hpa-policy   Deployment/hpa-example   0%/50%      1         100       1          4m
hpa-policy   Deployment/hpa-example   190%/50%    1         100       1          4m23s
hpa-policy   Deployment/hpa-example   190%/50%    1         100       4          4m31s
hpa-policy   Deployment/hpa-example   200%/50%    1         100       4          5m16s
hpa-policy   Deployment/hpa-example   200%/50%    1         100       4          6m16s
hpa-policy   Deployment/hpa-example   85%/50%     1         100       4          7m16s
hpa-policy   Deployment/hpa-example   81%/50%     1         100       4          8m16s
hpa-policy   Deployment/hpa-example   81%/50%     1         100       7          8m31s
hpa-policy   Deployment/hpa-example   57%/50%     1         100       7          9m16s
hpa-policy   Deployment/hpa-example   51%/50%     1         100       7          10m
hpa-policy   Deployment/hpa-example   58%/50%     1         100       7          11m
```


You can see that the CPU usage of the workload is 190% at 4m23s, which exceeds the target value. In this case, scaling is triggered to expand the workload to four replicas/pods. In the subsequent several minutes, the CPU usage does not decrease until 7m16s. This is because the new pods may not be successfully created. The possible cause is that resources are insufficient and the pods are in the pending state. During this period, nodes are being scaled out.

At 7m16s, the CPU usage decreases, indicating that the pods are successfully created and start to bear traffic. The CPU usage decreases to 81% at 8m, still greater than the target value (50%) and the high threshold (70%). Therefore, 7 pods are added at 9m16s, and the CPU usage decreases to 51%, which is within the range of 30% to 70%. From then on, the number of pods remains 7.

In the following output, you can see the workload scaling process and the time when the HPA policy takes effect.

```
# kubectl describe deploy hpa-example
...
Events:
  Type    Reason             Age    From                   Message
  ----    ------             ----   ----                   -------
  Normal  ScalingReplicaSet  25m    deployment-controller  Scaled up replica set hpa-example-79dd795485
to 1
  Normal  ScalingReplicaSet  20m    deployment-controller  Scaled up replica set hpa-example-79dd795485
to 4
  Normal  ScalingReplicaSet  16m    deployment-controller  Scaled up replica set hpa-example-79dd795485
to 7
# kubectl describe hpa hpa-policy
...
Events:
  Type    Reason             Age    From                       Message
  ----    ------             ----   ----                       -------
  Normal  SuccessfulRescale  20m    horizontal-pod-autoscaler  New size: 4; reason: cpu resource utilization
(percentage of request) above target
  Normal  SuccessfulRescale  16m    horizontal-pod-autoscaler  New size: 7; reason: cpu resource utilization
(percentage of request) above target
```

Check the number of nodes. The following output shows that two nodes are added.

```
# kubectl get node
NAME           STATUS   ROLES    AGE     VERSION
192.168.0.120  Ready    <none>   3m5s    v1.17.9-r0-CCE21.1.1.3.B001-17.36.8
192.168.0.136  Ready    <none>   6m58s   v1.17.9-r0-CCE21.1.1.3.B001-17.36.8
192.168.0.183  Ready    <none>   18m     v1.17.9-r0-CCE21.1.1.3.B001-17.36.8
192.168.0.26   Ready    <none>   71m     v1.17.9-r0-CCE21.1.1.3.B001-17.36.8
```

You can also view the scaling history on the console. For example, the CA policy is executed once when the CPU allocation rate in the cluster is greater than 70%, and the number of nodes in the node pool is increased from 2 to 3. The new node is automatically added by autoscaler based on the pending state of pods in the initial phase of HPA.

The node scaling process is as follows:

1. After the number of pods changes to 4, the pods are in Pending state due to insufficient resources. As a result, the default scale-out policy of the autoscaler add-on is triggered, and the number of nodes is increased by one.
2. The second node scale-out is triggered because the CPU allocation rate in the cluster is greater than 70%. As a result, the number of nodes is increased by one, which is recorded in the scaling history on the console. Scaling based on the allocation rate ensures that the cluster has sufficient resources.

Step 3 Stop accessing the workload and check the number of pods.

```
# kubectl get hpa hpa-policy --watch
NAME         REFERENCE                    TARGETS    MINPODS   MAXPODS   REPLICAS   AGE
hpa-policy   Deployment/hpa-example   50%/50%    1         100       7          12m
hpa-policy   Deployment/hpa-example   21%/50%    1         100       7          13m
hpa-policy   Deployment/hpa-example   0%/50%     1         100       7          14m
hpa-policy   Deployment/hpa-example   0%/50%     1         100       7          18m
hpa-policy   Deployment/hpa-example   0%/50%     1         100       3          18m
hpa-policy   Deployment/hpa-example   0%/50%     1         100       3          19m
hpa-policy   Deployment/hpa-example   0%/50%     1         100       3          19m
hpa-policy   Deployment/hpa-example   0%/50%     1         100       3          19m
hpa-policy   Deployment/hpa-example   0%/50%     1         100       3          19m
hpa-policy   Deployment/hpa-example   0%/50%     1         100       3          23m
hpa-policy   Deployment/hpa-example   0%/50%     1         100       3          23m
hpa-policy   Deployment/hpa-example   0%/50%     1         100       1          23m
```

You can see that the CPU usage is 21% at 13m. The number of pods is reduced to 3 at 18m, and then reduced to 1 at 23m.

In the following output, you can see the workload scaling process and the time when the HPA policy takes effect.

```
# kubectl describe deploy hpa-example
...
Events:
  Type    Reason             Age    From                   Message
  ----    ------             ----   ----                   -------
  Normal  ScalingReplicaSet  25m    deployment-controller  Scaled up replica set hpa-example-79dd795485
to 1
  Normal  ScalingReplicaSet  20m    deployment-controller  Scaled up replica set hpa-example-79dd795485
to 4
  Normal  ScalingReplicaSet  16m    deployment-controller  Scaled up replica set hpa-example-79dd795485
to 7
  Normal  ScalingReplicaSet  6m28s  deployment-controller  Scaled down replica set hpa-
example-79dd795485 to 3
  Normal  ScalingReplicaSet  72s    deployment-controller  Scaled down replica set hpa-
example-79dd795485 to 1
# kubectl describe hpa hpa-policy
...
Events:
  Type    Reason             Age    From                       Message
  ----    ------             ----   ----                       -------
  Normal  SuccessfulRescale  20m    horizontal-pod-autoscaler  New size: 4; reason: cpu resource utilization
(percentage of request) above target
  Normal  SuccessfulRescale  16m    horizontal-pod-autoscaler  New size: 7; reason: cpu resource utilization
(percentage of request) above target
  Normal  SuccessfulRescale  6m45s  horizontal-pod-autoscaler  New size: 3; reason: All metrics below target
  Normal  SuccessfulRescale  90s    horizontal-pod-autoscaler  New size: 1; reason: All metrics below target
```

You can also view the HPA policy execution history on the console. Wait until the one node is reduced.

The reason why the other two nodes in the node pool are not reduced is that they both have pods in the kube-system namespace (and these pods are not created by DaemonSets). For details, see **Node Scaling Mechanisms**.

----End

Summary

By using HPA and CA, auto scaling can be effortlessly implemented in various scenarios. Additionally, the scaling process of nodes and pods can be conveniently tracked.

7.2 Elastic Scaling of CCE Pods to CCI

The bursting add-on functions as a virtual kubelet to connect Kubernetes clusters to APIs of other platforms. This add-on is mainly used to extend Kubernetes APIs to serverless container services such as Huawei Cloud CCI.

With this add-on, you can schedule Deployments, StatefulSets, jobs, and CronJobs running in CCE clusters to **CCI** during peak hours. In this way, you can reduce consumption caused by cluster scaling.

Installing the Add-on

1. Log in to the CCE console.
2. Click the name of the target CCE cluster to go to the cluster console.
3. In the navigation pane, choose **Add-ons**.
4. Select the **CCE Cloud Bursting Engine for CCI** add-on and click **Install**.
5. Configure the add-on parameters.

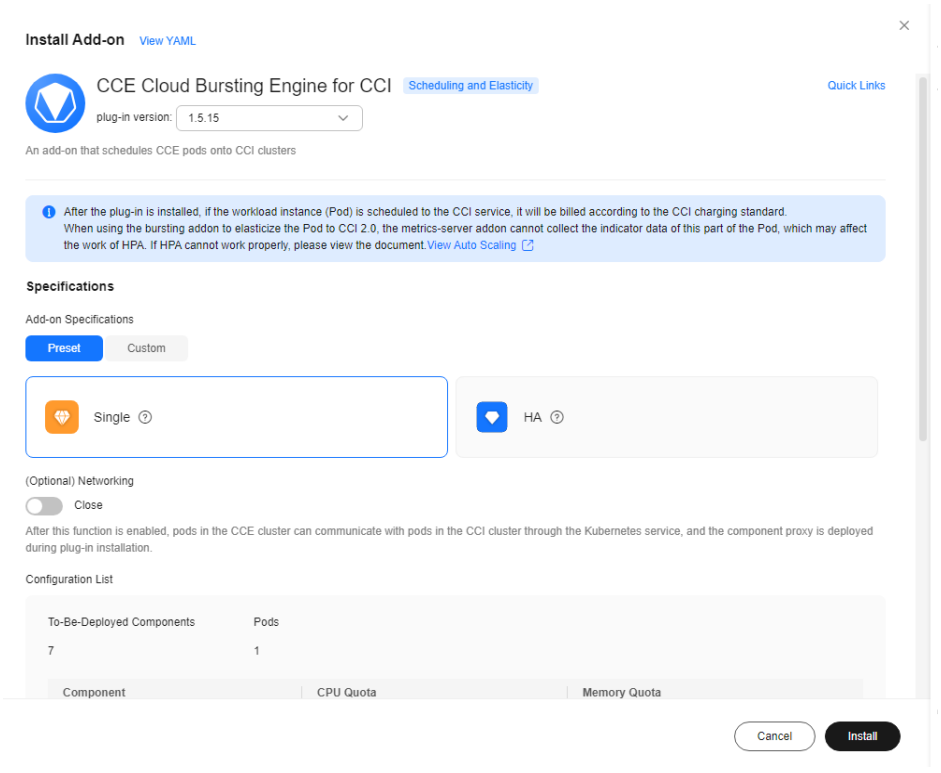


Table 7-1 Add-on parameters

Parameter	Description
Version	Add-on version. There is a mapping between add-on versions and CCE cluster versions. For more details, see "Change History" in **CCE Cloud Bursting Engine for CCI**.

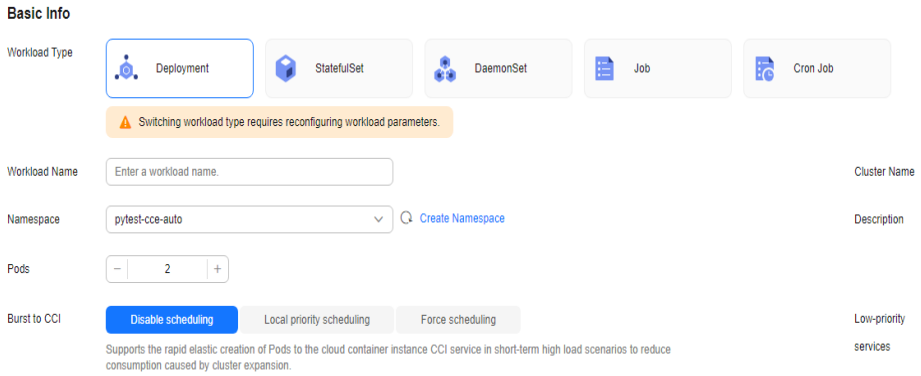
Parameter	Description

Specifications	Number of pods required for running the add-on.
	• If you select **Preset**, you can select **Single** or **HA**.
	• If you select **Custom**, you can modify the number of replicas, vCPUs, and memory of each add-on component as required.
	NOTE
	• The bursting add-on 1.5.2 or later uses more node resources. You need to reserve sufficient pods before upgrading the add-on.
	  • **Single** (only one pod for the add-on): There must be a node that has at least seven schedulable pods. If **Networking** is enabled, eight schedulable pods are required.
	  • **HA** (two pods for the add-on): There must be two nodes, each of which must have at least seven schedulable pods, a total of 14 schedulable pods. If **Networking** is enabled, eight schedulable pods are required on each node, a total of 16 schedulable pods.
	• The resource usage of the add-on varies depending on the workloads scaled to CCI. The pods, secrets, ConfigMaps, PVs, and PVCs requested by the services occupy VM resources. You are advised to evaluate the service usage and apply for VMs based on the following specifications: For 1,000 pods and 1,000 ConfigMaps (300 KB), nodes with 2 vCPUs and 4-GiB memory are recommended. For 2,000 pods and 2,000 ConfigMaps, nodes with 4 vCPUs and 8-GiB memory are recommended. For 4,000 pods and 4,000 ConfigMaps, nodes with 8 vCPUs and 16-GiB memory are recommended.

Networking	If this option is enabled, pods in the CCE cluster can communicate with pods in CCI through Services. The component proxy will be automatically deployed upon add-on installation. For details, see **Networking**.

Creating a Workload

1. Log in to the CCE console.
2. Click the name of the target CCE cluster to go to the cluster console.
3. In the navigation pane, choose **Workloads**.
4. Click **Create Workload**. For details, see **Creating a Workload**.
5. Specify basic information. Set **Burst to CCI** to **Force scheduling**. For more information about scheduling policies, see **Scheduling Pods to CCI**.



CAUTION

When you schedule a workload in a CCE cluster to CCI, TCP probes cannot be used for health check.

6. Configure the container parameters.
7. Click **Create Workload**.
8. On the **Workloads** page, click the name of the created workload to go to the workload details page.
9. View the node where the workload is running. If the workload is running on a CCI node, it has been scheduled to CCI.

Uninstalling the Add-on

1. Log in to the CCE console.
2. Click the name of the target CCE cluster to go to the cluster console.
3. In the navigation pane, choose **Add-ons**.
4. Select the **CCE Cloud Bursting Engine for CCI** add-on and click **Uninstall**.

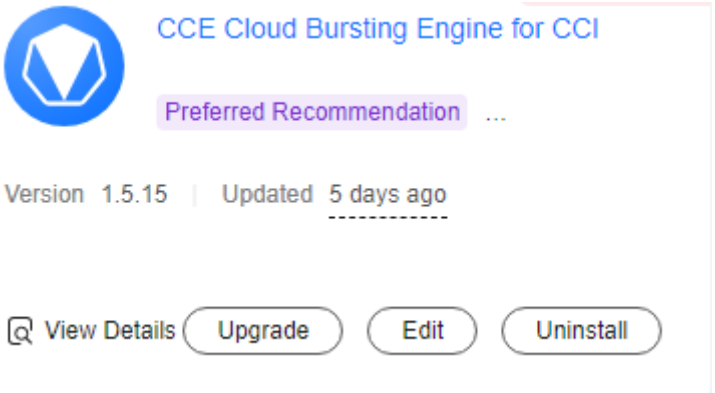


Table 7-2 Special scenarios for uninstalling the add-on

Scenario	Symptom	Description
There are no nodes in the CCE cluster that the bursting add-on needs to be uninstalled from.	Failed to uninstall the bursting add-on.	If the bursting add-on is uninstalled from the cluster, a job for clearing resources will be started in the cluster. To ensure that the job can be started, there is at least one node in the cluster that can be scheduled.
The CCE cluster is deleted, but the bursting add-on is not uninstalled.	There are residual resources in the namespace on CCI. If the resources are not free, additional expenditures will be generated.	The cluster is deleted, but the resource clearing job is not executed. You can manually clear the namespace and residual resources.

For more information about the bursting add-on, see **CCE Cloud Bursting Engine for CCI**.

7.3 Auto Scaling Based on Prometheus Metrics

Kubernetes' default HPA policy only allows for auto scaling based on CPU and memory usage. However, in more complex service scenarios, this may not be sufficient to meet routine O&M requirements. To address this, CCE offers a Cloud Native Cluster Monitoring (kube-prometheus-stack) add-on that integrates into the open-source Prometheus ecosystem. This add-on allows for monitoring of various components and provides multiple preset monitoring dashboards that are ready to use out-of-the-box. This document describes how to convert Huawei Cloud Prometheus metrics into metrics that can be used by HPA, providing a more convenient scaling mechanism for applications.

Prerequisites

- A cluster has been created.
- You can access the cluster using kubectl. For details, see **Connecting to a Cluster Using kubectl**.

Step 1: Install Cloud Native Cluster Monitoring

Step 1 Log in to the CCE console and click the cluster name to access the cluster console. In the navigation pane, choose **Add-ons**.

Step 2 Locate the Cloud Native Cluster Monitoring add-on and click **Install**.

You are advised to focus on the following configurations, and adjust any other configurations as necessary. For details, see **Cloud Native Cluster Monitoring**.

- **Local Data Storage**: Enable this option to store the monitoring data in local storage. You can determine whether to report the monitoring data to AOM or a third-party monitoring platform.
- **Custom Metric Collection**: Enable this option in this practice. If this option is not enabled, custom metrics cannot be collected.

Step 3 Click **Install**.

----End

Step 2: Obtain Prometheus Monitoring Data

In this section, HPA is performed based on metrics related to pods, for example, pod metrics. You can also perform HPA based on metrics irrelevant to pods, for example, external load balancer metrics. For details, see **Auto Scaling Based on ELB Monitoring Metrics**.

The following describes how to deploy a **sample-app** application and expose the **container_memory_working_set_bytes_per_second** metric in Prometheus standard mode to identify the number of bytes per second in the working set of the container memory. For more information about Prometheus metrics, see **METRIC TYPES**.

Step 1 Deploy the test application.

1. Write a **sample-app.yaml** file. The file content is as follows:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: sample-app
  labels:
    app: sample-app
spec:
  replicas: 1
  selector:
    matchLabels:
      app: sample-app
  template:
    metadata:
      labels:
        app: sample-app
    spec:
      containers:
      - image: swr.cn-east-3.myhuaweicloud.com/container/autoscale-demo:v0.1.2 # Sample image
        name: metrics-provider
        resources:
          requests:
            cpu: 250m
            memory: 512Mi
          limits:
            cpu: 250m
            memory: 512Mi
        ports:
        - name: http
          containerPort: 8080   #Container port
      imagePullSecrets:
        - name: default-secret
---
apiVersion: v1
kind: Service
metadata:
  name: sample-app
  namespace: default
  labels:
```



```
    app: sample-app
spec:
  ports:
    - port: 80
      name: http
      protocol: TCP
      targetPort: 8080
  selector:
    app: sample-app
  type: ClusterIP
```

NOTE

The application exposes **container_memory_working_set_bytes_per_second**, which is used to check the working memory size of a container per second.

2. Create a workload.

```
kubectl apply -f sample-app.yaml
```

Step 2 Create a ServiceMonitor to monitor custom metrics.

1. Create a **servicemonitor.yaml** file. The file content is as follows:

```
apiVersion: monitoring.coreos.com/v1
kind: ServiceMonitor
metadata:
  name: sample-app  # ServiceMonitor name
  namespace: default
spec:
  endpoints:        # Endpoints of the service to be monitored, including the name, port number, path, protocol, and more
  - interval: 30s   # Prometheus operator checks whether a service needs to be added to the monitored target list every 30 seconds.
    port: http
    path: /metrics
  namespaceSelector:
    any: true
  selector:
    matchLabels:
      app: sample-app  # Label of the object whose data needs to be collected
```

2. Create ServiceMonitor.

```
kubectl apply -f servicemonitor.yaml
```

----End

Step 3: Modify Configuration Files

Step 1 Modify Prometheus' **adapter-config**.

You can modify the **rules** field in **adapter-config** to convert the metrics exposed by Prometheus to metrics that can be associated with HPA.

```
kubectl -n monitoring edit configmap user-adapter-config
```

Step 2 Add a custom metric collection rule to the **rules** field. You can add multiple collection rules by adding multiple configurations under the **rules** field. For details, see **Metrics Discovery and Presentation Configuration**.

The following is an example of a custom collection rule:

```
rules:
- seriesQuery: container_memory_working_set_bytes{namespace!="",pod!=""}
  resources:
    overrides:
      namespace:
        resource: namespace
      pod:
    resource: pod
```



```
  name:
    matches: ^(.*)_bytes
    as: ${1}_bytes_per_second #The value of ${1} is the value that matches ^(.*) in matches:"^(.*)_bytes".
  metricsQuery: sum(<<.Series>>{<<.LabelMatchers>>}) by (<<.GroupBy>>)
```

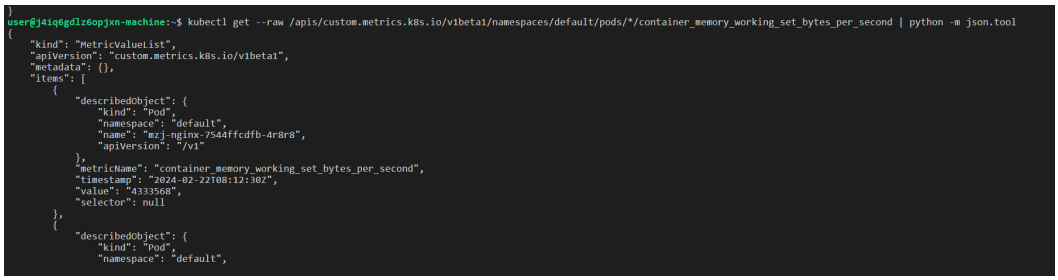
- **seriesQuery**: indicates the PromQL request data. It specifies the metrics to be obtained by users. You can configure this parameter as needed.
- **metricsQuery**: aggregates the data requested by PromQL in **seriesQuery**.
- **resources**: specifies data label in PromQL, which is used to match resources. The resources here refer to the api-resource in a cluster, such as pods, namespaces, and nodes. You can run kubectl api-resources -o wide to check the resources. The key corresponds to **LabelName** in the Prometheus data. You have to ensure that the Prometheus metric data contains **LabelName**.
- **name**: indicates that Prometheus metric names are converted to readable metric names based on regular expression matching. In this example, **container_memory_working_set_bytes** is converted to **container_memory_working_set_bytes_per_second**.

Step 3 Redeploy the **custom-metrics-apiserver** workload in the **monitoring** namespace.

```
kubectl -nmonitoring delete pod -l app=custom-metrics-apiserver
```

Step 4 Run the following command to check whether the metric is added:

```
kubectl get --raw /apis/custom.metrics.k8s.io/v1beta1/namespaces/default/pods/*/container_memory_working_set_bytes_per_second
```



----End

Step 4: Create an HPA Policy

Step 1 Create an HPA policy using custom metrics.

1. Create an **hpa.yaml** file. The file content is as follows:

```
kind: HorizontalPodAutoscaler
apiVersion: autoscaling/v2
metadata:
  name: sample-app-memory-high
spec:
# Description of an HPA object. HPA dynamically changes the number of pods of the object.
  scaleTargetRef:
    apiVersion: apps/v1
    kind: Deployment
    name: sample-app
# Minimum number of pods and maximum number of pods of the HPA
  minReplicas: 1
  maxReplicas: 10
#Monitored metric array. Multiple types of metrics can coexist.
  metrics:
  - type: Pods
    pods:
      metric:
        name: container_memory_working_set_bytes_per_second   # Use the custom container metrics.
```



```
    target:
      type: AverageValue  # Target value of the AverageValue type. For the pod metrics, only the target values of the AverageValue type are supported.
      averageValue: 1024000m   # 1024000m specifies 1 KB.
```

2. Create the HPA policy.

```
kubectl apply -f hpa.yaml
```

Step 2 Check whether the HPA policy takes effect.

```
kubectl get hpa sample-app-memory-high
```

```
NAME                    REFERENCE                  TARGETS              MINPODS   MAXPODS   REPLICAS   AGE
sample-app-memory-high  Deployment/sample-app      9896345600m/1024     1         10        10         2m21s
user@j4iq6gdlz6opjxn-machine:~$
```

The number of replicas has been increased from 1 to 10.

----End

7.4 Auto Scaling Based on ELB Monitoring Metrics

Background

By default, Kubernetes scales a workload based on resource usage metrics such as CPU and memory. However, this mechanism cannot reflect the real-time resource usage when traffic bursts arrive, because the collected CPU and memory usage data lags behind the actual load balancer traffic metrics. For some services (such as flash sale and social media) that require fast auto scaling, scaling based on this rule may not be performed in a timely manner and cannot meet these services' actual needs. In this case, auto scaling based on ELB QPS data can respond to service requirements more timely.

Solution

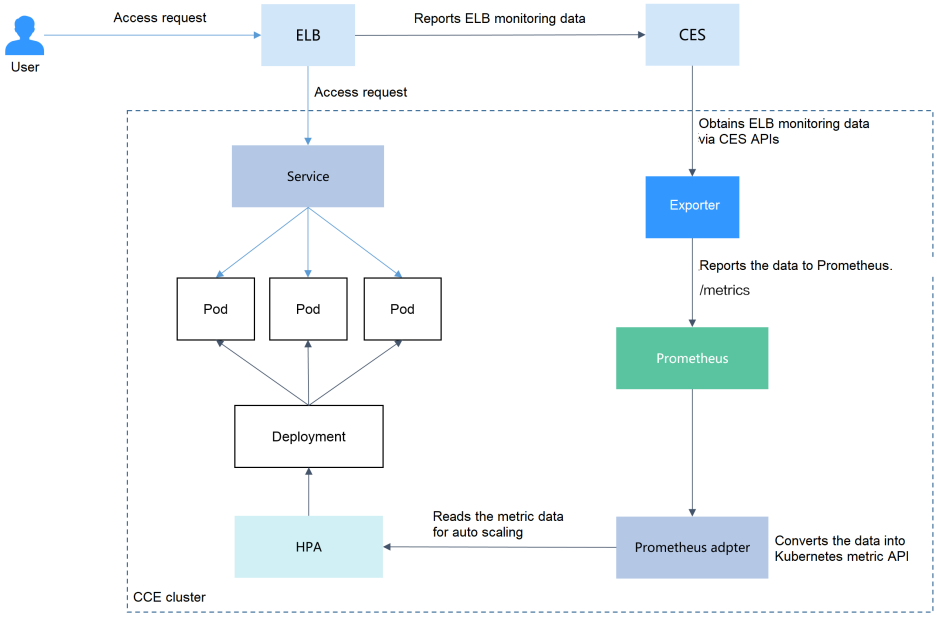
This section describes an auto scaling solution based on ELB monitoring metrics. Compared with CPU/memory usage-based auto scaling, auto scaling based on ELB QPS data is more targeted and timely.

The key of this solution is to obtain the ELB metric data and report the data to Prometheus, convert the data in Prometheus to the metric data that can be identified by HPA, and then perform auto scaling based on the converted data.

The implementation scheme is as follows:

1. Develop a Prometheus exporter to obtain ELB metric data, convert the data into the format required by Prometheus, and report it to Prometheus. This section uses **cloudeye-exporter** as an example.
2. Convert the Prometheus data into the Kubernetes metric API for the HPA controller to use.
3. Set an HPA rule to use ELB monitoring data as auto scaling metrics.

Figure 7-2 ELB traffic flows and monitoring data



NOTE

Other metrics can be collected in the similar way.

Prerequisites

- You are familiar with Prometheus.
- You have installed the Cloud Native Cluster Monitoring add-on (kube-prometheus-stack) of version 3.10.1 or later in the cluster.

  NOTE

  Local Data Storage must be enabled for **Data Storage Configuration**.

Building an Exporter Image

This section uses **cloudeye-exporter** to monitor load balancer metrics. To develop an exporter, see **Appendix: Developing an Exporter**.

Step 1 Log in to a VM that can access the Internet and has Docker installed and write a Dockerfile.

```
vi Dockerfile
```

The content is as follows:

```
FROM ubuntu:18.04
RUN apt-get update \
 && apt-get install -y git ca-certificates curl \
  && update-ca-certificates \
   && curl -O  https://dl.google.com/go/go1.14.14.linux-amd64.tar.gz \
    && tar -zxf go1.14.14.linux-amd64.tar.gz -C /usr/local \
     && git clone -b master https://github.com/huaweicloud/cloudeye-exporter \
      && export PATH=$PATH:/usr/local/go/bin \
       && export GO111MODULE=on \
        && export GOPROXY=https://goproxy.cn,direct \
         && export GONOSUMDB=* \
          && cd cloudeye-exporter \
```



```
                && go build
CMD ["/cloudeye-exporter/cloudeye-exporter -config=/tmp/clouds.yml"]
```

Step 2 Build an image. The image name is **cloudeye-exporter** and the image version is 1.0.

```
docker build --network host . -t cloudeye-exporter:1.0
```

Step 3 Push the image to SWR.

1. (Optional) Log in to the SWR console, choose **Organizations** in the navigation pane, and click **Create Organization** in the upper right corner of the page.

   Skip this step if you already have an organization.

2. In the navigation pane, choose **My Images** and then click **Upload Through Client**. On the page displayed, click **Generate a temporary login command** and click  to copy the command.

3. Run the login command copied in the previous step on the cluster node. If the login is successful, the message "Login Succeeded" is displayed.

4. Tag the **cloudeye-exporter** image.

   docker tag *{Image name 1:Tag 1}*|*{Image repository address}*|*{Organization name}*|*{Image name 2:Tag 2}*

   - *{Image name 1:Tag 1}*: name and tag of the local image to be uploaded.
   - *{Image repository address}*: The domain name at the end of the login command in **Step 3.2** is the image repository address, which can be obtained on the SWR console.
   - *{Organization name}*: name of the organization created in **Step 3.1**.
   - *{Image name 2:Tag 2}*: desired image name and tag to be displayed on the SWR console.

   The following is an example:

   docker tag cloudeye-exporter:1.0 swr.ap-southeast-1.myhuaweicloud.com/cloud-develop/cloudeye-exporter:1.0

5. Push the image to the image repository.

   docker push *{Image repository address}*|*{Organization name}*|*{Image name 2:Tag 2}*

   The following is an example:

   docker push swr.ap-southeast-1.myhuaweicloud.com/cloud-develop/cloudeye-exporter:1.0

   The following information will be returned upon a successful push:

   ```
   ...
   030***: Pushed
   1.0: digest: sha256:eb7e3bbd*** size: **
   ```

   To view the pushed image, go to the SWR console and refresh the **My Images** page.

----End

Deploying the Exporter

Prometheus can dynamically monitor pods if you add Prometheus annotations to the pods (the default path is **/metrics**). This section uses **cloudeye-exporter** as an example.

Common annotations in Prometheus are as follows:

- **prometheus.io/scrape**: If the value is **true**, the pod will be monitored.
- **prometheus.io/path**: URL from which the data is collected. The default value is **/metrics**.
- **prometheus.io/port**: port number of the endpoint to collect data from.
- **prometheus.io/scheme**: Defaults to **http**. If HTTPS is configured for security purposes, change the value to **https**.

Step 1 Use kubectl to connect to the cluster.

Step 2 Create a secret, which will be used by **cloudeye-exporter** for authentication.

1. Create the **clouds.yml** file with the following content:

```
global:
  prefix: "huaweicloud"
  scrape_batch_size: 10
auth:
  auth_url: "https://iam.ap-southeast-1.myhuaweicloud.com/v3"
  project_name: "ap-southeast-1"
  access_key: "*********"
  secret_key: "**********"
  region: "ap-southeast-1"
```

   Parameters in the preceding content are described as follows:

   - **auth_url**: indicates the IAM endpoint, which can be obtained from **Regions and Endpoints**.
   - **project_name**: indicates the project name. On the **My Credential** page, view the project name and project ID in the **Projects** area.
   - **access_key** and **secret_key**: You can obtain them from **Access Keys**.
   - **region**: indicates the region name, which must correspond to the project in **project_name**.

2. Obtain the Base64-encrypted string of the preceding file.

```
cat clouds.yml | base64 -w0 ;echo
```

   Information similar to the following is displayed:

```
ICAga*****
```

3. Create the **clouds-secret.yaml** file with the following content:

```
apiVersion: v1
kind: Secret
data:
  clouds.yml: ICAga*****  # Replace it with the Base64-encrypted string.
metadata:
  annotations:
    description: ''
  name: 'clouds.yml'
  namespace: default #Namespace where the secret is in, which must be the same as the deployment's namespace.
  labels: {}
type: Opaque
```

4. Create a secret.

```
kubectl apply -f clouds-secret.yaml
```


Step 3 Create the **cloudeye-exporter-deployment.yaml** file with the following content:

```
kind: Deployment
apiVersion: apps/v1
metadata:
  name: cloudeye-exporter
  namespace: default
spec:
  replicas: 1
  selector:
    matchLabels:
      app: cloudeye-exporter
      version: v1
  template:
    metadata:
      labels:
        app: cloudeye-exporter
        version: v1
    spec:
      volumes:
        - name: vol-166055064743016314
          secret:
            secretName: clouds.yml
            defaultMode: 420
      containers:
        - name: container-1
          image: swr.ap-southeast-1.myhuaweicloud.com/cloud-develop/cloudeye-exporter:1.0  # exporter
image path built above
          command:
            - /cloudeye-exporter/cloudeye-exporter
            - '-config=/tmp/clouds.yml'
          resources: {}
          volumeMounts:
            - name: vol-166055064743016314
              readOnly: true
              mountPath: /tmp
          terminationMessagePath: /dev/termination-log
          terminationMessagePolicy: File
          imagePullPolicy: IfNotPresent
      restartPolicy: Always
      terminationGracePeriodSeconds: 30
      dnsPolicy: ClusterFirst
      securityContext: {}
      imagePullSecrets:
        - name: default-secret
      schedulerName: default-scheduler
  strategy:
    type: RollingUpdate
    rollingUpdate:
      maxUnavailable: 25%
      maxSurge: 25%
  revisionHistoryLimit: 10
  progressDeadlineSeconds: 600
```

Create the preceding workload.

```
kubectl apply -f cloudeye-exporter-deployment.yaml
```

Step 4 Create the **cloudeye-exporter-service.yaml** file.

```
apiVersion: v1
kind: Service
metadata:
  name: cloudeye-exporter
  namespace: default
  labels:
    app: cloudeye-exporter
    version: v1
  annotations:
    prometheus.io/port: '8087'     #Port number of the endpoint to collect data from.
    prometheus.io/scrape: 'true'   #If it is set to true, the resource is the monitoring target.
```



```
    prometheus.io/path: "/metrics"  #URL from which the data is collected. The default value is /metrics.
    prometheus.io/scheme: "http"    #The default value is http. If https is set for security purposes, you need
to change it to https.
spec:
  ports:
    - name: cce-service-0
      protocol: TCP
      port: 8087
      targetPort: 8087
  selector:
    app: cloudeye-exporter
    version: v1
  type: ClusterIP
```

Create the preceding Service.

```
kubectl apply -f cloudeye-exporter-service.yaml
```

----End

Interconnecting with Prometheus

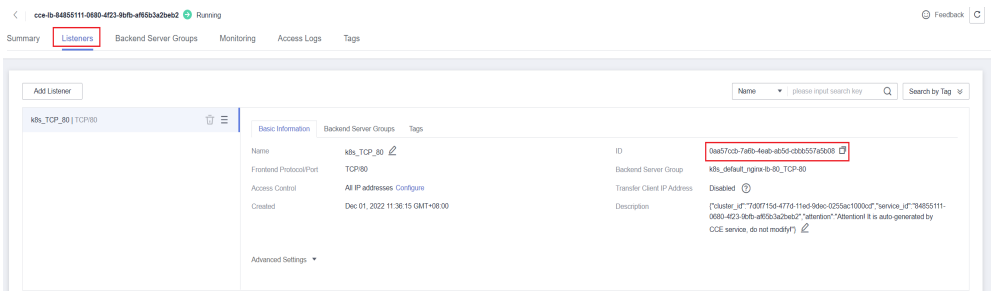
After collecting monitoring data, Prometheus needs to convert the data into the Kubernetes metric API for the HPA controller to perform auto scaling.

In this example, the ELB metrics associated with the workload need to be monitored. Therefore, the target workload must use the Service or ingress of the **LoadBalancer** type.

Step 1 View the access mode of the workload to be monitored and obtain the ELB listener ID.

1. On the CCE cluster console, choose **Networking**. On the **Services** or **Ingresses** tab page, view the Service or ingress of the **LoadBalancer** type and click the load balancer to access the load balancer page.

2. On the **Listeners** tab, view the listener corresponding to the workload and copy the listener ID.



Step 2 Use kubectl to connect to the cluster and add Prometheus configurations. In this example, collect load balancer metrics. For details about advanced usage, see **Configuration**.

1. Create the **prometheus-additional.yaml** file, add the following content to the file, and save the file:

```
- job_name: elb_metric
  params:
    services: ['SYS.ELB']
  kubernetes_sd_configs:
    - role: endpoints
  relabel_configs:
    - action: keep
      regex: '8087'
      source_labels:
        - __meta_kubernetes_service_annotation_prometheus_io_port
    - action: replace
      regex: ([^:]+)(?::\d+)?;(\d+)
      replacement: $1:$2
      source_labels:
        - __address__
        - __meta_kubernetes_service_annotation_prometheus_io_port
      target_label: __address__
    - action: labelmap
      regex: __meta_kubernetes_service_label_(.+)
    - action: replace
      source_labels:
        - __meta_kubernetes_namespace
      target_label: kubernetes_namespace
    - action: replace
      source_labels:
        - __meta_kubernetes_service_name
      target_label: kubernetes_service
```

2. Use the preceding configuration file to create a secret named **additional-scrape-configs**.

```
kubectl create secret generic additional-scrape-configs --from-file prometheus-additional.yaml -n monitoring --dry-run=client -o yaml | kubectl apply -f -
```

3. Edit the **persistent-user-config** configuration item to enable AdditionalScrapeConfigs.

```
kubectl edit configmap persistent-user-config -n monitoring
```

Add *--common.prom.default-additional-scrape-configs-key=prometheus-additional.yaml* under **operatorConfigOverride** to enable AdditionalScrapeConfigs as follows:

```
...
data:
  lightweight-user-config.yaml: |
    customSettings:
      additionalScrapeConfigs: []
      agentExtraArgs: []
      metricsDeprecated:
        globalDeprecateMetrics: []
      nodeExporterConfigOverride: []
      operatorConfigOverride:
      - --common.prom.default-additional-scrape-configs-key=prometheus-additional.yaml
...
```

4. Go to Prometheus to check whether custom metrics are successfully collected.

Step 3 Modify the **user-adapter-config** configuration item.

```
kubectl edit configmap user-adapter-config -nmonitoring
```

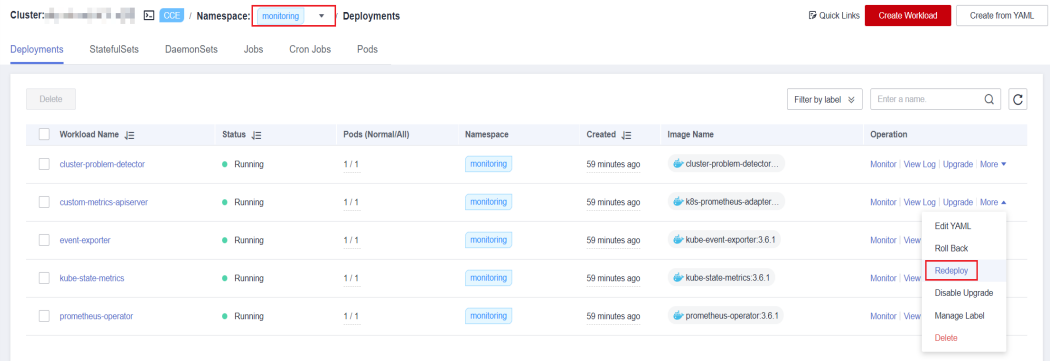
Add the following content to the **rules** field, replace **lbaas_listener_id** with the listener ID obtained in **Step 1**, and save the file.

```
apiVersion: v1
data:
```



```
config.yaml: |-
  rules:
  - metricsQuery: sum(<<.Series>>{<<.LabelMatchers>>,lbaas_listener_id="*****"}) by (<<.GroupBy>>)
    resources:
      overrides:
        kubernetes_namespace:
          resource: namespace
        kubernetes_service:
          resource: service
    name:
      matches: huaweicloud_sys_elb_(.*)
      as: "elb01_${1}"
    seriesQuery: '{lbaas_listener_id="*****"}'
  ...
```

Step 4 Redeploy the **custom-metrics-apiserver** workload in the **monitoring** namespace.



----End

Creating an HPA Policy

After the data reported by the exporter to Prometheus is converted into the Kubernetes metric API by using the Prometheus adapter, you can create an HPA policy for auto scaling.

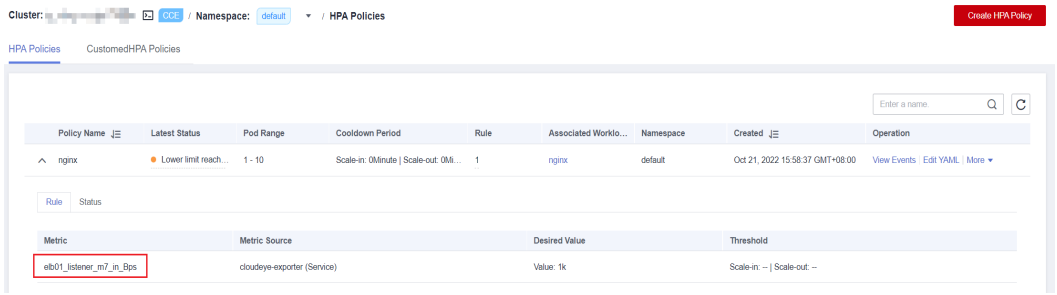
Step 1 Create an HPA policy. The inbound traffic of the ELB load balancer is used to trigger scale-out. When the value of **m7_in_Bps** (inbound traffic rate) exceeds 1000, the nginx Deployment will be scaled.

```
apiVersion: autoscaling/v2
kind: HorizontalPodAutoscaler
metadata:
  name: nginx
  namespace: default
spec:
  scaleTargetRef:
    apiVersion: apps/v1
    kind: Deployment
    name: nginx
  minReplicas: 1
  maxReplicas: 10
  metrics:
    - type: Object
      object:
        metric:
          name: elb01_listener_m7_in_Bps  #Monitoring metric name
        describedObject:
          apiVersion: v1
          kind: Service
          name: cloudeye-exporter
        target:
```



```
    type: Value
    value: 1000
```

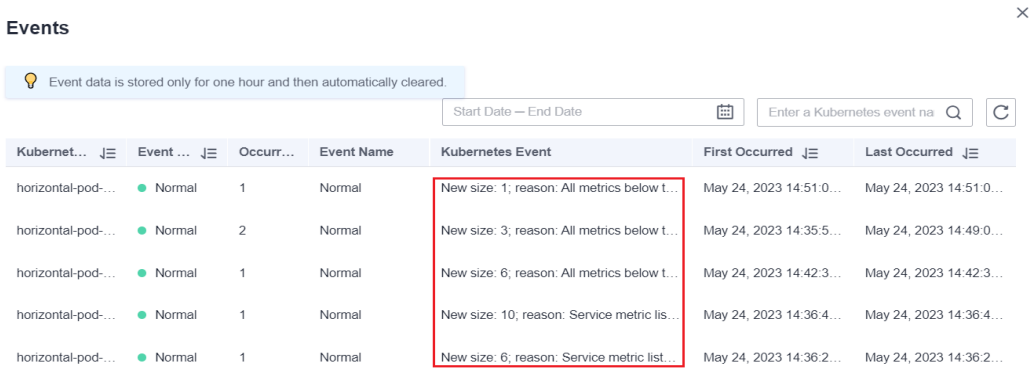
Figure 7-3 Created HPA Policy



Step 2 After the HPA policy is created, perform a pressure test on the workload (accessing the pods through ELB). Then, the HPA controller determines whether scaling is required based on the configured value.

In the **Events** dialog box, obtain scaling records in the **Kubernetes Event** column.

Figure 7-4 Scaling events



----End

ELB Listener Metrics

The following table lists the ELB listener metrics that can be collected using the method described in this section.

Table 7-3 ELB listener metrics

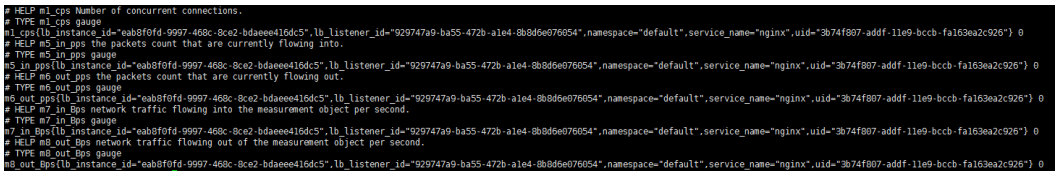
Metric	Name	Unit	Description
m1_cps	Concurrent Connections	Count	Number of concurrent connections processed by a load balancer.

Metric	Name	Unit	Description
m1e_server_rps	Reset Packets from Backend Servers	Count/Second	Number of reset packets sent from the backend server to clients. These reset packages are generated by the backend server and then forwarded by load balancers.
m1f_lvs_rps	Reset Packets from Load Balancers	Count/Second	Number of reset packets sent from load balancers.
m21_client_rps	Reset Packets from Clients	Count/Second	Number of reset packets sent from clients to the backend server. These reset packages are generated by the clients and then forwarded by load balancers.
m22_in_bandwidth	Inbound Bandwidth	bit/s	Inbound bandwidth of a load balancer.
m23_out_bandwidth	Outbound Bandwidth	bit/s	Outbound bandwidth of a load balancer.
m2_act_conn	Active Connections	Count	Number of current active connections.
m3_inact_conn	Inactive Connections	Count	Number of current inactive connections.
m4_ncps	New Connections	Count	Number of current new connections.
m5_in_pps	Incoming Packets	Count	Number of packets sent to a load balancer.
m6_out_pps	Outgoing Packets	Count	Number of packets sent from a load balancer.
m7_in_Bps	Inbound Rate	byte/s	Number of incoming bytes per second on a load balancer.
m8_out_Bps	Outbound Rate	byte/s	Number of outgoing bytes per second on a load balancer.

Appendix: Developing an Exporter

Prometheus periodically calls the **/metrics** API of the exporter to obtain metric data. Applications only need to report monitoring data through **/metrics**. You can select a Prometheus client in a desired language and integrate it into applications to implement the **/metrics** API. For details about the client, see **Prometheus CLIENT LIBRARIES**. For details about how to write the exporter, see **WRITING EXPORTERS**.

The monitoring data must be in the format that Prometheus supports. Each data record provides the ELB ID, listener ID, namespace where the Service is located, Service name, and Service UID as labels, as shown in the following figure.



To obtain the preceding data, perform the following steps:

Step 1 Obtain all Services.

The **annotations** field in the returned information contains the ELB associated with the Service.

- kubernetes.io/elb.id
- kubernetes.io/elb.class

Step 2 Use APIs in **Querying Listeners** to get the listener ID based on the load balancer ID obtained in the previous step.

Step 3 Obtain the ELB monitoring data.

The ELB monitoring data is obtained using the CES APIs described in **Querying Monitoring Data of Multiple Metrics** . For details about ELB monitoring metrics, see **Monitoring Metrics**. Example:

- **m1_cps**: number of concurrent connections
- **m5_in_pps**: number of incoming data packets
- **m6_out_pps**: number of outgoing data packets
- **m7_in_Bps**: incoming rate
- **m8_out_Bps**: outgoing rate

Step 4 Aggregate data in the format that Prometheus supports and expose the data through the **/metrics** API.

The Prometheus client can easily call the **/metrics** API. For details, see **CLIENT LIBRARIES**. For details about how to develop an exporter, see **WRITING EXPORTERS**.

----End

7.5 Auto Scaling of Multiple Applications Using Nginx Ingresses

Deploying applications in multiple pods in a production environment can enhance their stability and reliability, but it can also lead to increased resource waste and costs. To strike a balance between resource utilization and application performance, manually adjusting the number of pods may not be efficient or effective.

However, if the application uses Nginx ingresses to route and forward external traffic, you can configure HPA policies using the

nginx_ingress_controller_requests metric. This allows for dynamic adjustment of pods based on traffic changes, optimizing resource utilization.

Prerequisites

- The NGINX Ingress Controller add-on has been installed in the cluster.
- You have installed the Cloud Native Cluster Monitoring add-on in the cluster and enabled **Local Data Storage** for the add-on.
- You have connected the cluster with the kubectl command line tool or CloudShell.
- The pressure testing tool Apache Benchmark has been installed.

Creating a Workload and a Service for the Workload

This section provides an example of how to route external traffic for two Services using Nginx ingresses.

Step 1 Create a **test-app** workload and a Service for it.

1. Write a **test-app.yaml** file.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: test-app
  labels:
    app: test-app
spec:
  replicas: 1
  selector:
    matchLabels:
      app: test-app
  template:
    metadata:
      labels:
        app: test-app
    spec:
      containers:
      - image: skto/sample-app:v2
        name: metrics-provider
        ports:
        - name: http
          containerPort: 8080
---
apiVersion: v1
kind: Service
metadata:
  name: test-app
  namespace: default
  labels:
    app: test-app
spec:
  ports:
    - port: 8080
      name: http
      protocol: TCP
      targetPort: 8080
  selector:
    app: test-app
  type: ClusterIP
```

2. Deploy the **test-app** workload and the corresponding Service.

```
kubectl apply -f test-app.yaml
```


Step 2 Create a **sample-app** workload and a Service for it.

1. Write a **sample-app.yaml** file.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: sample-app
  labels:
    app: sample-app
spec:
  replicas: 1
  selector:
    matchLabels:
      app: sample-app
  template:
    metadata:
      labels:
        app: sample-app
    spec:
      containers:
      - image: skto/sample-app:v2
        name: metrics-provider
        ports:
        - name: http
          containerPort: 8080
---
apiVersion: v1
kind: Service
metadata:
  name: sample-app
  namespace: default
  labels:
    app: sample-app
spec:
  ports:
    - port: 80
      name: http
      protocol: TCP
      targetPort: 8080
  selector:
    app: sample-app
  type: ClusterIP
```

2. Deploy the **sample-app** workload and the corresponding Service.

```
kubectl apply -f sample-app.yaml
```

Step 3 Deploy an ingress.

1. Write an **ingress.yaml** file.

```
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: test-ingress
  namespace: default
spec:
  ingressClassName: nginx
  rules:
    - host: test.example.com
      http:
        paths:
          - backend:
              service:
                name: sample-app
                port:
                  number: 80
            path: /
            pathType: ImplementationSpecific
          - backend:
              service:
                name: test-app
```



```
          port:
            number: 8080
        path: /home
        pathType: ImplementationSpecific
```

- **host**: specifies the Service access domain name. In this example, **test.example.com** is used.
- **path**: specifies the URL to be accessed. After receiving a request, the system matches the request with the corresponding Service based on the routing rules and accesses the corresponding pod through the Service.
- **backend**: consists of the Service name and Service port and specifies the Service forwarded by the current path.

2. Deploy an ingress.

```
kubectl apply -f ingress.yaml
```

3. Obtain an ingress.

```
kubectl get ingress -o wide
```

```
user@mdkkoee8n52s50m-machine:~$ kubectl get ingress -o wide
NAME           CLASS   HOSTS              ADDRESS                      PORTS   AGE
test-ingress   nginx   test.example.com   [redacted],192.168.0.151   80      2d4h
```

4. After the deployment is successful, log in to the target node and add the service domain name and the IP address of the load balancer associated with NGINX Ingress Controller to the local **hosts** file of the node. The IP address of the load balancer associated with NGINX Ingress Controller is that obtained in **Step 3.3**.

```
export NGINXELB=xx.xx.xx.xx
echo -n "${NGINXELB}  test.example.com" >> /etc/hosts
```

5. Log in to the cluster node and access the host address through the **/** and **/home** paths.

   NGINX Ingress Controller accesses **sample-app** and **test-app** based on the preceding configurations.

```
# curl test.example.com/
Hello from '/' path!

# curl test.example.com/home
Hello from '/home' path!
```

----End

Modifying user-adapter-config in Prometheus

Step 1 Run the following command to edit **user-adapter-config**:

```
kubectl -n monitoring edit configmap user-adapter-config
```

Step 2 Add the following rules to the ConfigMap of the adapter:

```
apiVersion: v1
data:
  config.yaml: |
    rules:
    - metricsQuery: sum(rate(<<.Series>>{<<.LabelMatchers>>}[2m])) by (<<.GroupBy>>)
      name:
        as: ${1}_per_second
        matches: ^(.*)_requests
      resources:
        namespaced: false
        overrides:
          exported_namespace:
            resource: namespace
          service:
```



```
        resource: service
    seriesQuery: nginx_ingress_controller_requests
  resourceRules:
    cpu:
      containerQuery: sum(rate(container_cpu_usage_seconds_total{<<.LabelMatchers>>,container!="",pod!
=""}[1m])) by (<<.GroupBy>>)
      nodeQuery: sum(rate(container_cpu_usage_seconds_total{<<.LabelMatchers>>, id='/'}[1m])) by
(<<.GroupBy>>)
      resources:
        overrides:
          instance:
            resource: node
          namespace:
            resource: namespace
          pod:
            resource: pod
      containerLabel: container
    memory:
      containerQuery: sum(container_memory_working_set_bytes{<<.LabelMatchers>>,container!="",pod!
=""}) by (<<.GroupBy>>)
      nodeQuery: sum(container_memory_working_set_bytes{<<.LabelMatchers>>,id='/'}) by (<<.GroupBy>>)
      resources:
        overrides:
          instance:
            resource: node
          namespace:
            resource: namespace
          pod:
            resource: pod
      containerLabel: container
```

Step 3 Restart **custom-metrics-apiserver**.

```
kubectl -n monitoring delete pod -l app=custom-metrics-apiserver
```

Step 4 Log in to the cluster node and access the host address through the **/** and **/home** paths for multiple times.

```
# curl test.example.com/
Hello from '/' path!

# curl test.example.com/home
Hello from '/home' path!
```

Step 5 Run the following command to check whether the metric is added:

```
kubectl get --raw /apis/custom.metrics.k8s.io/v1beta1/namespaces/default/services/*/
nginx_ingress_controller_per_second | python -m json.tool
```

```
user@lvb6mb5e3expf6p-machine:~$ kubectl get --raw /apis/custom.metrics.k8s.io/v1beta1/namespaces/default/services/*/nginx_ingress_controller_per_second
{
    "kind": "MetricValueList",
    "apiVersion": "custom.metrics.k8s.io/v1beta1",
    "metadata": {},
    "items": [
        {
            "describedObject": {
                "kind": "Service",
                "namespace": "default",
                "name": "sample-app",
                "apiVersion": "/v1"
            },
            "metricName": "nginx_ingress_controller_per_second",
            "timestamp": "2024-02-21T09:07:07Z",
            "value": "0",
            "selector": null
        },
        {
            "describedObject": {
                "kind": "Service",
                "namespace": "default",
                "name": "test-app",
                "apiVersion": "/v1"
            },
            "metricName": "nginx_ingress_controller_per_second",
            "timestamp": "2024-02-21T09:07:07Z",
            "value": "0",
            "selector": null
        }
    ]
```

----End

Creating an HPA Policy

Step 1 Create an **hpa.yaml** file and configure auto scaling for the **test-app** and **sample-app** workloads based on Prometheus metrics.

```
apiVersion: autoscaling/v2
kind: HorizontalPodAutoscaler
metadata:
  name: sample-hpa  # HPA name
spec:
  scaleTargetRef:
    apiVersion: apps/v1
    kind: Deployment
    name: sample-app  # Deployment name
  minReplicas: 1      # Minimum number of pods
  maxReplicas: 10     # Maximum number of pods
  metrics:
    - type: Object
      object:
        metric:
          name: nginx_ingress_controller_per_second  # Metric
        describedObject:
          apiVersion: v1
          kind: service
          name: sample-app  # Service of the Deployment
        target:
          type: Value
          value: 30   # Scaling is triggered when the metric value is within the range of (Actual value/30)±0.1.
---
apiVersion: autoscaling/v2
kind: HorizontalPodAutoscaler
metadata:
  name: test-hpa
spec:
  scaleTargetRef:
    apiVersion: apps/v1
    kind: Deployment
    name: test-app
  minReplicas: 1
  maxReplicas: 10
  metrics:
    - type: Object
      object:
        metric:
          name: nginx_ingress_controller_per_second
        describedObject:
          apiVersion: v1
          kind: service
          name: test-app
        target:
          type: Value
          value: 30
```

Step 2 Deploy the HPA policy.

```
kubectl apply -f hpa.yaml
```

Step 3 Check the HPA deployment.

```
kubectl get hpa
```

```
user@lvb6mb5e3expf6p-machine:~$ kubectl get hpa
NAME         REFERENCE                TARGETS   MINPODS   MAXPODS   REPLICAS   AGE
sample-hpa   Deployment/sample-app    0/30      1         10        1          171m
test-hpa     Deployment/test-app      0/30      1         10        1          171m
user@lvb6mb5e3expf6p-machine:~$
```

----End

Verifying Scaling

Step 1 Log in to the target cluster node and perform a pressure testing on the **/home** path.

```
ab -c 50 -n 5000 test.example.com/home
```

Step 2 Check the HPA.

```
kubectl get hpa
```

```
user@lvb6mb5e3expf6p-machine:~$ kubectl get hpa |grep test-hpa
test-hpa      Deployment/test-app      45454m/30   1         10        2          128m
user@lvb6mb5e3expf6p-machine:~$
```

Step 3 Log in to the target cluster node and perform a pressure testing on the root path.

```
ab -c 50 -n 5000 test.example.com/
```

Step 4 Check the HPA.

```
kubectl get hpa
```

```
user@lvb6mb5e3expf6p-machine:~$ kubectl get hpa |grep sample-hpa
sample-hpa    Deployment/sample-app    45454m/30   1         10        2          129m
user@lvb6mb5e3expf6p-machine:~$
```

Compared with the HPA metrics obtained before the pressure testing, the service application is scaled out when the number of requests exceeds the threshold.

----End

8 Monitoring

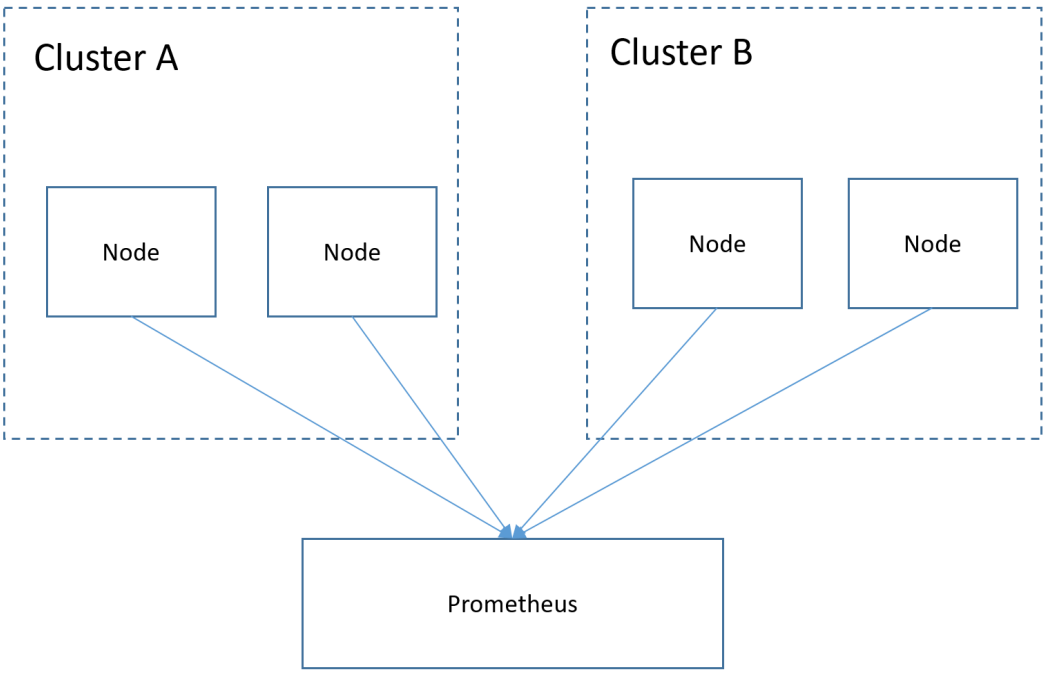
8.1 Monitoring Multiple Clusters Using Prometheus

Application Scenarios

Generally, a user has different clusters for different purposes, such as production, testing, and development. To monitor, collect, and view metrics of these clusters, you can deploy a set of Prometheus.

Solution Architecture

Multiple clusters are connected to the same Prometheus monitoring system, as shown in the following figure. This reduces maintenance and resource costs and facilitates monitoring information aggregation.



Prerequisites

- The target cluster has been created.
- Prometheus has been properly connected to the target cluster.
- Prometheus has been installed on a Linux host using a binary file. For details, see **Installation**.

Procedure

Step 1 Obtain the **bearer_token** information of the target cluster.

1. Create the RBAC permission in the target cluster.

   Log in to the background node of the target cluster and create the **prometheus_rbac.yaml** file.

```
apiVersion: v1
kind: ServiceAccount
metadata:
  name: prometheus-test
  namespace: kube-system

---
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRole
metadata:
  name: prometheus-test
rules:
- apiGroups:
  - ""
  resources:
  - nodes
  - services
  - endpoints
  - pods
  - nodes/proxy
  verbs:
  - get
  - list
  - watch
- apiGroups:
  - "extensions"
  resources:
    - ingresses
  verbs:
  - get
  - list
  - watch
- apiGroups:
  - ""
  resources:
  - configmaps
  - nodes/metrics
  verbs:
  - get
- nonResourceURLs:
  - /metrics
  verbs:
  - get
---
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRoleBinding
metadata:
  name: prometheus-test
roleRef:
  apiGroup: rbac.authorization.k8s.io
  kind: ClusterRole
```



```
  name: prometheus-test
subjects:
- kind: ServiceAccount
  name: prometheus-test
  namespace: kube-system
```

Run the following command to create the RBAC permission:

kubectl apply -f prometheus_rbac.yaml

2. Obtain the **bearer_token** information of the target cluster.

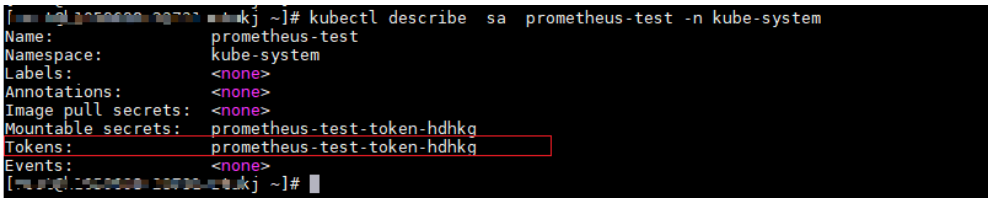
   NOTE

   - In clusters earlier than v1.21, a token is obtained by mounting the secret of the service account to a pod. Tokens obtained this way are permanent. This approach is no longer recommended starting from version 1.21. Service accounts will stop auto creating secrets in clusters from version 1.25.

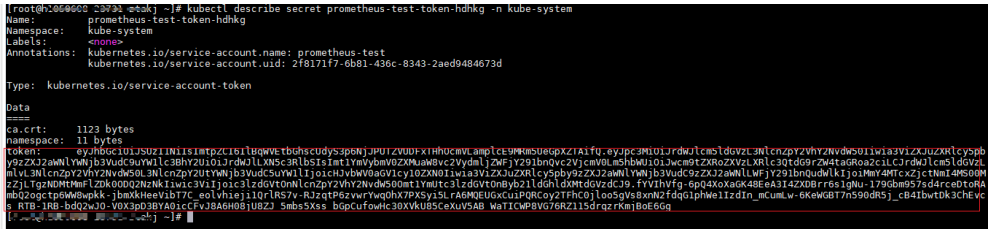
     In clusters of version 1.21 or later, you can use the **TokenRequest** API to **obtain the token** and use the projected volume to mount the token to the pod. Such tokens are valid for a fixed period. When the mounting pod is deleted, the token automatically becomes invalid. For details, see **Service Account Token Security Improvement**.
   - If you need a token that never expires, you can also **manually manage secrets for service accounts**. Although a permanent service account token can be manually created, you are advised to use a short-lived token by calling the **TokenRequest** API for higher security.

   Obtain the **serviceaccount** information.

   kubectl describe sa prometheus-test -n kube-system



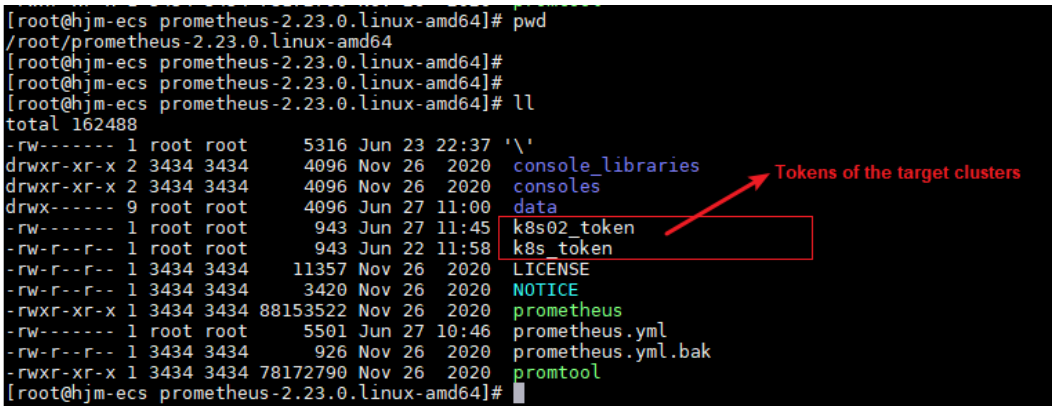
   kubectl describe secret prometheus-test-token-hdhkg -n kube-system



   Record the token value, which is the **bearer_token** information to be collected.

Step 2 Configure **bearer_token** information.

Log in to the host where Prometheus is located, go to the Prometheus installation directory, and save the token information of the target cluster in a file.



Step 3 Configure a Prometheus monitoring job.

The example job monitors container metrics. To monitor other metrics, you can add jobs and compile capture rules.

```
 - job_name: k8s_cAdvisor
   scheme: https
   bearer_token_file: k8s_token # Token file in the previous step.
   tls_config:
     insecure_skip_verify: true
   kubernetes_sd_configs:  # kubernetes automatic discovery configuration
   - role: node    # Automatic discovery of the node type
     bearer_token_file: k8s_token # Token file in the previous step
     api_server: https://192.168.0.153:5443  # API server address of the Kubernetes cluster
     tls_config:
       insecure_skip_verify: true   # Skip the authentication on the server.
   relabel_configs:  ## Modify the existing label of the target cluster before capturing metrics.
   - target_label: __address__
     replacement: 192.168.0.153:5443
     action: replace
     ## Convert metrics_path to /api/v1/nodes/${1}/proxy/metrics/cadvisor.
     # Obtain data from kubelet using the API server proxy.
   - source_labels: [__meta_kubernetes_node_name]   # Specifies the source label to be processed.
     regex: (.+)    # Matched value of the source label. (.+) indicates that any value of the source label can be matched.
     target_label: __metrics_path__     # Specifies the label to be replaced.
     replacement: /api/v1/nodes/${1}/proxy/metrics/cadvisor  # Indicates the new label, that is, the value of __metrics_path__. ${1} indicates the value that matches the regular expression, that is, node name.
   - target_label: cluster
     replacement: xxxxx   ## (Optional) Enter the cluster information.

### The following job monitors another cluster.
 - job_name: k8s02_cAdvisor
   scheme: https
   bearer_token_file: k8s02_token # Token file in the previous step
   tls_config:
     insecure_skip_verify: true
   kubernetes_sd_configs:
   - role: node
     bearer_token_file: k8s02_token # Token file in the previous step
     api_server: https://192.168.0.147:5443  # API server address of the Kubernetes cluster
     tls_config:
       insecure_skip_verify: true   # Skip the authentication on the server.
   relabel_configs:  ## Modify the existing label of the target cluster before capturing metrics.
   - target_label: __address__
     replacement: 192.168.0.147:5443
     action: replace

   - source_labels: [__meta_kubernetes_node_name]
     regex: (.+)
     target_label: __metrics_path__
     replacement: /api/v1/nodes/${1}/proxy/metrics/cadvisor
```



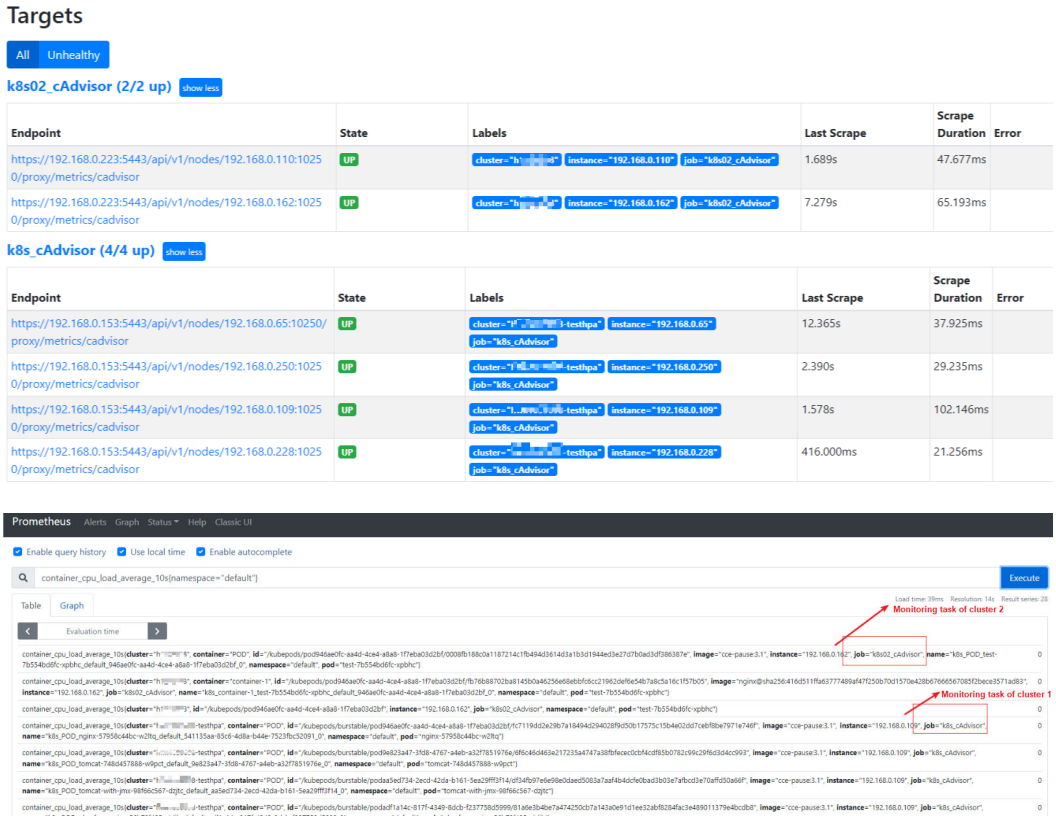
```
  - target_label: cluster
    replacement: xxxx    ## (Optional) Enter the cluster information.
```

Step 4 Enable Prometheus.

After the configuration, enable Prometheus.

./prometheus --config.file=prometheus.yml

Step 5 Log in to Prometheus and view the monitoring information.



----End

8.2 Monitoring GPU Metrics Using dcgm-exporter

Application Scenarios

If a cluster contains GPU nodes, learn about the GPU resources used by GPU applications, such as the GPU usage, memory usage, running temperature, and power. You can configure auto scaling policies or set alarm rules based on the obtained GPU metrics. This section walks you through how to observe GPU resource usage based on open source Prometheus and DCGM Exporter. For more details about DCGM Exporter, see **DCGM Exporter**.

NOTICE

DCGM Exporter is an open-source component that specifically applies to the native GPUs (nvidia.com/gpu) within the Kubernetes community. It is important to note that GPU virtualization resources provided by CCE cannot be monitored.

Prerequisites

- You have created a cluster and there are GPU nodes and GPU related services running in the cluster.
- The CCE AI Suite (NVIDIA GPU) and Cloud Native Cluster Monitoring add-ons have been installed in the cluster.
  - CCE AI Suite (NVIDIA GPU) is a device management add-on that supports GPUs in containers. To use GPU nodes in the cluster, this add-on must be installed. Select and install the corresponding GPU driver based on the GPU type and CUDA version.
  - Cloud Native Cluster Monitoring monitors the cluster metrics. During the installation, you can interconnect this add-on with Grafana to gain a better observability of your cluster.

    NOTE

    - The deployment mode of the add-on should be **Local Data Storage**.
    - The configuration for interconnecting with Grafana is supported by the Cloud Native Cluster Monitoring add-on of a version earlier than 3.9.0. For the add-on of version 3.9.0 or later, if Grafana is required, install the Grafana add-on separately..

Collecting GPU Monitoring Metrics

This section describes how to deploy the dcgm-exporter component in the cluster to collect GPU metrics and expose GPU metrics through port 9400.

Step 1 Log in to a node with an EIP bound and that uses the Docker container engine.

Step 2 Pull the dcgm-exporter image to the local host. The image address comes from the DCGM official example. For details, see **https://github.com/NVIDIA/dcgm-exporter/blob/main/dcgm-exporter.yaml**.

```
docker pull nvcr.io/nvidia/k8s/dcgm-exporter:3.0.4-3.0.0-ubuntu20.04
```

Step 3 Push the dcgm-exporter image to SWR.

1. (Optional) Log in to the SWR console, choose **Organizations** in the navigation pane, and click **Create Organization** in the upper right corner of the page.

   Skip this step if you already have an organization.
2. In the navigation pane, choose **My Images** and then click **Upload Through Client**. On the page displayed, click **Generate a temporary login command** and click  to copy the command.
3. Run the login command copied in the previous step on the cluster node. If the login is successful, the message "Login Succeeded" is displayed.
4. Add a tag to the dcgm-exporter image.

docker tag *{Image name 1:Tag 1}|{Image repository address}|{Organization name}|{Image name 2:Tag 2}*

- *{Image name 1:Tag 1}*: name and tag of the local image to be uploaded.
- *{Image repository address}*: The domain name at the end of the login command in **2** is the image repository address, which can be obtained on the SWR console.
- *{Organization name}*: name of the organization created in **1**.
- *{Image name 2:Tag 2}*: desired image name and tag to be displayed on the SWR console.

The following is an example:

```
docker tag nvcr.io/nvidia/k8s/dcgm-exporter:3.0.4-3.0.0-ubuntu20.04 swr.cn-east-3.myhuaweicloud.com/container/dcgm-exporter:3.0.4-3.0.0-ubuntu20.04
```

5. Push the image to the image repository.

   docker push *{Image repository address}|{Organization name}|{Image name 2:Tag 2}*

   The following is an example:

   ```
   docker push swr.cn-east-3.myhuaweicloud.com/container/dcgm-exporter:3.0.4-3.0.0-ubuntu20.04
   ```

   The following information will be returned upon a successful push:

   ```
   489a396b91d1: Pushed
   ...
   c3f11d77a5de: Pushed
   3.0.4-3.0.0-ubuntu20.04: digest: sha256:bd2b1a73025*** size: 2414
   ```

6. To view the pushed image, go to the SWR console and refresh the **My Images** page.

Step 4 Deploy dcgm-exporter.

When deploying dcgm-exporter on CCE, add some specific configurations to monitor GPU information. The detailed YAML file is as follows. The information in red is important.

NOTICE

After Cloud Native Cluster Monitoring is interconnected with AOM, metrics will be reported to the AOM instance you select. **Basic metrics** are free. Custom metrics are billed based on the standard pricing of AOM. For details, see **Pricing Details**.

```
apiVersion: apps/v1
kind: DaemonSet
metadata:
  name: "dcgm-exporter"
  namespace: "monitoring"      # Select a namespace as required.
  labels:
    app.kubernetes.io/name: "dcgm-exporter"
    app.kubernetes.io/version: "3.0.0"
spec:
  updateStrategy:
    type: RollingUpdate
  selector:
    matchLabels:
      app.kubernetes.io/name: "dcgm-exporter"
      app.kubernetes.io/version: "3.0.0"
  template:
    metadata:
```



```
    labels:
      app.kubernetes.io/name: "dcgm-exporter"
      app.kubernetes.io/version: "3.0.0"
    name: "dcgm-exporter"
  spec:
    containers:
    - image: "swr.cn-east-3.myhuaweicloud.com/container/dcgm-exporter:3.0.4-3.0.0-ubuntu20.04"   # The SWR image address of dcgm-exporter. The address is the image address in 5.
      env:
      - name: "DCGM_EXPORTER_LISTEN"                  # Service port number
        value: ":9400"
      - name: "DCGM_EXPORTER_KUBERNETES"              # Supports mapping of Kubernetes metrics to pods.
        value: "true"
      - name: "DCGM_EXPORTER_KUBERNETES_GPU_ID_TYPE"   # GPU ID type. The value can be uid or device-name.
        value: "device-name"
      name: "dcgm-exporter"
      ports:
      - name: "metrics"
        containerPort: 9400
      resources:      # Request and limit resources as required.
        limits:
          cpu: '200m'
          memory: '256Mi'
        requests:
          cpu: 100m
          memory: 128Mi
      securityContext:      # Enable the privilege mode for the dcgm-exporter container.
        privileged: true
        runAsNonRoot: false
        runAsUser: 0
      volumeMounts:
      - name: "pod-gpu-resources"
        readOnly: true
        mountPath: "/var/lib/kubelet/pod-resources"
      - name: "nvidia-install-dir-host"      # The environment variables configured in the dcgm-exporter image depend on the file in the /usr/local/nvidia directory of the container.
        readOnly: true
        mountPath: "/usr/local/nvidia"
    imagePullSecrets:
      - name: default-secret
    volumes:
    - name: "pod-gpu-resources"
      hostPath:
        path: "/var/lib/kubelet/pod-resources"
    - name: "nvidia-install-dir-host"       # The directory where the GPU driver is installed.
      hostPath:
        path: "/opt/cloud/cce/nvidia"       #If the GPU add-on version is 2.0.0 or later, replace the driver installation directory with /usr/local/nvidia.
    affinity:       # Label generated when CCE creates GPU nodes. You can set node affinity for this component based on this label.
      nodeAffinity:
        requiredDuringSchedulingIgnoredDuringExecution:
          nodeSelectorTerms:
          - matchExpressions:
            - key: accelerator
              operator: Exists
---
kind: Service
apiVersion: v1
metadata:
  name: "dcgm-exporter"
  namespace: "monitoring"      # Select a namespace as required.
  labels:
    app.kubernetes.io/name: "dcgm-exporter"
    app.kubernetes.io/version: "3.0.0"
spec:
  selector:
```



```
    app.kubernetes.io/name: "dcgm-exporter"
    app.kubernetes.io/version: "3.0.0"
  ports:
  - name: "metrics"
    port: 9400
---
apiVersion: monitoring.coreos.com/v1
kind: ServiceMonitor
metadata:
  labels:
    app.kubernetes.io/name: "dcgm-exporter"
    app.kubernetes.io/version: "3.0.0"
  name: dcgm-exporter
  namespace: monitoring     #Select a namespace as required.
spec:
  endpoints:
  - honorLabels: true
    interval: 15s
    path: /metrics
    port: metrics
    relabelings:
    - action: labelmap
      regex: __meta_kubernetes_service_label_(.+)
    - action: replace
      sourceLabels:
      - __meta_kubernetes_namespace
      targetLabel: kubernetes_namespace
    - action: replace
      sourceLabels:
      - __meta_kubernetes_service_name
      targetLabel: kubernetes_service
    scheme: http
  namespaceSelector:
    matchNames:
    - monitoring        # Select a namespace as required.
  selector:
    matchLabels:
      app.kubernetes.io/name: "dcgm-exporter"
```

Step 5 Monitor application GPU metrics.

1. Run the following command to check whether the dcgm-exporter is running properly:

   ```
   kubectl get po -n monitoring -owide
   ```

   Information similar to the following is displayed:

   ```
   # kubectl get po -n monitoring -owide
   NAME                                  READY   STATUS    RESTARTS   AGE   IP            NODE
   NOMINATED NODE   READINESS GATES
   alertmanager-alertmanager-0           0/2     Pending   0          19m   <none>        <none>
   <none>           <none>
   custom-metrics-apiserver-5bb67f4b99-grxhq   1/1     Running   0          19m   172.16.0.6
   192.168.0.73   <none>           <none>
   dcgm-exporter-hkr77                   1/1     Running   0          17m   172.16.0.11   192.168.0.73
   <none>           <none>
   grafana-785cdcd47-9jlgr               1/1     Running   0          19m   172.16.0.9    192.168.0.73
   <none>           <none>
   kube-state-metrics-647b6585b8-6l2zm   1/1     Running   0          19m   172.16.0.8
   192.168.0.73   <none>           <none>
   node-exporter-xvk82                   1/1     Running   0          19m   192.168.0.73   192.168.0.73
   <none>           <none>
   prometheus-operator-5ff8744d5f-mhbqv   1/1     Running   0          19m   172.16.0.7
   192.168.0.73   <none>           <none>
   prometheus-server-0                   2/2     Running   0          19m   172.16.0.10   192.168.0.73
   <none>           <none>
   ```

2. Call the **dcgm-exporter** API to verify the collected application GPU information.

   172.16.0.11 indicates the pod IP address of the dcgm-exporter.

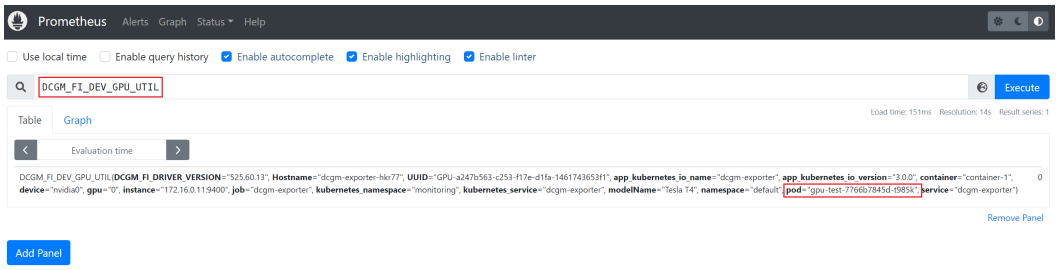

```
curl 172.16.0.11:9400/metrics | grep DCGM_FI_DEV_GPU_UTIL
```

```
[roo~ ~]# curl 172.16.0.11:9400/metrics | grep DCGM_FI_DEV_GPU_UTIL
  % Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
                                 Dload  Upload   Total   Spent    Left  Speed
100  5514    0  5514    0     0  5384k      # HELP DCGM_FI_DEV_GPU_UTIL GPU utilization (in %).
0# TYPE DCGM_FI_DEV_GPU_UTIL gauge
 --DCGM_FI_DEV_GPU_UTIL{gpu="0",UUID="GPU-a247b563-c253-f17e-d1fa-1461743653f1",device="nvidia0",modelName="Tesla T4",Hostname="dcgm-exporter-hkr77",DCGM_FI_DRIVER_VE
RSION="525.60.13",container="container-1",namespace="default",pod="gpu-test-7766b7845d-t985k"} 0
:--:-- --:--:-- --:--:-- 5384k
```

Step 6 View metric monitoring information on the Prometheus page.

After prometheus and the related add-on are installed, a ClusterIP Service is created by default. To allow external systems to access the Service, create a NodePort or a LoadBalancer Service. For details, see **Monitoring Custom Metrics Using Prometheus**.

As shown in the following figure, you can view the GPU usage and other related metrics on the GPU node. For more GPU metrics, see **Observable Metrics**.



Step 7 Log in to the Grafana page to view GPU information.

If you have installed Grafana, you can import **NVIDIA DCGM Exporter dashboard** to display GPU metrics.

For details, see **Manage dashboards**.

----End

Observable Metrics

The following table lists some observable GPU metrics. For details about more metrics, see **Field Identifiers**.

Table 8-1 Usage

Metric Name	Metric Type	Unit	Description
DCGM_FI_DEV_GPU_UTIL	Gauge	%	GPU usage
DCGM_FI_DEV_MEM_COPY_UTIL	Gauge	%	Memory usage
DCGM_FI_DEV_ENC_UTIL	Gauge	%	Encoder usage
DCGM_FI_DEV_DEC_UTIL	Gauge	%	Decoder usage

Table 8-2 Memory

Metric Name	Metric Type	Unit	Description
DCGM_FI_DEV_FB_FREE	Gauge	MB	Number of remaining frame buffers. The frame buffer is called VRAM.
DCGM_FI_DEV_FB_USED	Gauge	MB	Number of used frame buffers. The value is the same as the value of **memory-usage** in the **nvidia-smi** command.

Table 8-3 Temperature and power

Metric Name	Metric Type	Unit	Description
DCGM_FI_DEV_GPU_TEMP	Gauge	°C	Current GPU temperature of the device
DCGM_FI_DEV_POWER_USAGE	Gauge	W	Power usage of the device

8.3 Reporting Prometheus Monitoring Data to a Third-Party Monitoring Platform

Application Scenarios

The Cloud Native Cluster Monitoring add-on can report Prometheus metrics collected from clusters to a specified platform, for example, AOM or a third-party

platform that supports Prometheus metrics. This section explains how to configure settings for Cloud Native Cluster Monitoring to send collected metrics to a third-party's Prometheus instance.

Step 1: Obtain the Data Reporting Address

Prometheus provides standard Remote Write APIs. You can enter the source address (Remote Write URL) in the Cloud Native Cluster Monitoring add-on for storing the locally collected monitoring data in a Prometheus instance remotely.

- If the Prometheus instance for receiving data is provided by a third-party vendor, view the Remote Write URL on the vendor's console.
- If the Prometheus instance for receiving data is an on-premises one, the Remote Write URL is **https://** *{prometheus_addr}* **/api/v1/write**, where *{prometheus_addr}* indicates the IP address and port number for external access.

Step 2: Obtain the Authentication Mode

- For the third-party Prometheus instance, go to the vendor's console to view the token or account password used for authorized access.
- For the on-premises Prometheus instance, perform the following steps to obtain a token:
  a. If this Prometheus instance is deployed in a Kubernetes cluster, view the token in the corresponding container. If this Prometheus instance is deployed on a VM, skip this step.
  ```
  kubectl exec -ti -n monitoring prometheus-server-0 sh
  ```
  Replace the variables in the command as needed:
  - *monitoring*: indicates the namespace where a Prometheus pod is in.
  - *prometheus-server-0*: indicates the name of a Prometheus pod.

  b. Check the location of the configuration file.
  ```
  ps -aux | grep prometheus
  ```
  Information similar to the following is displayed:
  
  c. View and record the token information in **prometheus.env.yaml**.
  ```
  cat /etc/prometheus/config_out/prometheus.env.yaml
  ```



```
alerting:
  alert_relabel_configs:
  - action: labeldrop
    regex: prometheus_replica
  alertmanagers:
  - path_prefix: /
    scheme: http
    kubernetes_sd_configs:
    - role: endpoints
      namespaces:
        names:
        - monitoring
    api_version: v2
    relabel_configs:
    - action: keep
      source_labels:
      - __meta_kubernetes_service_name
      regex: alertmanager
    - action: keep
      source_labels:
      - __meta_kubernetes_endpoint_port_name
      regex: http-web
remote_write:
- url: https://100.79.29.98:8149/v1/7a34c707d93f4d91960567949ded4b50/b578a7c9-e17e-450c-ac8d-f69e88fa657b/push
  remote_timeout: 30s
  headers:
    cluster_id: 83f85f1d-6ef0-11ee-bacc-0255ac100b0e
    cluster_name: cce-00492128-v125
  name: cia_write_aom
  tls_config:
    insecure_skip_verify: true
  authorization:
    type: Bearer
    credentials: 0000000100000012A0CC6E5B1DEF40907B9C9F4648BCB198B0BE91033F01B62ED9461841CD40EE7313181FDAF670B5
```

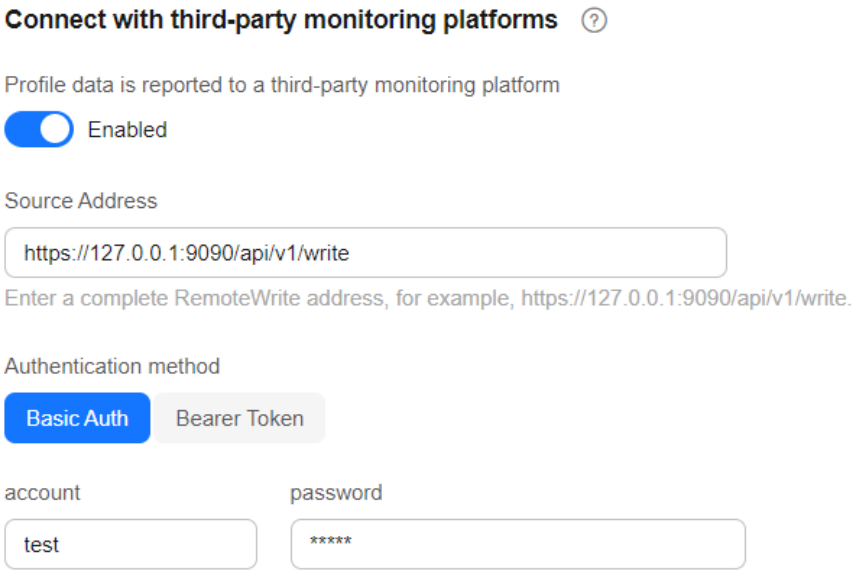
Step 3: Connect to a Third-Party Monitoring Platform

Step 1 Log in to the CCE console, click the name of a cluster with the Cloud Native Cluster Monitoring add-on installed to access the cluster console.

Step 2 In the navigation pane, choose **Settings** and click the **Monitoring** tab.

Step 3 Enable **Connect with third-party monitoring platforms** so that the data collected by Cloud Native Cluster Monitoring can be reported to a third-party monitoring platform.

- **Source Address**: Remote Write URL obtained in **step 1**, for example, **https://127.0.0.1:9090/api/v1/write**.
- **Authentication method**: Select the authentication method supported by the third-party monitoring platform in **step 2**.
  - **Basic Auth**: Enter the user name and password.
  - **Bearer Token**: Enter the identity credential (token).

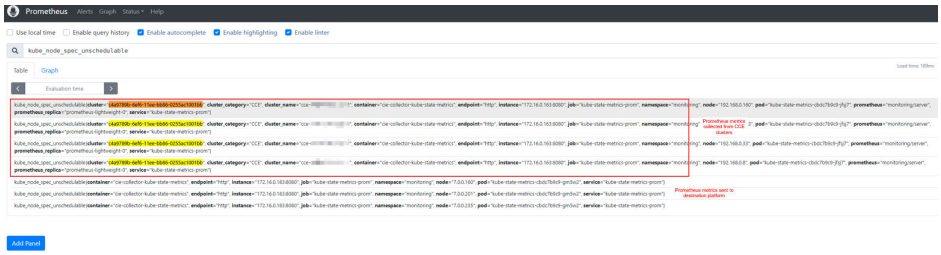


Step 4 Click **Confirm Configuration**.

----End

Step 4: Check the Data Sending and Receiving Statuses

After the preceding configuration is complete, log in to the Prometheus console supported by the third-party platform and view the Prometheus metrics with remote write on the **Graph** page.



8.4 Obtaining Prometheus Data Using PromQL Statements

Prometheus Query Language (PromQL) is a language that retrieves and consolidates time series data. Prometheus, an open-source monitoring system, is responsible for collecting and storing this data. Each time series has a unique identifier and a series of timestamp-value pairs. PromQL is a fundamental part of Prometheus, using simple expressions that include identifiers and tags to retrieve and consolidate time series data. This allows you to quickly identify and resolve issues as needed.

For details about how to use PromQL, see **QUERYING PROMETHEUS**.

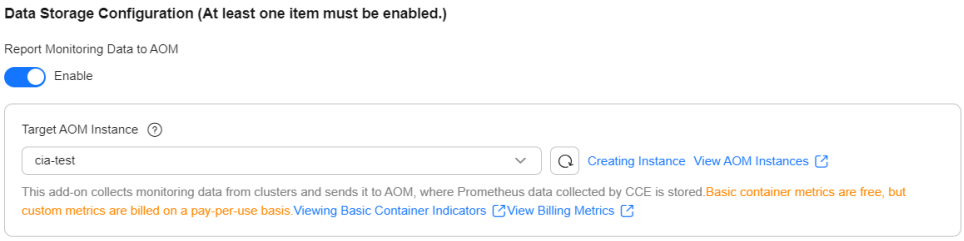
Obtaining Huawei Cloud Prometheus Monitoring Data from the Console

Step 1 Install the Cloud Native Cluster Monitoring add-on in a cluster to collect Prometheus monitoring data.

1. Log in to the CCE console and click the cluster name to access the cluster console. In the navigation pane, choose **Add-ons**.
2. Locate the **Cloud Native Cluster Monitoring** add-on and click **Install**.

   You are advised to focus on the following configurations, and adjust any other configurations as necessary. For details, see **Cloud Native Cluster Monitoring**.

   - **Report Monitoring Data to AOM**: After this function is enabled, the add-on will report monitoring data to AOM.
   - **Target AOM Instance**: Select an AOM instance for the add-on to report metrics.



3. Click **Install**.

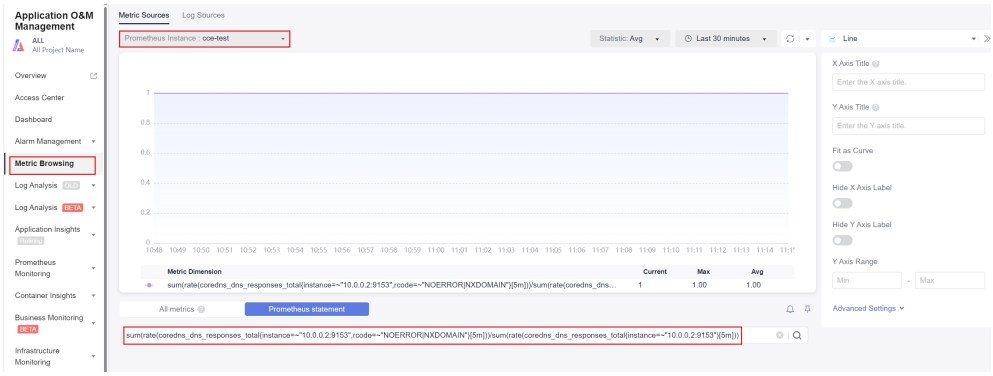
Step 2 Go to the AOM console to check monitoring data.

1. Log in to the AOM 2.0 console. In the navigation pane, choose **Metric Browsing**.
2. Select the Prometheus instance interconnected with AOM, select **Prometheus statement**.

   For example, to obtain the number of requests received by CoreDNS and the response success rate, run the following PromQL statement:

   ```
   sum(rate(coredns_dns_responses_total{instance=~"10.0.0.2:9153",rcode=~"NOERROR|NXDOMAIN"}[5m]))/sum(rate(coredns_dns_responses_total{instance=~"10.0.0.2:9153"}[5m]))
   ```

   10.0.0.2 is the IP address of the CoreDNS container. The following figure shows the command output.



----End

Obtaining Open-Source Prometheus Monitoring Data Through the Console

Step 1 After the Cloud Native Cluster Monitoring add-on is installed in a cluster, create a NodePort or LoadBalancer Service for Prometheus to access the external networks.

NOTICE

After external access is provided, you can access the Prometheus web page without authentication, which poses security risks. If you have high security requirements, you can do security hardening. You can use, for example, the Nginx reverse proxy and HTTP basic authentication to protect the console and restrict users who can access the Prometheus web page.

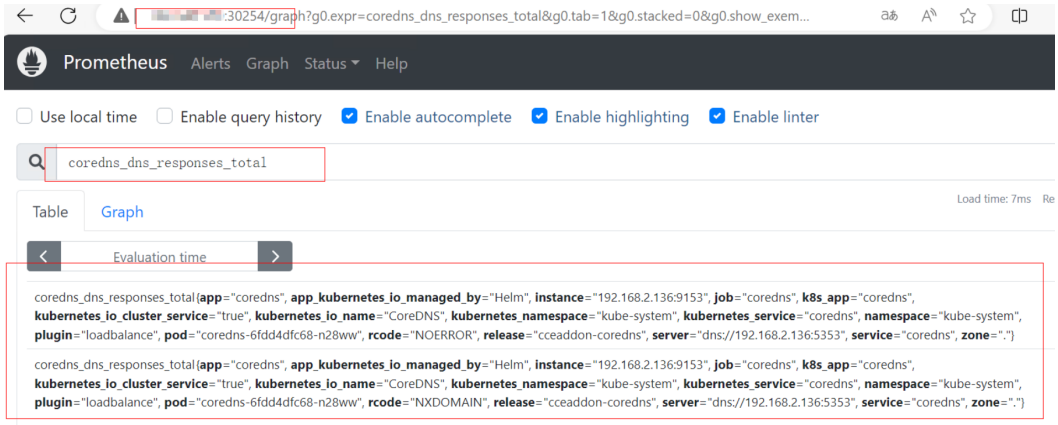
The following shows an example for creating a NodePort Service:

```
apiVersion: v1
kind: Service
```



```
metadata:
  name: prom-np
  labels:
    app.kubernetes.io/name: prometheus
    prometheus: server
  namespace: monitoring
spec:
  selector:
    app.kubernetes.io/name: prometheus
    prometheus: server
  externalTrafficPolicy: Cluster
  ports:
    - name: cce-service-0
      targetPort: 9090
      nodePort: 0
      port: 9090
      protocol: TCP
  type: NodePort
```

Step 2 After an EIP is bound to a node, enter *Node EIP:Node port* in the address box of a browser to obtain the monitoring data through PromQL.



----End

Obtaining Huawei Cloud Prometheus Monitoring Data Through APIs

Step 1 Log in to the AOM 2.0 console. In the navigation pane, choose **Prometheus Monitoring** > **Instances**.

Step 2 Click the name of the Prometheus instance interconnected with AOM and click **Settings**.

Step 3 Check the Grafana data source configurations and copy the public or intranet HTTP URL as required.

NOTE

If no access code is created, create one first.

Step 4 Use an HTTP URL to obtain Prometheus monitoring data.

The following shows an example. (For more information about how to use HTTP APIs to obtain Prometheus monitoring data, see **HTTP API**.)

```
GET <HTTP URL>/api/v1/query
Content-Type: application/json
Authorization: <Token>
{
"query":" coredns_dns_responses_total",
"time":" 1708655317.719",
"timeout":"1000"
}
```

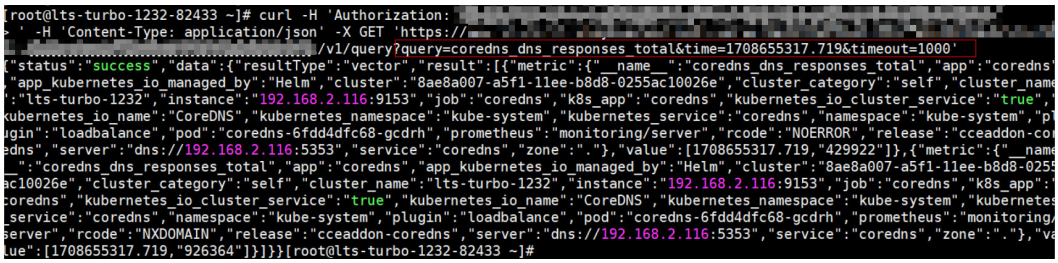
In the preceding command, *<HTTP URL>* specifies the HTTP URL in the previous step, and *<Token>* specifies the password obtained in the previous step. Other URL query parameters are as follows:

- **query**: Prometheus expression query string
- **time**: timestamp for obtaining monitoring data
- **timeout**: timeout interval, in milliseconds

The following shows an example command:

```
curl -H 'Authorization: <Token>' -H 'Content-Type: application/json' -X GET '<HTTP URL>/api/v1/query?
query=coredns_dns_responses_total&time=1708655317.719&timeout=1000'
```

The expected results are as follows:



----End

Obtaining Open-Source Prometheus Monitoring Data Through APIs

Step 1 Obtain the HTTP API URL.

- If you access open-source Prometheus in a cluster, the HTTP API UR is the default Service address **http://*<cluster IP>*:9090** of Prometheus server.
- If you use the public network to access open-source Prometheus, you need to associate a LoadBalancer Service to the Prometheus server. **http://*<ELB IP>*:9090** is the HTTP API URL.

Step 2 Use HTTP APIs to obtain Prometheus monitoring data.

The following describes how to obtain open-source Prometheus monitoring data through the HTTP APIs in the cluster.

- Obtain instantaneous monitoring data.

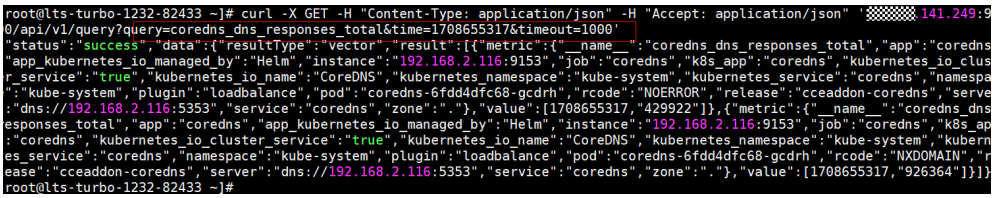
  ```
  GET <HTTP API>/api/v1/query
  Content-Type: application/json
  Param:
  {
  "query":" coredns_dns_responses_total",
  ```

```
"time":" 1708655317.719",
"timeout":"1000"
}
```

The following shows an example command:

```
curl -X GET -H "Content-Type: application/json" '<HTTP API>/api/v1/query?
query=coredns_dns_responses_total&time=1708655317&timeout=1000'
```

The expected results are as follows:



- Obtain monitoring data within a specified time range.

```
GET <HTTP API>/api/v1/query
Content-Type: application/json
Param:
{
"query":" coredns_dns_responses_total",
"start":1708655317,
"end":1708655318,
"step":30
}
```

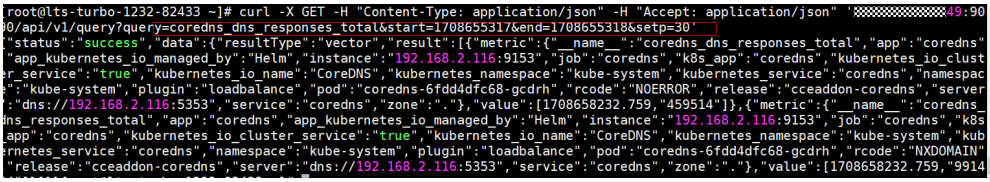
Other URL query parameters are as follows:

- **start**: time when you start to obtain monitoring data
- **end**: time when you stop obtaining the monitoring data
- **step**: step of the data interval when the monitoring data is returned

The following shows an example statement:

```
curl -X GET -H "Content-Type: application/json" -H "Accept: application/json" '<HTTP API>/api/v1/
query?query=coredns_dns_responses_total&start=1708655317&end=1708655318&setp=30'
```

The expected results are as follows:



----End

9 Cluster

9.1 Suggestions on CCE Cluster Selection

When you use CCE to create a Kubernetes cluster, there are multiple configuration options and terms. This section compares the key configurations for CCE clusters and provides recommendations to help you create a cluster that better suits your needs.

Cluster Types

CCE supports CCE Turbo clusters and CCE standard clusters to meet your requirements. This section describes the differences between these two types of clusters.

Table 9-1 Cluster types

Category	Subcategory	CCE Turbo Cluster	CCE Standard Cluster
Cluster	Positioning	Next-gen container cluster designed for Cloud Native 2.0, with accelerated computing, networking, and scheduling	Standard cluster for common commercial use
	Node type	Deployment of VMs and bare-metal servers	Deployment of VMs and bare-metal servers
Networking	Model	**Cloud Native Network 2.0**: applies to large-scale and high-performance scenarios. Max networking scale: 2,000 nodes	**Cloud Native Network 1.0**: applies to common, smaller-scale scenarios. • Tunnel network model • VPC network model

Category	Subcategory	CCE Turbo Cluster	CCE Standard Cluster
	Performance	Flattens the VPC network and container network into one, achieving zero performance loss.	Overlays the VPC network with the container network, causing certain performance loss.
	Container network isolation	Associates pods with security groups. Unifies security isolation in and out the cluster via security groups' network policies.	• Tunnel network model: supports network policies for intra-cluster communications. • VPC network model: supports no isolation.
Security	Isolation	• Physical machine: runs Kata containers, allowing VM-level isolation. • VM: runs common containers, isolated by cgroups.	Runs common containers, isolated by cgroups.

Cluster Versions

Due to the fast iteration, many bugs are fixed and new features are added in the new Kubernetes versions. The old versions will be gradually eliminated. When creating a cluster, select the latest commercial version supported by CCE.

Network Models

This section describes the network models supported by CCE clusters. You can select one model based on your requirements.

NOTICE

After clusters are created, the network models cannot be changed. Exercise caution when selecting the network models.

Table 9-2 Network model comparison

Dimension	Tunnel Network	VPC Network	Cloud Native Network 2.0
Application scenarios	• Low requirements on performance: As the container tunnel network requires additional VXLAN tunnel encapsulation, it has about 5% to 15% of performance loss when compared with the other two container network models. Therefore, the container tunnel network applies to the scenarios that do not have high performance requirements, such as web applications, and middle-end and back-end services with a small number of access requests. • Large-scale networking: Different from the VPC network that is limited by the VPC route quota, the container tunnel network does not have any restriction	• High performance requirements: As no tunnel encapsulation is required, the VPC network model delivers the performance close to that of a VPC network when compared with the container tunnel network model. Therefore, the VPC network model applies to scenarios that have high requirements on performance, such as AI computing and big data computing. • Small- and medium-scale networks: Due to the limitation on VPC route tables, it is recommended that the number of nodes in a cluster be less than or equal to 1000.	• High performance requirements: Cloud Native Network 2.0 uses VPC networks to construct container networks, eliminating the need for tunnel encapsulation or NAT when containers communicate. This makes Cloud Native Network 2.0 ideal for scenarios that demand high bandwidth and low latency, such as live streaming and e-commerce flash sales. • Large-scale networking: Cloud Native Network 2.0 supports up to 2,000 ECS nodes and 100,000 pods.

Dimension	Tunnel Network	VPC Network	Cloud Native Network 2.0
	on the infrastructure. In addition, the container tunnel network controls the broadcast domain to the node level. The container tunnel network supports a maximum of 2000 nodes.		
Core technology	OVS	IPvlan and VPC route	VPC ENI/sub-ENI
Applicable clusters	CCE standard cluster	CCE standard cluster	CCE Turbo cluster
Container network isolation	Kubernetes native NetworkPolicy for pods	No	Pods support security group isolation.
Interconnecting pods to a load balancer	Interconnected through a NodePort	Interconnected through a NodePort	Directly interconnected using a dedicated load balancer Interconnected using a shared load balancer through a NodePort
Managing container IP addresses	• Separate container CIDR blocks needed • Container CIDR blocks divided by node and dynamically added after being allocated	• Separate container CIDR blocks needed • Container CIDR blocks divided by node and statically allocated (the allocated CIDR blocks cannot be changed after a node is created)	Container CIDR blocks divided from a VPC subnet (You do not need to configure separate container CIDR blocks.)

Dimension	Tunnel Network	VPC Network	Cloud Native Network 2.0
Network performance	Performance loss due to VXLAN encapsulation	No tunnel encapsulation, and cross-node traffic forwarded through VPC routers (The performance is so good that is comparable to that of the host network, but there is a loss caused by NAT.)	Container network integrated with VPC network, eliminating performance loss
Networking scale	A maximum of 2000 nodes are supported.	Suitable for small- and medium-scale networks due to the limitation on VPC route tables. It is recommended that the number of nodes be less than or equal to 1000. Each time a node is added to the cluster, a route is added to the VPC route tables (including the default and custom ones). Evaluate the cluster scale that is limited by the VPC route tables before creating the cluster. For details about route tables, see **Constraints**.	A maximum of 2000 nodes are supported. In a cloud-native network 2.0 cluster, containers' IP addresses are assigned from VPC CIDR blocks, and the number of containers supported is restricted by these blocks. Evaluate the cluster's scale limitations before creating it.

For more information, see **Container Network Models Overview**.

Cluster CIDR Blocks

There are node CIDR blocks, container CIDR blocks, and Service CIDR blocks in CCE clusters. When planning network addresses, note that:

- These three types of CIDR blocks cannot overlap with each other. Otherwise, a conflict will occur. All subnets (including those created from the secondary CIDR block) in the VPC where the cluster resides cannot conflict with the container and Service CIDR blocks.

- There are sufficient IP addresses in each CIDR block.
  - The IP addresses in a node CIDR block must match the cluster scale. Otherwise, nodes cannot be created due to insufficient IP addresses.
  - The IP addresses in a container CIDR block must match the service scale. Otherwise, pods cannot be created due to insufficient IP addresses.

In complex scenarios, for example, multiple clusters use the same VPC or clusters are interconnected across VPCs, determine the number of VPCs, the number of subnets, the container CIDR blocks, and the communication modes of the Service CIDR blocks. For details, see **Planning CIDR Blocks for a Cluster**.

Service Forwarding Modes

kube-proxy is a key component of a Kubernetes cluster. It is responsible for load balancing and forwarding between a Service and its backend pod.

CCE supports the iptables and IPVS forwarding modes.

- IPVS allows higher throughput and faster forwarding. It applies to scenarios where the cluster scale is large or the number of Services is large.
- iptables is the traditional kube-proxy mode. This mode applies to the scenario where the number of Services is small or there are a large number of short concurrent connections on the client.

If high stability is required and the number of Services is less than 2000, the iptables forwarding mode is recommended. In other scenarios, the IPVS forwarding mode is recommended.

For details, see **Comparing iptables and IPVS**.

Node Specifications

The minimum specifications of a node are 2 vCPUs and 4 GiB memory. Evaluate based on service requirements before configuring the nodes. However, using many low-specification ECSs is not the optimal choice. The reasons are as follows:

- The upper limit of network resources is low, which may result in a single-point bottleneck.
- Resources may be wasted. If each container running on a low-specification node needs a lot of resources, the node cannot run multiple containers and there may be idle resources in it.

Advantages of using large-specification nodes are as follows:

- The upper limit of the network bandwidth is high. This ensures higher resource utilization for high-bandwidth applications.
- Multiple containers can run on the same node, and the network latency between containers is low.
- The efficiency of pulling images is higher. This is because an image can be used by multiple containers on a node after being pulled once. Low-specifications ECSs cannot respond promptly because the images are pulled many times and it takes more time to scale these nodes.

Additionally, select a proper vCPU/memory ratio based on your requirements. For example, if a service container with large memory but fewer CPUs is used,

configure the specifications with the vCPU/memory ratio of 1:4 for the node where the container resides to reduce resource waste.

Container Engines

CCE supports the containerd and Docker container engines. **containerd is recommended for its shorter traces, fewer components, higher stability, and less consumption of node resources**. Since Kubernetes 1.24, Dockershim is removed and Docker is no longer supported by default. For details, see **Kubernetes is Moving on From Dockershim: Commitments and Next Steps**. CCE clusters 1.27 do not support the Docker container engine.

Use containerd in typical scenarios. The Docker container engine is supported only in the following scenarios:

- Docker in Docker (usually in CI scenarios)
- Running the Docker commands on the nodes
- Calling Docker APIs

Node OS

Service container runtimes share the kernel and underlying calls of nodes. To ensure compatibility, select a Linux distribution version that is the same as or close to that of the final service container image for the node OS.

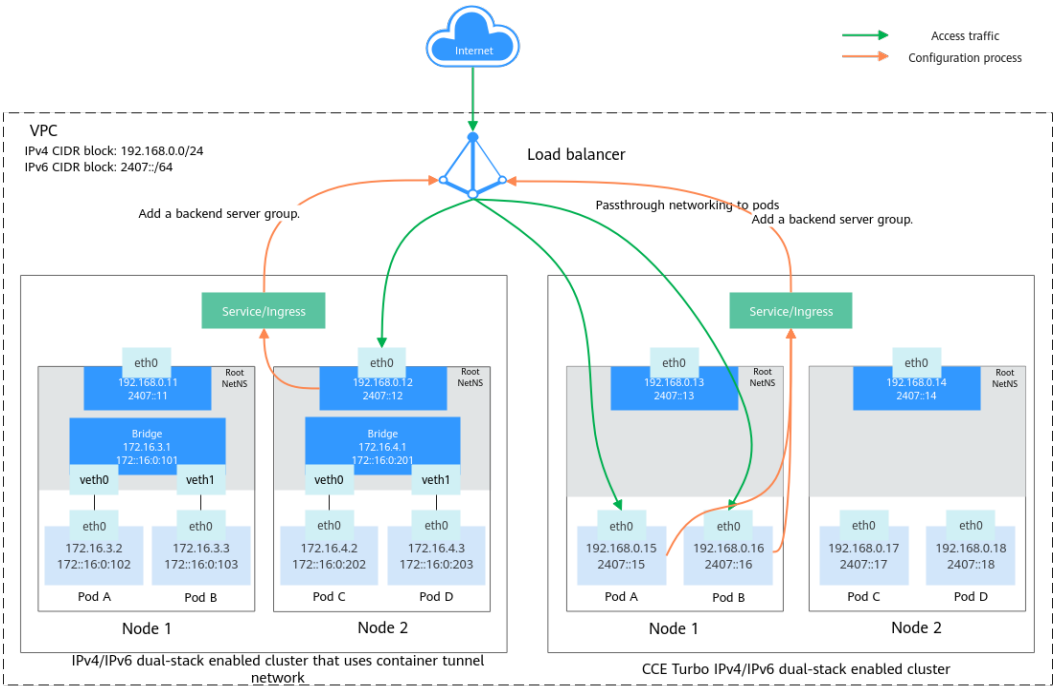
9.2 Creating an IPv4/IPv6 Dual-Stack Cluster in CCE

This section describes how to set up a VPC with IPv6 CIDR block and create a cluster and nodes with an IPv6 address in the VPC, so that the nodes can access the Internet.

Overview

IPv6 addresses are used to deal with the problem of IPv4 address exhaustion. If a worker node (such as an ECS) in the current cluster uses IPv4, the node can run in dual-stack mode after IPv6 is enabled. Specifically, the node has both IPv4 and IPv6 addresses, which can be used to access the intranet or public network.

Figure 9-1 Diagram of an IPv4/IPv6 dual-stack enabled cluster



Application Scenarios

- If your application needs to provide Services for users who use IPv6 clients, you can use IPv6 EIPs or the IPv4 and IPv6 dual-stack function.
- If your application needs to both provide Services for users who use IPv6 clients and analyze the access request data, you can use only the IPv4 and IPv6 dual-stack function.
- If internal communication is required between your application systems or between your application system and another system (such as the database system), you can use only the IPv4 and IPv6 dual-stack function.

For details about the dual-stack, see **IPv4 and IPv6 Dual-Stack Network** and **IPv6 EIP**.

Constraints

- Clusters that support IPv4/IPv6 dual-stack:

Cluster Type	Cluster Network Model	Version	Remarks
CCE standard cluster	Container tunnel network	v1.15 or later	IPv4/IPv6 dual-stack will be generally available for clusters of v1.23. ELB dual-stack is not supported.

Cluster Type	Cluster Network Model	Version	Remarks
CCE Turbo cluster	Cloud Native 2.0 Network	v1.23.8-r0 or later v1.25.3-r0 or later	Currently, Kata containers do not support IPv4/IPv6 dual-stack. Only ECS-VM or ECS-physical server (c6.22xlarge.4.physical or c7.32xlarge.4.physical) supports IPv4/IPv6 dual-stack.

- Worker nodes and master nodes in Kubernetes clusters use IPv4 addresses to communicate with each other.
- When there is a **DNAT** Service in a cluster, only IPv4 addresses are supported.
- Only one IPv6 address can be bound to each NIC.
- When IPv4/IPv6 dual-stack is enabled for the cluster, DHCP unlimited lease cannot be enabled for the selected node subnet.
- If a dual-stack cluster is used, do not change the load balancer protocol version on the ELB console.
- ELB dual-stack can be used in only CCE Turbo clusters with the following restrictions.

Application Scenario	Dedicated Load Balancer	Shared Load Balancer
ELB ingress	Dual stack is supported. Layer-7 dedicated load balancers can only communicate with their backend servers using IPv4. For details, see **Does ELB Support IPv6 Networks?** If an ingress uses IPv6/IPv4 dual-stack, related alarms will be generated. (Backends with IPv6 addresses cannot be added to the associated load balancer.) You can view related alarms by referring to the events of the corresponding ingress.	Only IPv4 is supported.
Nginx ingress	Dual-stack is supported when the following conditions are met: • For clusters from v1.19 to v1.23, nginx-ingress of v2.1.7 or later supports dual-stack. • For clusters of v1.25 or later, nginx-ingress of v2.2.5 or later supports dual-stack.	Only IPv4 is supported.

Application Scenario	Dedicated Load Balancer	Shared Load Balancer
LoadBalancer Service	• Layer 7 (HTTP/HTTPS): Dual-stack is supported. Layer-7 dedicated load balancers can only communicate with their backend servers using IPv4. For details, see **Does ELB Support IPv6 Networks?** If a Service uses IPv6/IPv4 dual-stack, related alarms will be generated. (Backends with IPv6 addresses cannot be added to the associated load balancer.) You can view related alarms by referring to the events of the corresponding Service. To avoid alarms, you can select the IPv4 protocol when creating a Service and select a dedicated Layer-7 load balancer with dual-stack enabled. • Layer 4 (TCP/UDP): Dual-stack is supported.	Only IPv4 is supported.

Step 1: Create a VPC

Before creating your VPCs, determine how many VPCs, the number of subnets, and what IP address ranges you will need. For details, see **Network Planning**.

NOTE

- The basic operations for IPv4 and IPv6 dual-stack networks are the same as those for IPv4 networks. Only some parameters are different.
- For details about the IPv6 billing policy, supported ECS types, and supported regions, see **IPv4 and IPv6 Dual-Stack Network**.

Perform the following operations to create a VPC named **vpc-ipv6** and its default subnet named **subnet-ipv6**.

1. Log in to the management console.
2. Click in the upper left corner of the management console and select a region and a project.
3. Under **Networking**, select **Virtual Private Cloud**.
4. Click **Create VPC**.
5. Configure the VPC and subnet following instructions. For details about the mandatory parameters, see **Table 9-3** and **Table 9-4**. For details about other parameters, see **Creating a VPC and Subnet**.

   When configuring a subnet, select **Enable** for **IPv6 CIDR Block** to automatically allocate an IPv6 CIDR block to the subnet. IPv6 cannot be disabled after the subnet is created. Currently, you are not allowed to specify a custom IPv6 CIDR block.

Table 9-3 VPC configuration parameters

Parameter	Description	Example Value
Region	Specifies the desired region. Regions are geographic areas that are physically isolated from each other. The networks inside different regions are not connected to each other, so resources cannot be shared across different regions. For lower network latency and faster access to your resources, select the region nearest you.	AP-Singapore
Name	VPC name.	vpc-ipv6
IPv4 CIDR Block	Specifies the Classless Inter-Domain Routing (CIDR) block of the VPC. The CIDR block of a subnet can be the same as the CIDR block for the VPC (for a single subnet in the VPC) or a subset (for multiple subnets in the VPC). The following CIDR blocks are supported: 10.0.0.0/8–24 172.16.0.0/12–24 192.168.0.0/16–24	192.168.0.0/16
Enterprise Project	When creating a VPC, you can add the VPC to an enabled enterprise project. An enterprise project facilitates project-level management and grouping of cloud resources and users. The name of the default project is **default**. For details about how to create and manage enterprise projects, see ***Enterprise Management User Guide***.	default

Table 9-4 Subnet parameters

Parameter	Description	Example Value
Subnet Name	Specifies the subnet name.	subnet-ipv6
AZ	An AZ is a geographic location with independent power supply and network facilities in a region. AZs are physically isolated, and AZs in the same VPC are interconnected through an internal network.	AZ 2

Parameter	Description	Example Value
IPv4 CIDR Block	Specifies the IPv4 CIDR block for the subnet. This value must be within the VPC CIDR range.	192.168.0.0/24
IPv6 CIDR Block	Select **Enable** for **IPv6 CIDR Block**. An IPv6 CIDR block will be automatically assigned to the subnet. IPv6 cannot be disabled after the subnet is created. Currently, you are not allowed to specify a custom IPv6 CIDR block.	N/A
Associated Route Table	Specifies the default route table to which the subnet will be associated. You can change the route table to a custom route table.	Default
Advanced Settings		
Gateway	Specifies the gateway address of the subnet. This IP address is used to communicate with other subnets.	192.168.0.1
DNS Server Address	By default, two DNS server addresses are configured. You can change them if necessary. When multiple IP addresses are available, separate them with a comma (,).	100.125.x.x
IPv4 DHCP Lease Time	Specifies the period during which a client can use an IP address automatically assigned by the DHCP server. After the lease time expires, a new IP address will be assigned to the client. If a DHCP lease time is changed, the new lease automatically takes effect when half of the current lease time has passed. To make the change take effect immediately, restart the ECS or log in to the ECS to cause the DHCP lease to automatically renew. **CAUTION** When IPv4/IPv6 dual-stack is enabled for the cluster, DHCP unlimited lease cannot be enabled for the selected node subnet.	365 days or 300 hours

6. Click **Create Now**.

Step 2: Create a CCE Cluster

Creating a CCE cluster

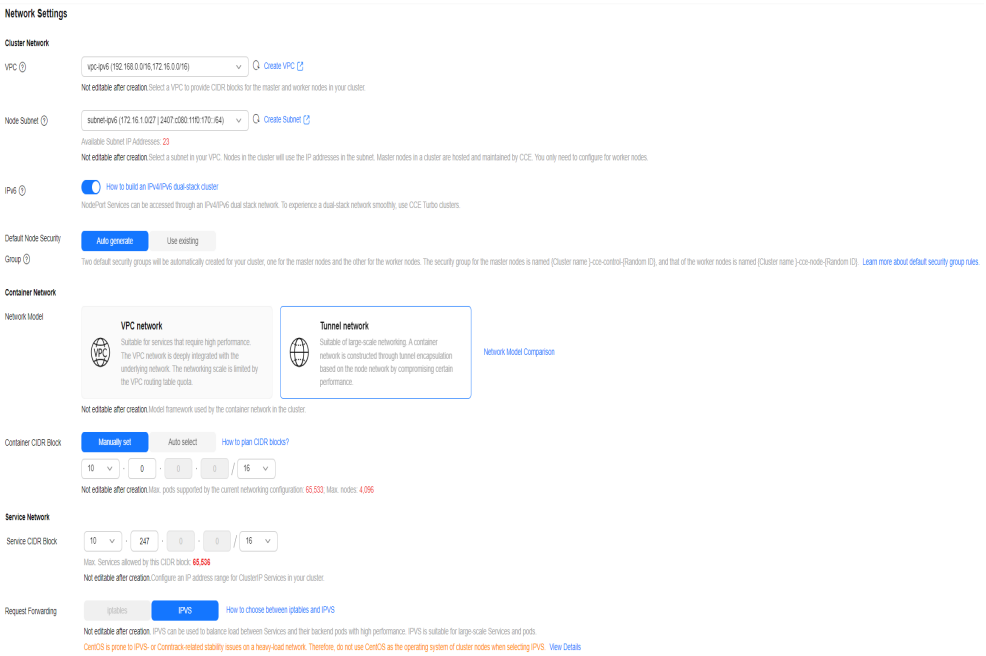
1. Log in to the CCE console and create a cluster.

   Complete the network settings as follows. For other configurations, see **Buying a CCE Cluster**.

   - **Network Model**: Select **Tunnel network**.
   - **VPC**: Select the created VPC **vpc-ipv6**.

- **Subnet**: Select a subnet with IPv6 enabled.
- **IPv6**: Enable this function. After this function is enabled, cluster resources, including nodes and workloads, can be accessed through IPv6 CIDR blocks.
- **Container CIDR Block**: A proper mask must be set for the container CIDR block. The mask determines the number of available nodes in the cluster. If the mask of the container CIDR block in the cluster is set improperly, there will be only a small number of available nodes in the cluster.

Figure 9-2 Configuring network settings



2. Create a node.

   The CCE console displays the nodes that support IPv6. You can directly select a node. For details, see **Creating a Node**.

   After the creation is complete, access the cluster details page. Then, click the node name to go to the ECS details page and view the automatically allocated IPv6 address.

Step 3: Buy a Shared Bandwidth and Adding an IPv6 Address to It

By default, the IPv6 address can only be used for private network communication. If you want to use this IPv6 address to access the Internet or be accessed by IPv6 clients on the Internet, buy a shared bandwidth and add the IPv6 address to it.

If you already have a shared bandwidth, you can add the IPv6 address to the shared bandwidth without purchasing one.

Buying a Shared Bandwidth

1. Log in to the management console.
2. Click  in the upper left corner of the management console and select a region and a project.

3. Choose **Service List** > **Networking** > **Virtual Private Cloud**.
4. In the navigation pane, choose **Elastic IP and Bandwidth** > **Shared Bandwidths**.
5. In the upper right corner, click **Buy Shared Bandwidth**. On the displayed page, configure parameters following instructions.

Table 9-5 Parameters

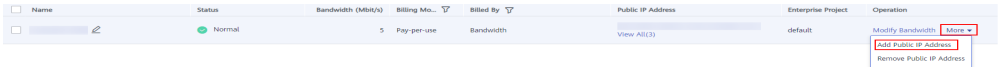
Parameter	Description	Example Value
Billing Mode	Specifies the billing mode of a shared bandwidth. The billing mode can be: • **Yearly/Monthly**: You pay for the bandwidth by year or month before using it. No charges will be incurred for the bandwidth during its validity period. • **Pay-per-use**: You pay for the bandwidth based on the amount of time you use the bandwidth.	Yearly/ Monthly
Region	Specifies the desired region. Regions are geographic areas that are physically isolated from each other. The networks inside different regions are not connected to each other, so resources cannot be shared across different regions. For lower network latency and faster access to your resources, select the region nearest you.	AP-Singapore -
Billed By	Specifies the shared bandwidth billing factor.	Select **Bandwidth**.
Bandwidth	Specifies the shared bandwidth size in Mbit/s. The minimum bandwidth that can be purchased is 5 Mbit/s.	10
Name	Specifies the name of the shared bandwidth.	Bandwidth-001
Enterprise Project	When assigning the shared bandwidth, you can add the shared bandwidth to an enabled enterprise project. An enterprise project facilitates project-level management and grouping of cloud resources and users. The name of the default project is **default**. For details about how to create and manage enterprise projects, see ***Enterprise Management User Guide***.	default
Required Duration	Specifies the required duration of the shared bandwidth to be purchased. Configure this parameter only in yearly/monthly billing mode.	2 months

6. Click Next.

Adding an IPv6 Address to a Shared Bandwidth

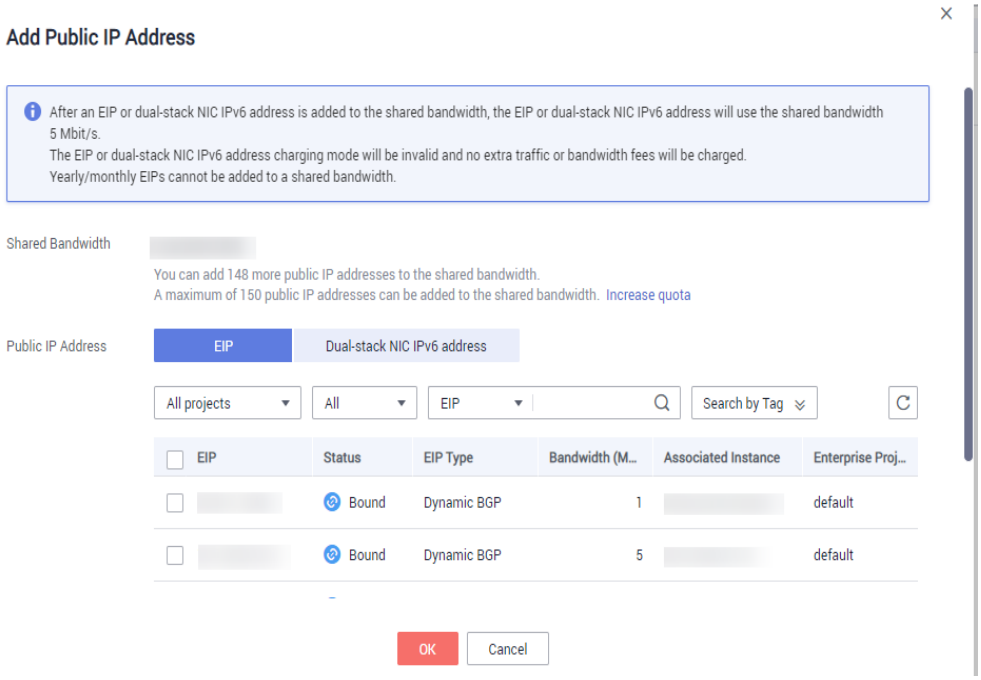
1. On the shared bandwidth list page, locate the row containing the target shared bandwidth and click **Add Public IP Address** in the **Operation** column.

   Figure 9-3 Adding an IPv6 address to a shared bandwidth



2. Add the IPv6 address to the shared bandwidth.

   Figure 9-4 Adding a dual-stack NIC IPv6 address



3. Click **OK**.

Verifying the Result

Log in to an ECS and ping an IPv6 address on the Internet to verify the connectivity. **ping6 ipv6.baidu.com** is used as an example here. The execution result is displayed in **Figure 9-5**.

Figure 9-5 Result verification

```
root@ecs-tang:~# ping6 ipv6.baidu.com
PING ipv6.baidu.com(2400:da00:2::29) 56 data bytes
64 bytes from 2400:da00:2::29: icmp_seq=1 ttl=42 time=45.6 ms
64 bytes from 2400:da00:2::29: icmp_seq=2 ttl=42 time=45.1 ms
64 bytes from 2400:da00:2::29: icmp_seq=3 ttl=42 time=44.8 ms
64 bytes from 2400:da00:2::29: icmp_seq=4 ttl=42 time=45.1 ms
```


9.3 Creating a Custom CCE Node Image

Custom CCE node images are created using the open source tool **HashiCorp Packer** of v1.7.2 or later and the **open source plug-in**. The cce-image-builder template is provided to help you quickly build images.

Packer is used to create custom container images. It offers builders, provisioners, and post-processors that can be flexibly combined to automatically create image files concurrently through JSON or HCL template files.

Packer has the following advantages:

1. Automatic build process: You can use Packer configuration files to specify and automate the build process.
2. High compatibility with cloud platforms: Packer can interconnect with most cloud platforms and various third-party plug-ins.
3. Easy-to-use configuration files: Packer configuration files are simple and intuitive to write and read. Parameter definitions are easy to understand.
4. Diverse image build functions: Common functional modules are supported. For example, the provisioner supports the shell module in remote script execution, the file module in remote file transfer, and the breakpoint module for process pauses.

Constraints

- Suggestions on using CCE node images:
  - You are advised to use the default node images maintained by CCE. These images have passed strict tests and updated in a timely manner, providing better compatibility, stability, and security.
  - Use the base images provided by CCE to create custom images. Huawei Cloud EulerOS 2.0 and Ubuntu 22.04 custom images are not supported.
  - The component package on which nodes depend for running is preset in the base image. The package version varies with the cluster version. For custom images, CCE does not push component package updates.
- When customizing an image, exercise caution when modifying kernel parameters. Any improper kernel parameter modification will deteriorate the system running efficiency. For details about the reference values, see **Modifying Node Kernel Parameters**.

  Modifying the following kernel parameters will affect the system performance: **tcp_keepalive_time**, **tcp_max_tw_buckets**, **somaxconn**, **max_user_instances**, **max_user_watches**, **netdev_max_backlog**, **net.core.wmem_max**, and **net.core.rmem_max**.

  To modify node kernel parameters, fully verify the modification in a test environment before applying the modification to the production environment.

Precautions

- Before you create an image, prepare:

  - An ECS executor: An ECS x86 server is used as the Linux executor. You are advised to select CentOS7 and bind an EIP to it so that it can access the public network and install Packer.
  - Authentication credentials: Obtain the AK/SK of the tenant or user with required permissions. For details, see **How Do I Obtain an Access Key (AK/SK)**.
  - Security group: Packer creates a temporary ECS and uses a key pair to log in to the ECS using SSH. Ensure that **TCP:22** is enabled in the security group. For details, see **Security Group Configuration Examples**.
- When you create a custom node image, make sure:
  - You follow the instructions in this section to prevent unexpected problems.
  - You have the **sudo root** or **root** permissions required to log in to VMs created from base images.
- When the creation is complete:
  - The image creation process uses certain charging resources, including ECSs, EVS disks, EIPs, bandwidth, and IMS images. These resources are automatically released when the image is successfully created or fails to be created. Release the resources in time to ensure no charges are incurred unexpectedly.

Obtaining an Image ID

Step 1 Log in to the CCE console and click the cluster name to access the cluster console. In the navigation pane, choose **Nodes**.

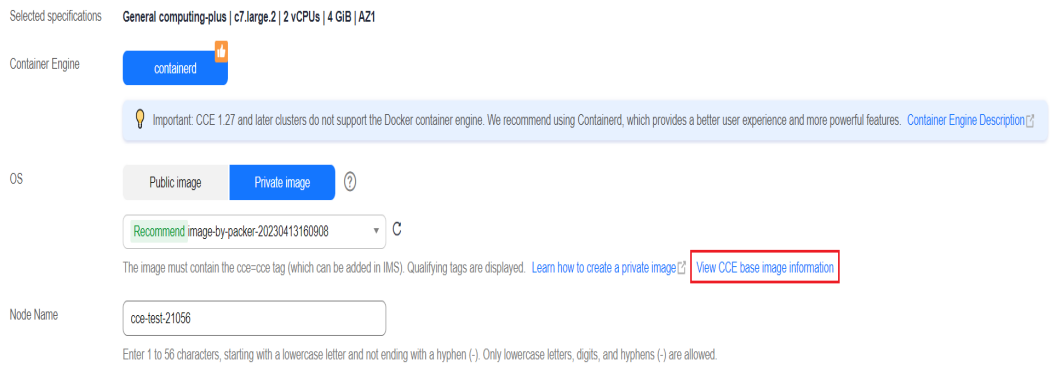
Step 2 Click **Create Node** in the upper right corner and select **OS** to **Private image**.

Step 3 Click **View CCE base image information**. In the displayed dialog box, copy the image ID.

NOTICE

The image ID varies depending on the region. If the region is changed, obtain the image ID again.

Figure 9-6 Obtaining an Image ID



----End

Creating a Node Image

Step 1 Download cce-image-builder.

Log in to the ECS executor, download and decompress cce-image-builder.

```
wget https://cce-north-4.obs.cn-north-4.myhuaweicloud.com/cce-image-builder/cce-image-builder.tgz

tar zvxf cce-image-builder.tgz
cd cce-image-builder/
```

NOTE

The cce-image-builder contains:

- turbo-node.pkr.hcl # Packer configuration template used for creating the image. For details about how to modify the template, see **Step 3**.
- scripts/* # CCE image creation preset in the template. Do not modify it. Otherwise, the image might become unavailable.
- user-scripts/* **# Custom package script directory preset in the template.** Take example.sh as an example. When you create a custom image, the image is automatically uploaded to the temporary server and executed.
- user-packages/* **# Custom package directory preset in the template.** Take **example.package** as an example. When you create a custom image, the image is automatically uploaded to **/tmp/example.package** in the temporary server.

Step 2 Install Packer.

Download and install the **HashiCorp Packer**. For details, see **Install Packer**.

NOTE

The Packer version needs to be 1.10.0.

Take the CentOS 7 executor as an example. Run the following command to automatically install Packer (**This example is for reference only. For detailed operations, see the official guide**):

```
# Configure the yum repository and install Packer.
sudo yum install -y yum-utils
sudo yum-config-manager --add-repo https://rpm.releases.hashicorp.com/RHEL/hashicorp.repo
sudo yum -y install packer-1.10.0

# Configure an alias to avoid duplicate Packer binary in the OS and check the Packer version.
rpm -q packer
alias packer=$(rpm -ql packer)
packer -v
```

Step 3 Define Packer template parameters.

The **cce-image-builder/turbo-node.pkr.hcl** file defines the process of building an image using Packer. For details, see **Packer Documentation**.

NOTE

- Parameters of **variables** or **variable**

  turbo-node.pkr.hcl defines the parameters required in the process of building an image. You can configure the parameters based on the live environment. For details, see **Table 1**.

- Parameter of **packer**

  required_plugins defines the add-on dependency of Packer, including the add-on source and version range. When you run **packer init**, the add-on is automatically downloaded and initialized.

```
packer {
  required_plugins {
    huaweicloud = {
      version = ">= 1.0.4"
      source  = "github.com/huaweicloud/huaweicloud"
    }
  }
}
```

- Parameter of **source**

  The preceding defined variables are referred to automatically configure the parameters required for creating an ECS.

- Parameter of **build**

  The scripts are executed from top to bottom. Common modules such as the file upload module and script execution shell module are supported. The corresponding scripts and files are stored in the **user-scripts** and **user-packages** directories, respectively, in **cce-image-builder**.

  Example:

```
build {
  sources = ["source.huaweicloud-ecs.builder"]

# Example:
  provisioner "file" {
    source      = "<source file path>"
    destination = "<destination file path>"
  }

  provisioner "shell" {
    scripts = [
      "<source script file: step1.sh>",
      "<source script file: step2.sh>"
    ]
  }

  provisioner "shell" {
    inline = ["echo foo"]
  }
}
```

Step 4 Configure environment variables.

Configure the following environment variables on the executor:

```
export REGION_NAME=xxx
export IAM_ACCESS_KEY=xxx
export IAM_SECRET_KEY=xxx
export ECS_VPC_ID=xxx
export ECS_NETWORK_ID=xxx
export ECS_SECGRP_ID=xxx
export CCE_SOURCE_IMAGE_ID=xxx
export PKR_VAR_ecs_flavor=xxx
```


Table 9-6 Variables configuration

Parameter	Description	Remarks
REGION_NAME	Region to which the project belongs	To obtain the region information, go to **My Credentials**.
IAM_ACCESS_KEY	Access key for user authentication	Apply for a temporary AK and delete it when the image is built successfully.
IAM_SECRET_KEY	Secret key for user authentication	Apply for a temporary SK and delete it when the image is built successfully.
ECS_VPC_ID	VPC ID	Used by the temporary ECS server, which must be the same as that of the executor
ECS_NETWORK_ID	Network ID of the subnet	Used by the temporary ECS server. It is recommended that the value be the same as that of the executor. It is not the subnet ID.
ECS_SECGRP_ID	Security group ID	Used by the temporary ECS. The public IP address of the executor must be allowed to pass through port 22 in the inbound direction of the security group to ensure that the executor can log in to the temporary ECS using SSH.
CCE_SOURCE_IMAGE_ID	Latest CCE node image ID	For details, see **Obtaining an Image ID**.
PKR_VAR_ecs_flavor	Specifications of a temporary ECS	Enter a node flavor supported by CCE. The recommended flavor is 2 vCPUs and 4 GiB memory or higher. For details about the flavor name, see **A Summary List of x86 ECS Specifications**.

Note: Retain the default values of other parameters. To change the values, refer to the description in the variable definition in **turbo-node.pkr.hcl** and configure the value using environment variables.

Use the ECS flavor variable **ecs_az** as an example. If no AZ is specified, select a random AZ. If you want to specify an AZ, configure an environment variable. The same applies to other parameters.

```
# export PKR_VAR_<variable name>=<variable value>
export PKR_VAR_ecs_az=xxx
```

Step 5 Customize scripts and files.

Compile scripts and files by referring to the file and shell modules defined by the **build** field in the **pkr.hcl** file, and store the scripts and files in the **user-scripts** and **user-packages** directories in **cce-image-builder**.

NOTICE

When customizing an image, exercise caution when modifying kernel parameters. Any improper kernel parameter modification will deteriorate the system running efficiency. For details about the reference values, see **Modifying Node Kernel Parameters**.

Modifying the following kernel parameters will affect the system performance: **tcp_keepalive_time**, **tcp_max_tw_buckets**, **somaxconn, max_user_instances**, **max_user_watches**, **netdev_max_backlog**, **net.core.wmem_max**, and **net.core.rmem_max**.

To modify node kernel parameters, fully verify the modification in a test environment before applying the modification to the production environment.

Step 6 Create a custom image.

After custom parameter settings, create an image. The creation will take 3 to 5 minutes.

```
make image
```

NOTE

In the encapsulation script **packer.sh**:

- Automatic access of hashicorp.com by Packer is disabled by default for privacy protection and security purposes.
  ```
  export CHECKPOINT_DISABLE=false
  ```
- The debugging detailed logs option is enabled by default for better visibility and traceability. The local Packer build logs **packer_{timestamp}.log** is specified so that the logs can be packed to the **/var/log/** directory during build. If sensitive information is involved, remove the related logic.
  ```
  export PACKER_LOG=1
  export PACKER_BUILD_TIMESTAMP=$(date +%Y%m%d%H%M%S)
  export PACKER_LOG_PATH="packer_$PACKER_BUILD_TIMESTAMP.log"
  ```

For details about Packer configuration, see **Configuring Packer**.

After the image is created, information similar to the following will display.

```
==> huaweicloud-ecs.builder: Setting a 15m0s timeout for the next provisioner...
==> huaweicloud-ecs.builder: Provisioning with shell script: /tmp/packer-shell1759174699
==> huaweicloud-ecs.builder: Setting a 15m0s timeout for the next provisioner...
==> huaweicloud-ecs.builder: Uploading packer_20210530185050.log => /var/log/packer_20210530185050.log
    huaweicloud-ecs.builder: packer_20210530185050.log 43.63 KiB / 43.50 KiB [==============================] 100.29% 0s
==> huaweicloud-ecs.builder: Stopping server: 9c901ac9-37b5-40af-934e-7190e6fa088e ...
    huaweicloud-ecs.builder: Waiting for server to stop: 9c901ac9-37b5-40af-934e-7190e6fa088e ...
==> huaweicloud-ecs.builder: Creating the image: image-by-packer-20210530185050
==> huaweicloud-ecs.builder: Waiting for image image-by-packer-20210530185050 to become available ...
    huaweicloud-ecs.builder: Image: 64e940f4-d674-4ae1-89cc-299501581c59
==> huaweicloud-ecs.builder: Deleted temporary floating IP '494617cc-a7c9-442a-b3e8-3b90c2c3f804' (94.74.101.22)
==> huaweicloud-ecs.builder: Terminating the source server: 9c901ac9-37b5-40af-934e-7190e6fa088e ...
==> huaweicloud-ecs.builder: Deleting volume: bf769e29-e1fd-407b-bbec-79f353a3e671 ...
==> huaweicloud-ecs.builder: Deleting temporary keypair: packer_60b36e0b-1f16-acc5-df04-d045aba70856 ...
Build 'huaweicloud-ecs.builder' finished after 3 minutes 53 seconds.

==> Wait completed after 3 minutes 53 seconds

==> Builds finished. The artifacts of successful builds are:
--> huaweicloud-ecs.builder: An image was created: 64e940f4-d674-4ae1-89cc-299501581c59
[Sun May 30 18:54:45 CST 2021] packer.sh finish.
```

Step 7 Clean up build files.

Clear the build files on the executor, mainly the authentication credentials in **turbo-node.pkr.hcl**.

- If the authentication credentials are temporary, directly release the executor.
- If they are built automatically, add post-processor in the configuration file to execute related operations.

----End

Common Issues

- When the packer is used to create an image, the latest Huawei Cloud ECS open-source plugin is automatically obtained from GitHub. However, this process may fail due to the network environment.

  To solve the problem, apply either of the following methods:

  - Create an executor in a region such as CN-Hong Kong with a better network performance and connect the executor to the original region, for example, CN North-Beijing 4, to build a custom image.

    export REGION_NAME=cn-north-4

  - Download the corresponding plugin and initialize it to the local add-on path.

    To obtain the plugin releases, see **GitHub**.

    If the executor is CentOS 7.6 x86, and the downloaded plugin is packer-plugin-huaweicloud_v1.0.4_x5.0_linux_amd64.zip, run the following command:

    ```
    PLUGIN_PATH="$HOME/.packer.d/plugins/github.com/huaweicloud/huaweicloud"
    mkdir -p $PLUGIN_PATH
    unzip packer-plugin-huaweicloud_v1.0.4_x5.0_linux_amd64.zip -d /tmp/
    cp /tmp/packer-plugin-huaweicloud_v1.0.4_x5.0_linux_amd64 $PLUGIN_PATH/
    sha256sum /tmp/packer-plugin-huaweicloud_v1.0.4_x5.0_linux_amd64 | awk '{print $1}' > $PLUGIN_PATH/packer-plugin-huaweicloud_v1.0.4_x5.0_linux_amd64_SHA256SUM
    ll $PLUGIN_PATH/*
    ```

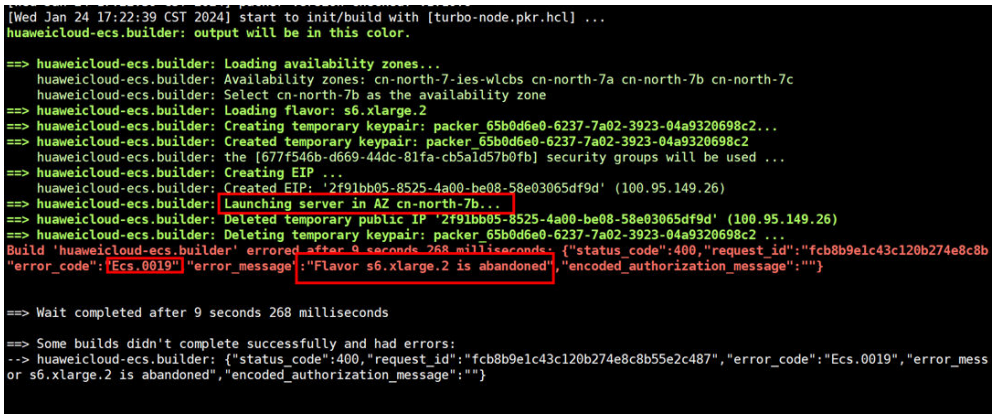
    Then, run the **make image** command to create an image.

- If the error message "PublicIp type is invalid" is displayed, you need to check the EIP type in different environments, run **export PKR_VAR_eip_type='*xxx*'**, and create an image. For details about EIP types, see **Assigning an EIP**.

  An example is as follows:

  ```
  export PKR_VAR_eip_type='5_bgp'
  ```

- If the error code **Ecs.0019** and the error message "Flavor xxxx is abandoned" are displayed, the flavor may be unavailable in the current AZ. Try again or change the flavor in the **turbo-node.pkr.hcl** file.



- If the error message "no such host" is displayed, the current IAM domain name may fail to be resolved.

  Configure the following environment variables on the host. *{IAM endpoint}* specifies the IAM domain name of the current region.

  ```
  export PKR_VAR_auth_url='{IAM endpoint}'
  ```

9.4 Executing the Pre- or Post-installation Commands During Node Creation

Background

When creating a node, use the pre- or -installation commands to install tools or perform security hardening on the node. This section provides guidance for you to correctly use the pre- or post-installation scripts. To use advanced installation scripts, store the scripts in OBS buckets to prevent problems such as excessive characters in the scripts. For details, see **Using OBS Buckets to Implement Custom Script Injection During Node Creation**.

Precautions

- Do not use pre- or post-installation scripts that take a long time to execute.

  The pre-installation script has a 15-minute time limit, while the post-installation script has a 30-minute time limit. If the node is not available within the designated time, the node reclaim process will be initiated. Therefore, do not use pre- or post-installation scripts that take a long time to execute.

- Do not directly use **reboot** in the script.

  CCE executes the post-installation command after installing mandatory components on a node. The node will be available only after the post-installation command is executed. If you run **reboot** directly, the node may be restarted before its status is reported. As a result, it cannot reach the running state within 30 minutes, and a rollback due to timeout will be triggered. Therefore, do not use **reboot**.

  If you need to restart a node, perform the following operations:

  – Run **shutdown -r** *<time >* in the script to delay the restart. For example, you can run **shutdown -r 1** to delay the restart for 1 minute.

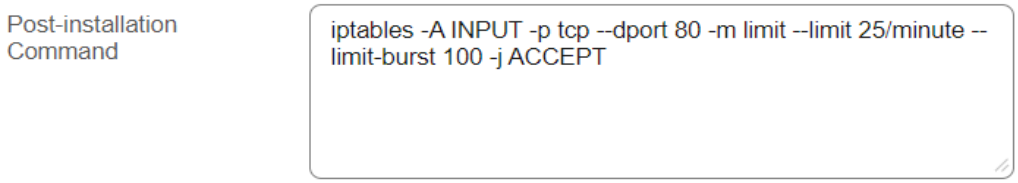
- After the node is available, manually restart it.

Procedure

Step 1 Log in to the CCE console. In the navigation pane, choose **Clusters**. Click the target cluster name to access the cluster console.

Step 2 Choose **Nodes** in the navigation pane, click the **Nodes** tab, click **Create Node** in the right corner, and configure the parameters.

Step 3 In the **Advanced Settings** area, enter pre- or post-installation commands.



For example, you can create iptables rules by running a post-installation command to allow a maximum of 25 TCP data packets to be addressed to port 80 per minute and allow a maximum of 100 data packets to be addressed to the port when the limit is exceeded to prevent DDoS attacks.

```
iptables -A INPUT -p tcp --dport 80 -m limit --limit 25/minute --limit-burst 100 -j ACCEPT
```

NOTE

The command example here is for reference only.

Step 4 After the configuration, enter the number of nodes to be purchased and click **Next: Confirm**.

Step 5 Click **Submit**.

----End

9.5 Using OBS Buckets to Implement Custom Script Injection During Node Creation

Background

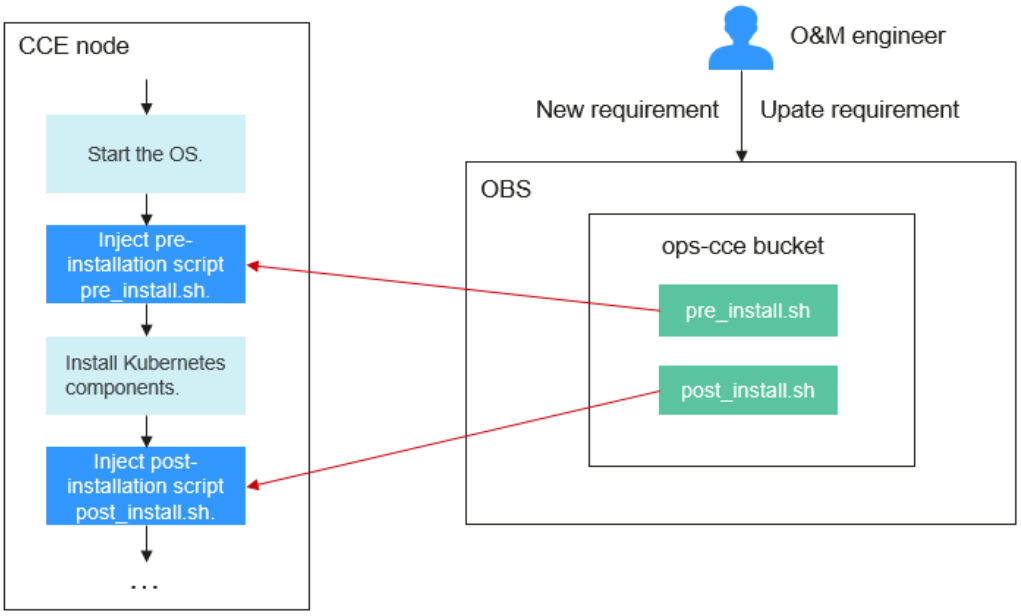
If you need to install some tools or perform custom security hardening on a node in advance, you need to inject some scripts when creating the node. CCE allows you to inject pre-installation and post-installation scripts when creating a node. However, this function has the following restrictions:

- The script characters are limited.
- The injected script content needs be frequently modified to meet various requirements and scenarios. However, CCE node pools have fixed scripts and do not support frequent modifications.

Solution

This section provides a simplified, scalable, easy-to-maintain best practice that combines CCE and OBS. It enables custom operations on CCE nodes.

The pre-installation and post-installation scripts are stored in an OBS bucket. When creating a node pool, the scripts directly retrieve the address of the corresponding OBS script and execute it. This approach eliminates the need to modify the configuration of the CCE node pool. If there are any new requirements, you can simply update the scripts in the OBS bucket.



Suggestions on Maintaining OBS Buckets

- If there is no OBS bucket dedicated for O&M, create an OBS bucket dedicated for O&M.
- Create a multi-level directory **tools/cce** in the bucket to represent CCE-specific tools for easy maintenance. You can also store other tool scripts in this directory later.

Precautions

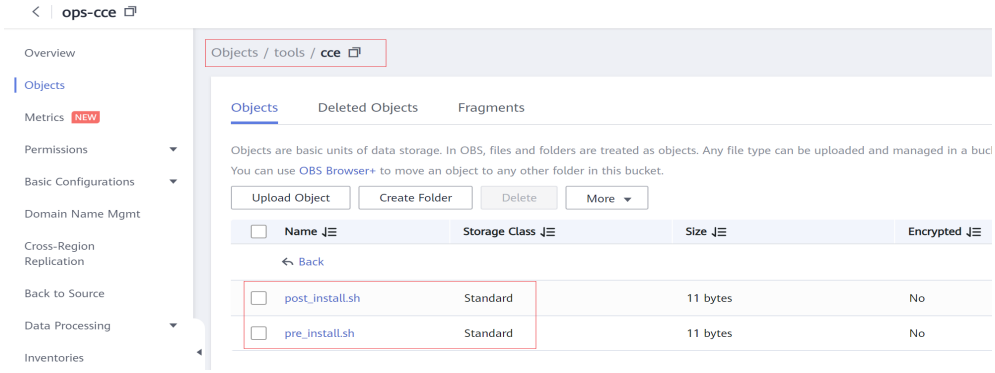
- If the custom operation implemented by the script fails, the normal service running is affected. You are advised to add a check program at the end of the script. If the check fails, stop the kubelet process in the post-installation script to prevent services from being scheduled to the node.
```
systemctl stop kubelet-monit
systemctl stop kubelet
```
- Do not include sensitive information in the scripts to prevent information leakage.

Procedure

Step 1 Create an OBS bucket.

Step 2 Upload the pre-installation and post-installation scripts. The **pre_install.sh** and **post_install.sh** scripts are used as examples.

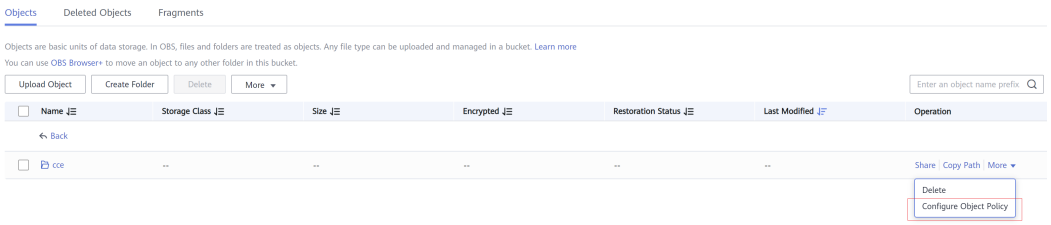
Figure 9-7 Uploading scripts



Step 3 Configure a read-only security policy for the scripts to ensure that the scripts can be downloaded without entering a password on the CCE nodes but cannot be downloaded from the Internet.

1. Configure a policy for the **tools/cce** directory and select a read-only policy template.

   Figure 9-8 Configuring an object policy



2. Modify the configuration information about the anonymous user, specified objects, and conditions.

   Figure 9-9 Anonymous user

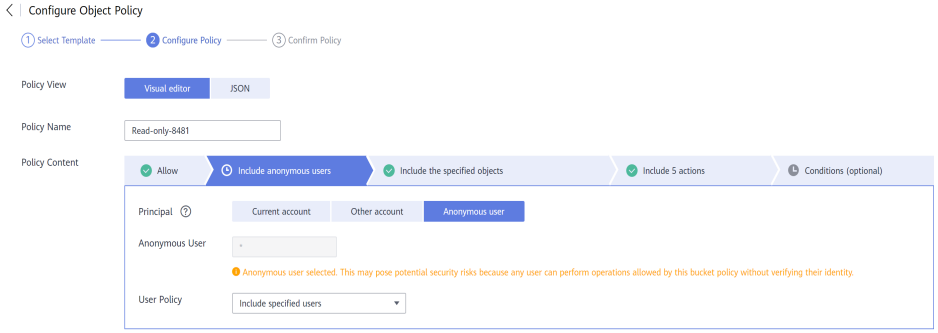


Figure 9-10 Specified objects

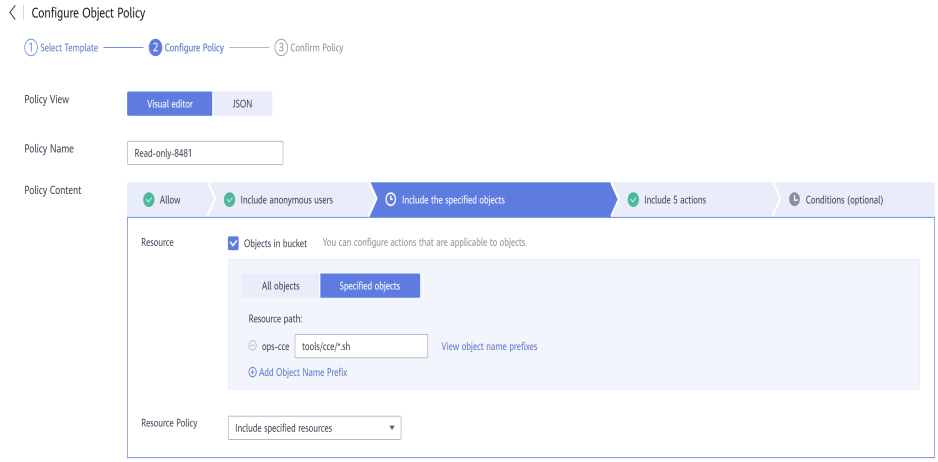
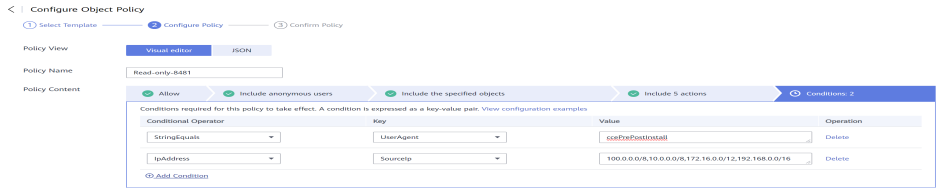


Figure 9-11 Conditions



Two conditions are set: **UserAgent** and **SourceIp**.

- **UserAgent** functions in the similar way as a key. The specified User-Agent request header and the corresponding key value must be carried during access.
- **SourceIp** is used to prevent access from external networks. Set this parameter to **100.0.0.0/8,10.0.0.0/8,172.16.0.0/12,192.168.0.0/16,214.0.0.0/8**, among which **100.0.0.0/8** and **214.0.0.0/8** are private IP ranges, among whom **10.0.0.0/8**, **172.16.0.0/12**, and **192.168.0.0/16** are commonly used.

For details about how to configure an OBS policy, see **Configuring an Object Policy** and **Bucket Policy Parameters**.

Step 4 Configure the pre-installation script and post-installation script when creating a node pool on CCE.

Enter the following scripts in the **Advanced ECS Settings** on the **Create Node Pool** page:

In the scripts below, the **curl** command is run to download **pre_install.sh** and **post_install.sh** from OBS to the **/tmp** directory, and then **pre_install.sh** and **post_install.sh** are executed.

Pre-installation script:

```
curl -H "User-Agent: ccePrePostInstall" https://ops-cce.obs.ap-southeast-1.myhuaweicloud.com/tools/cce/pre_install.sh -o  /tmp/pre_install.sh && bash -x /tmp/pre_install.sh > /tmp/pre_install.log 2>&1
```

Post-installation script:

```
curl -H "User-Agent: ccePrePostInstall" https://ops-cce.obs.ap-southeast-1.myhuaweicloud.com/tools/cce/post_install.sh -o  /tmp/post_install.sh && bash -x /tmp/post_install.sh > /tmp/post_install.log 2>&1
```

NOTE

- The actual value of **User-Agent** must be configured based on the OBS bucket policy.
- The bucket address in the link must be configured based on site requirements.

----End

9.6 Connecting to Multiple Clusters Using kubectl

Background

The kubectl command line tool relies on the kubeconfig configuration file to locate the necessary authentication information to select a cluster and communicate with its API server. By default, kubectl uses the **$HOME/.kube/config** file as the credential for accessing the cluster.

When working with CCE clusters on a daily basis, it is common to manage multiple clusters simultaneously. However, this can make using the kubectl command line tool to connect to clusters cumbersome, as it requires frequent switching of the kubeconfig file during routine O&M. This section introduces how to connect to multiple clusters using the same kubectl client.

NOTE

The file used to configure cluster access is called the kubeconfig file, but it does not mean that the file name is **kubeconfig**.

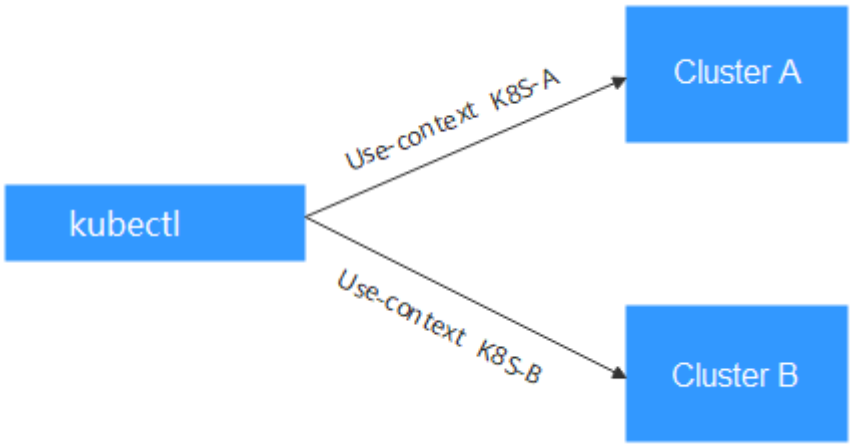
Solution

When performing O&M on Kubernetes clusters, it is often necessary to switch between multiple clusters. The following shows some typical solutions for cluster switchover:

- **Solution 1**: Specify **--kubeconfig** of kubectl to select the kubeconfig file used by each cluster and use aliases to simplify commands.
- **Solution 2**: Combine clusters, users, and credentials in multiple kubeconfig files into one configuration file and run **kubectl config use-context** to switch clusters.

  Compared with solution 1, this solution requires manual configuration of the kubeconfig file, which is relatively complex.

Figure 9-12 Using kubectl to connect to multiple clusters

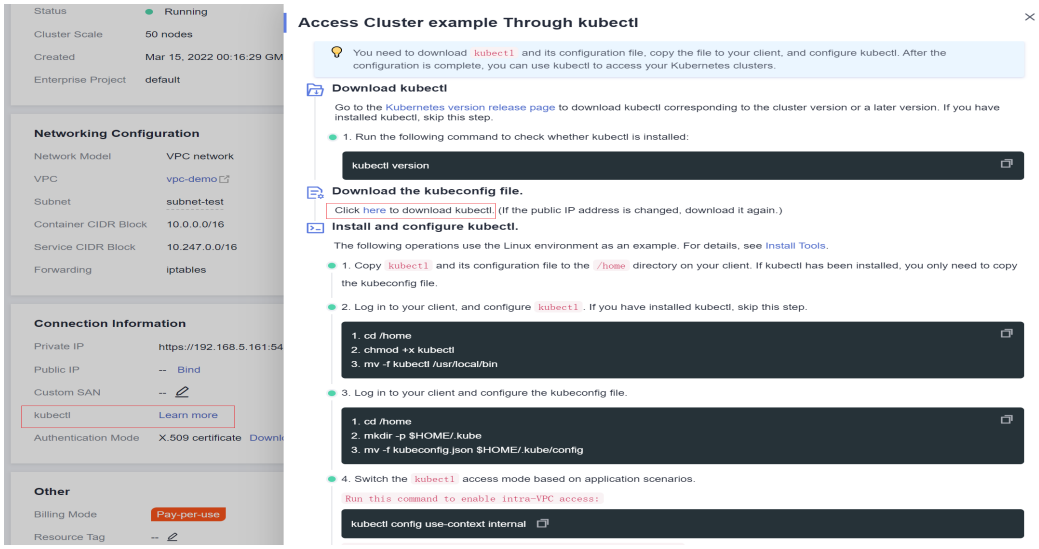


Prerequisites

- You have a Linux VM with the kubectl command line tool installed. The kubectl version must match the cluster version. For details, see **Install Tools**.
- The VM where kubectl is installed must be able to access the network of each cluster.

kubeconfig File Structure

kubeconfig is the configuration file of kubectl. You can download it on the cluster details page.



The content of the kubeconfig file is as follows:

```
{
    "kind": "Config",
    "apiVersion": "v1",
    "preferences": {},
    "clusters": [{
        "name": "internalCluster",
        "cluster": {
            "server": "https://192.168.0.85:5443",
```



```
            "certificate-authority-data": "LS0tLS1CRUULIE..."
        }
    }, {
        "name": "externalCluster",
        "cluster": {
            "server": "https://xxx.xxx.xxx.xxx:5443",
            "insecure-skip-tls-verify": true
        }
    }],
    "users": [{
        "name": "user",
        "user": {
            "client-certificate-data": "LS0tLS1CRUdJTiBDRVJ...",
            "client-key-data": "LS0tLS1CRUdJTiBS..."
        }
    }],
    "contexts": [{
        "name": "internal",
        "context": {
            "cluster": "internalCluster",
            "user": "user"
        }
    }, {
        "name": "external",
        "context": {
            "cluster": "externalCluster",
            "user": "user"
        }
    }],
    "current-context": "external"
}
```

It mainly consists of three sections.

- **clusters**: describes the cluster information, mainly the access address of the cluster.
- **users**: describes information about the users who access the cluster. It includes the **client-certificate-data** and **client-key-data** certificate files.
- **contexts**: describes the configuration contexts. You switch between contexts to access different clusters. A context is associated with **user** and **cluster**, that is, it defines which user accesses which cluster.

The preceding kubeconfig defines the private network address and public network address of the cluster as two clusters with two different contexts. You can switch the context to use different addresses to access the cluster.

Solution 1: Specify Different kubeconfig Files in Commands

Step 1 Log in to the VM where kubectl is installed.

Step 2 Download the kubeconfig files of the two clusters to the **/home** directory on the kubectl client. The following names are taken as examples.

Cluster Name	kubeconfig File Name
Cluster A	kubeconfig-a.json
Cluster B	kubeconfig-b.json

Step 3 Make kubectl access cluster A by default and move the **kubeconfig-a.json** file to **$HOME/.kube/config**.


```
cd /home
mkdir -p $HOME/.kube
mv -f kubeconfig-a.json $HOME/.kube/config
```

Step 4 Move the **kubeconfig-b.json** file of cluster B to **$HOME/.kube/config-test**.

```
mv -f kubeconfig-b.json $HOME/.kube/config-test
```

The name of the **config-test** file can be customized.

Step 5 Add **--kubeconfig** to specify the credential used by the kubectl commands when accessing cluster B. (There is no need to add **--kubeconfig** when running kubectl commands to access cluster A, because kubectl can access cluster A by default.) For example, run the following command to check the nodes in cluster B:

```
kubectl --kubeconfig=$HOME/.kube/config-test get node
```

If you frequently use a long command, the preceding method can be inconvenient. To simplify the command, you can use aliases. For example:

```
alias ka='kubectl --kubeconfig=$HOME/.kube/config'
alias kb='kubectl --kubeconfig=$HOME/.kube/config-test'
```

In the preceding information, **ka** and **kb** can be custom aliases. When running the kubectl command, you can directly enter **ka** or **kb** to replace **kubectl**. The **--kubeconfig** parameter is automatically added. For example, the command for checking nodes in cluster B can be simplified as follows:

```
kb get node
```

----End

Solution 2: Combine the kubeconfig Files of the Two Clusters Together

The following steps walk you through the procedure of modifying the kubeconfig files and accessing multiple clusters.

This example configures only the public network access to the clusters. If you want to access multiple clusters over private networks, retain the **clusters** field and ensure that the clusters can be accessed over private networks. Its configuration is similar to that described in this example.

Step 1 Download the kubeconfig files of the two clusters and delete the lines related to private network access, as shown in the following figure.

- Cluster A:

```
{
    "kind": "Config",
    "apiVersion": "v1",
    "preferences": {},
    "clusters": [ {
        "name": "externalCluster",
        "cluster": {
            "server": "https://119.xxx.xxx.xxx:5443",
            "insecure-skip-tls-verify": true
        }
    }],
    "users": [{
        "name": "user",
        "user": {
            "client-certificate-data": "LS0tLS1CRUdJTxM...",
            "client-key-data": "LS0tLS1CRUdJTiB...."
        }
    }],
    "contexts": [{
        "name": "external",
```

```
        "context": {
            "cluster": "externalCluster",
            "user": "user"
        }
    }],
    "current-context": "external"
}
```

- Cluster B:

```
{
    "kind": "Config",
    "apiVersion": "v1",
    "preferences": {},
    "clusters": [ {
        "name": "externalCluster",
        "cluster": {
            "server": "https://124.xxx.xxx.xxx:5443",
            "insecure-skip-tls-verify": true
        }
    }],
    "users": [{
        "name": "user",
        "user": {
            "client-certificate-data": "LS0tLS1CRUdJTxM...",
            "client-key-data": "LS0rTUideUdJTiB...."
        }
    }],
    "contexts": [{
        "name": "external",
        "context": {
            "cluster": "externalCluster",
            "user": "user"
        }
    }],
    "current-context": "external"
}
```

The preceding files have the same structure except that the **client-certificate-data** and **client-key-data** fields of **user** and the **clusters.cluster.server** field are different.

Step 2 Modify the **name** field as follows:

- Cluster A:

```
{
    "kind": "Config",
    "apiVersion": "v1",
    "preferences": {},
    "clusters": [ {
        "name": "Cluster-A",
        "cluster": {
            "server": "https://119.xxx.xxx.xxx:5443",
            "insecure-skip-tls-verify": true
        }
    }],
    "users": [{
        "name": "Cluster-A-user",
        "user": {
            "client-certificate-data": "LS0tLS1CRUdJTxM...",
            "client-key-data": "LS0tLS1CRUdJTiB...."
        }
    }],
    "contexts": [{
        "name": "Cluster-A-Context",
        "context": {
            "cluster": "Cluster-A",
            "user": "Cluster-A-user"
        }
    }],
```



```
    "current-context": "Cluster-A-Context"
}
```

- Cluster B:

```
{
    "kind": "Config",
    "apiVersion": "v1",
    "preferences": {},
    "clusters": [ {
        "name": "Cluster-B",
        "cluster": {
            "server": "https://124.xxx.xxx.xxx:5443",
            "insecure-skip-tls-verify": true
        }
    }],
    "users": [{
        "name": "Cluster-B-user",
        "user": {
            "client-certificate-data": "LS0tLS1CRUdJTxM...",
            "client-key-data": "LS0rTUideUdJTiB...."
        }
    }],
    "contexts": [{
        "name": "Cluster-B-Context",
        "context": {
            "cluster": "Cluster-B",
            "user": "Cluster-B-user"
        }
    }],
    "current-context": "Cluster-B-Context"
}
```

Step 3 Combine these two files.

The file structure remains unchanged. Combine the contents of **clusters**, **users**, and **contexts** as follows:

```
{
    "kind": "Config",
    "apiVersion": "v1",
    "preferences": {},
    "clusters": [ {
        "name": "Cluster-A",
        "cluster": {
            "server": "https://119.xxx.xxx.xxx:5443",
            "insecure-skip-tls-verify": true
        }
    },
     {
        "name": "Cluster-B",
        "cluster": {
            "server": "https://124.xxx.xxx.xxx:5443",
            "insecure-skip-tls-verify": true
        }
    }],
    "users": [{
        "name": "Cluster-A-user",
        "user": {
            "client-certificate-data": "LS0tLS1CRUdJTxM...",
            "client-key-data": "LS0tLS1CRUdJTiB...."
        }
    },
    {
        "name": "Cluster-B-user",
        "user": {
            "client-certificate-data": "LS0tLS1CRUdJTxM...",
            "client-key-data": "LS0rTUideUdJTiB...."
        }
    }],
    "contexts": [{
```

```
        "name": "Cluster-A-Context",
        "context": {
            "cluster": "Cluster-A",
            "user": "Cluster-A-user"
        }
    },
    {
        "name": "Cluster-B-Context",
        "context": {
            "cluster": "Cluster-B",
            "user": "Cluster-B-user"
        }
    }],
    "current-context": "Cluster-A-Context"
}
```

Step 4 Run the following command to copy the combined file to the kubectl configuration path:

mkdir -p $HOME/.kube

mv -f kubeconfig.json $HOME/.kube/config

Step 5 Run the kubectl command to check whether the two clusters can be accessed.

```
# kubectl config use-context Cluster-A-Context
Switched to context "Cluster-A-Context".
# kubectl cluster-info
Kubernetes control plane is running at https://119.xxx.xxx.xxx:5443
CoreDNS is running at https://119.xxx.xxx.xxx:5443/api/v1/namespaces/kube-system/services/coredns:dns/proxy

To further debug and diagnose cluster problems, use 'kubectl cluster-info dump'.

# kubectl config use-context Cluster-B-Context
Switched to context "Cluster-B-Context".
# kubectl cluster-info
Kubernetes control plane is running at https://124.xxx.xxx.xxx:5443
CoreDNS is running at https://124.xxx.xxx.xxx:5443/api/v1/namespaces/kube-system/services/coredns:dns/proxy

To further debug and diagnose cluster problems, use 'kubectl cluster-info dump'.
```

If you frequently use a long command, the preceding method can be inconvenient. To simplify the command, you can use aliases. For example:

```
alias ka='kubectl config use-context Cluster-A-Context;kubectl'
alias kb='kubectl config use-context Cluster-B-Context;kubectl'
```

In the preceding information, **ka** and **kb** can be custom aliases. When running the kubectl command, you can directly enter **ka** or **kb** to replace **kubectl**. You need to switch the context and then run the kubectl command. For example:

```
# ka cluster-info
Switched to context "Cluster-A-Context".
Kubernetes control plane is running at https://119.xxx.xxx.xxx:5443
CoreDNS is running at https://119.xxx.xxx.xxx:5443/api/v1/namespaces/kube-system/services/coredns:dns/proxy

To further debug and diagnose cluster problems, use 'kubectl cluster-info dump'.
```

----End

9.7 Selecting a Data Disk for the Node

When a node is created, a data disk is attached by default for a container runtime and kubelet. For details, see **Data Disk Space Allocation**. The data disk used by

the container runtime and kubelet cannot be detached, and the default capacity is 100 GiB. To cut costs, you can adjust the disk capacity to the minimum of 20 GiB or reduce the disk capacity attached to a node to the minimum of 10 GiB.

NOTICE

Adjusting the size of the data disk used by the container runtime and kubelet may incur risks. You are advised to evaluate the capacity adjustment and then perform the operations described in this section.

- If the disk capacity is too small, the image pull may fail. If different images need to be frequently pulled on the node, you are not advised to reduce the data disk capacity.
- Before a cluster upgrade, the system checks whether the data disk usage exceeds 95%. If the usage is high, the cluster upgrade may be affected.
- If Device Mapper is used, the disk capacity may be insufficient. You are advised to use the OverlayFS or select a large-capacity data disk.
- For dumping logs, application logs must be stored in a separate disk to prevent insufficient storage capacity of the dockersys volume from affecting service running.
- After reducing the data disk capacity, you are advised to install the npd add-on in the cluster to detect disk usage. If the disk usage of a node is high, resolve this problem by referring to **What If the Data Disk Capacity Is Insufficient?**

Constraints

- Only clusters of v1.19 or later allow reducing the capacity of the data disk used by container runtimes and kubelet.
- Only the EVS disk capacity can be adjusted. (Local disks are available only when the node specification is **disk-intensive** or **Ultra-high I/O**.)

Selecting a Data Disk

When selecting a data disk, consider the following factors:

- During image pull, the system downloads the image package (the .tar package) from the image repository, and decompresses the package. Then it deletes the package but retain the image file. During the decompression of the .tar package, the package and the decompressed image file coexist. Reserve the capacity for the decompressed files.
- Mandatory add-ons (such as everest and coredns) may be deployed on nodes during cluster creation. When calculating the data disk size, reserve about 2 GiB storage capacity for them.
- Logs are generated during application running. To ensure stable application running, reserve about 1 GiB storage capacity for each pod.

For details about the calculation formulas, see **OverlayFS** and **Device Mapper**.

OverlayFS

By default, the container engine and container image storage capacity of a node using the OverlayFS storage driver occupies 90% of the data disk capacity (you

are advised to retain this value). All the 90% storage capacity is used for dockersys partitioning. The calculation methods are as follows:

- Capacity for storing container engines and container images requires 90% of the data disk capacity by default.
  - Capacity for dockersys volume (in the **/var/lib/docker** directory) requires 90% of the data disk capacity. The entire container engine and container image capacity (need 90% of the data disk capacity by default) are in the **/var/lib/docker** directory.
- Capacity for storing temporary kubelet and emptyDir requires 10% of the data disk capacity.

On a node using the OverlayFS, when an image is pulled, the .tar package is decompressed after being downloaded. During this process, the .tar package and the decompressed image file are stored in the dockersys volume, occupying about twice the actual image storage capacity. After the decompression is complete, the .tar package is deleted. Therefore, during image pull, after deducting the storage capacity occupied by the system add-on images, ensure that the remaining capacity of the dockersys volume is greater than twice the actual image storage capacity. To ensure that the containers can run stably, reserve certain capacity in the dockersys volume for container logs and other related files.

When selecting a data disk, consider the following formula:

Capacity of dockersys volume > Actual total image storage capacity x 2 + Total system add-on image storage capacity (about 2 GiB) + Number of containers x Available storage capacity for a single container (about 1 GiB log storage capacity for each container)

NOTE

If container logs are output in the **json.log** format, they will occupy some capacity in the dockersys volume. If container logs are stored on persistent storage, they will not occupy capacity in the dockersys volume. Estimate the capacity of every container as required.

Example:

Assume that the node uses the OverlayFS and the data disk attached to this node is 20 GiB. According to **the preceding methods**, the capacity for storing container engines and images occupies 90% of the data disk capacity, and the capacity for the dockersys volume is 18 GiB (20 GiB x 90%). Additionally, mandatory add-ons may occupy about 2 GiB storage capacity during cluster creation. If you deploy a .tar package of 10 GiB, the package decompression takes 20 GiB of the dockersys volume's storage capacity. This, coupled with the storage capacity occupied by mandatory add-ons, exceeds the remaining capacity of the dockersys volume. As a result, the image pull may fail.

Device Mapper

By default, the capacity for storing container engines and container images of a node using the Device Mapper storage driver occupies 90% of the data disk capacity (you are advised to retain this value). The occupied capacity includes the dockersys volume and thinpool volume. The calculation methods are as follows:

- Capacity for storing container engines and container images requires 90% of the data disk capacity by default.

  - Capacity for the dockersys volume (in the **/var/lib/docker** directory) requires 20% of the capacity for storing container engines and container images.
  - Capacity for the thinpool volume requires 80% of the container engine and container image storage capacity.
- Capacity for storing temporary kubelet and emptyDir requires 10% of the data disk capacity.

On a node using the Device Mapper storage driver, when an image is pulled, the .tar package is temporarily stored in the dockersys volume. After the .tar package is decompressed, the image file is stored in the thinpool volume, and the package in the dockersys volume will be deleted. Therefore, during image pull, ensure that the dockersys partition space and thinpool space are sufficient, and note that the former is smaller than the latter. To ensure that the containers can run stably, reserve certain capacity in the dockersys volume for container logs and other related files.

When selecting a data disk, consider the following formulas:

- **Capacity for dockersys volume > Temporary storage capacity of the .tar package (approximately equal to the actual total image storage capacity) + Number of containers x Storage capacity of a single container (about 1 GiB log storage capacity must be reserved for each container)**
- **Capacity for thinpool volume > Actual total image storage capacity + Total add-on image storage capacity (about 2 GiB)**

NOTE

If container logs are output in the **json.log** format, they will occupy some capacity in the dockersys volume. If container logs are stored on persistent storage, they will not occupy capacity in the dockersys volume. Estimate the capacity of every container as required.

Example:

Assume that the node uses the Device Mapper and the data disk attached to this node is 20 GiB. According to **the preceding methods**, the container engine and image storage capacity occupies 90% of the data disk capacity, and the disk usage of the dockersys volume is 3.6 GiB. Additionally, the storage capacity of the mandatory add-ons may occupy about 2 GiB of the dockersys volume during cluster creation. The remaining storage capacity is about 1.6 GiB. If you deploy a .tar image package larger than 1.6 GiB, the storage capacity of the dockersys volume is insufficient for the package to be decompressed. As a result, the image pull may fail.

What If the Data Disk Capacity Is Insufficient?

Solution 1: Clearing images

Perform the following operations to clear unused images:

- Nodes that use containerd
  a. Obtain local images on the node.
  ```
  crictl images -v
  ```
  b. Delete the images that are not required by image ID.
  ```
  crictl rmi Image ID
  ```


- Nodes that use Docker

  a. Obtain local images on the node.
  ```
  docker images
  ```

  b. Delete the images that are not required by image ID.
  ```
  docker rmi Image ID
  ```

  NOTE

  Do not delete system images such as the cce-pause image. Otherwise, pods may fail to be created.

Solution 2: Expanding the disk capacity

Step 1 Expand the capacity of a data disk on the EVS console. For details, see **Expanding EVS Disk Capacity**.

Only the storage capacity of the EVS disk is expanded. You also need to perform the following steps to expand the capacity of the logical volume and file system.

Step 2 Log in to the CCE console and click the cluster. In the navigation pane, choose **Nodes**. Click **More** > **Sync Server Data** in the row containing the target node.

Step 3 Log in to the target node.

Step 4 Run the **lsblk** command to check the block device information of the node.

A data disk is divided depending on the container storage **Rootfs**:

Overlayfs: No independent thin pool is allocated. Image data is stored in **dockersys**.

1. Check the disk and partition sizes of the device.
```
# lsblk
NAME              MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
sda               8:0    0   50G  0 disk
└─sda1            8:1    0   50G  0 part /
sdb               8:16   0  150G  0 disk      # The data disk has been expanded to 150 GiB, but 50 GiB space is not allocated.
├─vgpaas-dockersys 253:0    0   90G  0 lvm   /var/lib/containerd
└─vgpaas-kubernetes 253:1    0   10G  0 lvm   /mnt/paas/kubernetes/kubelet
```
2. Expand the disk capacity.

   Add the new disk capacity to the **dockersys** logical volume used by the container engine.

   a. Expand the PV capacity so that LVM can identify the new EVS capacity. */dev/sdb* specifies the physical volume where dockersys is located.
   ```
   pvresize /dev/sdb
   ```

   Information similar to the following is displayed:

   ```
   Physical volume "/dev/sdb" changed
   1 physical volume(s) resized or updated / 0 physical volume(s) not resized
   ```

   b. Expand 100% of the free capacity to the logical volume. *vgpaas/dockersys* specifies the logical volume used by the container engine.
   ```
   lvextend -l+100%FREE -n vgpaas/dockersys
   ```

   Information similar to the following is displayed:

   ```
   Size of logical volume vgpaas/dockersys changed from <90.00 GiB (23039 extents) to 140.00 GiB (35840 extents).
   Logical volume vgpaas/dockersys successfully resized.
   ```


c. Adjust the size of the file system. */dev/vgpaas/dockersys* specifies the file system path of the container engine.

```
resize2fs /dev/vgpaas/dockersys
```

Information similar to the following is displayed:

```
Filesystem at /dev/vgpaas/dockersys is mounted on /var/lib/containerd; on-line resizing required
old_desc_blocks = 12, new_desc_blocks = 18
The filesystem on /dev/vgpaas/dockersys is now 36700160 blocks long.
```

3. Check whether the capacity is expanded.

```
# lsblk
NAME              MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
sda               8:0    0   50G  0 disk
└─sda1              8:1    0   50G  0 part /
sdb               8:16   0  150G  0 disk
├─vgpaas-dockersys 253:0    0   140G  0 lvm  /var/lib/containerd
└─vgpaas-kubernetes 253:1    0   10G  0 lvm  /mnt/paas/kubernetes/kubelet
```

Devicemapper: A thin pool is allocated to store image data.

1. Check the disk and partition sizes of the device.

```
# lsblk
NAME                        MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
vda                         8:0    0   50G  0 disk
└─vda1                        8:1    0   50G  0 part /
vdb                         8:16   0  200G  0 disk
├─vgpaas-dockersys            253:0    0   18G  0 lvm  /var/lib/docker
├─vgpaas-thinpool_tmeta         253:1    0    3G  0 lvm
│ └─vgpaas-thinpool           253:3    0   67G  0 lvm              # Space used by thinpool
│   ...
├─vgpaas-thinpool_tdata         253:2    0   67G  0 lvm
│ └─vgpaas-thinpool           253:3    0   67G  0 lvm
│   ...
└─vgpaas-kubernetes           253:4    0   10G  0 lvm  /mnt/paas/kubernetes/kubelet
```

2. Expand the disk capacity.

Option 1: Add the new disk capacity to the thin pool disk.

a. Expand the PV capacity so that LVM can identify the new EVS capacity. */dev/vdb* specifies the physical volume where thinpool is located.

```
pvresize /dev/vdb
```

Information similar to the following is displayed:

```
Physical volume "/dev/vdb" changed
1 physical volume(s) resized or updated / 0 physical volume(s) not resized
```

b. Expand 100% of the free capacity to the logical volume. *vgpaas/thinpool* specifies the logical volume used by the container engine.

```
lvextend -l+100%FREE -n vgpaas/thinpool
```

Information similar to the following is displayed:

```
Size of logical volume vgpaas/thinpool changed from <67.00 GiB (23039 extents) to <167.00
GiB (48639 extents).
Logical volume vgpaas/thinpool successfully resized.
```

c. Do not need to adjust the size of the file system, because the thin pool is not mounted to any devices.

d. Check whether the capacity is expanded. Run the **lsblk** command to check the disk and partition sizes of the device. If the new disk capacity has been added to the thin pool, the capacity is expanded.

```
# lsblk
NAME                        MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
vda                         8:0    0   50G  0 disk
└─vda1                        8:1    0   50G  0 part /
vdb                         8:16   0  200G  0 disk
├─vgpaas-dockersys            253:0    0   18G  0 lvm  /var/lib/docker
├─vgpaas-thinpool_tmeta         253:1    0    3G  0 lvm
```



```
│ └─vgpaas-thinpool              253:3    0   167G  0 lvm           # Thin pool space after
capacity expansion
│   ...
├─vgpaas-thinpool_tdata          253:2    0    67G  0 lvm
│ └─vgpaas-thinpool              253:3    0    67G  0 lvm
│   ...
└─vgpaas-kubernetes              253:4    0    10G  0 lvm  /mnt/paas/kubernetes/kubelet
```

Option 2: Add the new disk capacity to the **dockersys** disk.

a. Expand the PV capacity so that LVM can identify the new EVS capacity. */dev/vdb* specifies the physical volume where dockersys is located.

```
pvresize /dev/vdb
```

Information similar to the following is displayed:

```
Physical volume "/dev/vdb" changed
1 physical volume(s) resized or updated / 0 physical volume(s) not resized
```

b. Expand 100% of the free capacity to the logical volume. *vgpaas/dockersys* specifies the logical volume used by the container engine.

```
lvextend -l+100%FREE -n vgpaas/dockersys
```

Information similar to the following is displayed:

```
Size of logical volume vgpaas/dockersys changed from <18.00 GiB (4607 extents) to <118.00
GiB (30208 extents).
Logical volume vgpaas/dockersys successfully resized.
```

c. Adjust the size of the file system. */dev/vgpaas/dockersys* specifies the file system path of the container engine.

```
resize2fs /dev/vgpaas/dockersys
```

Information similar to the following is displayed:

```
Filesystem at /dev/vgpaas/dockersys is mounted on /var/lib/docker; on-line resizing required
old_desc_blocks = 3, new_desc_blocks = 15
The filesystem on /dev/vgpaas/dockersys is now 30932992 blocks long.
```

d. Check whether the capacity is expanded. Run the **lsblk** command to check the disk and partition sizes of the device. If the new disk capacity has been added to the dockersys, the capacity is expanded.

```
# lsblk
NAME                      MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
vda                       8:0    0   50G  0 disk
└─vda1                      8:1    0   50G  0 part /
vdb                       8:16   0  200G  0 disk
├─vgpaas-dockersys              253:0    0   118G  0 lvm  /var/lib/docker     # dockersys after
capacity expansion
├─vgpaas-thinpool_tmeta           253:1    0    3G  0 lvm
│ └─vgpaas-thinpool               253:3    0   67G  0 lvm
│   ...
├─vgpaas-thinpool_tdata           253:2    0   67G  0 lvm
│ └─vgpaas-thinpool               253:3    0   67G  0 lvm
│   ...
└─vgpaas-kubernetes               253:4    0   10G  0 lvm  /mnt/paas/kubernetes/kubelet
```

----End

9.8 Implementing Cost Visualization for a CCE Cluster

Background

The billing information of CCE is displayed based on the entire service by default. The costs of different clusters are not shown.

Solution

Add the **CCE-Cluster-ID** tag to the resources used in the clusters, obtain the costs by searching for this tag in cost center, and then analyze the costs by cluster to improve efficiency and cut costs.

Constraints

Generally, tags appear on the **Cost Tags** page 24 hours after resource expenditures are generated.

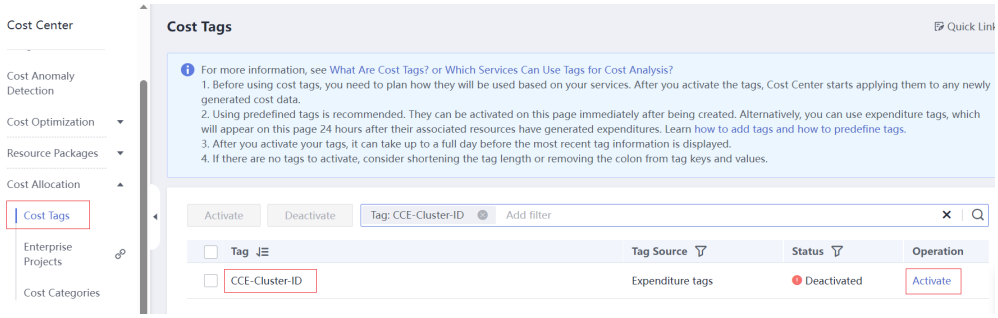
You can filter or group cost data by tag only after the tags are activated. If you activate the tags, they will be used to organize your resource costs generated thereafter.

Procedure

Step 1 Activate the **CCE-Cluster-ID** tag.

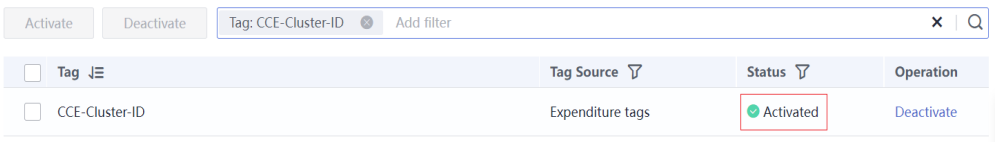
In **Cost Center**, choose **Cost Allocation** > **Cost Tags** in the navigation pane. Select **Tag** from the drop-down list for the filter criteria, search for **CCE-Cluster-ID**, and click **Activate** in the **Operation** column.

Figure 9-13 Activating the cost tag



The following information will be displayed.

Figure 9-14 Activation succeeded

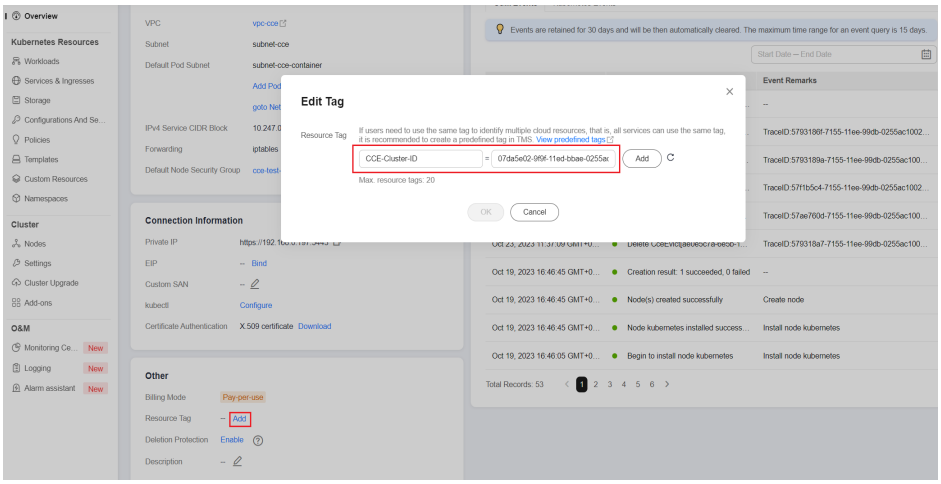


Step 2 Add the tag to resources used in a cluster.

Resources used in a cluster include master nodes, worker nodes, storage resources (such as EVS disks, SFS file systems, and OBS buckets), and network resources (such as load balancers and EIPs). By default, the **CCE-Cluster-ID** tag is added to the worker nodes.

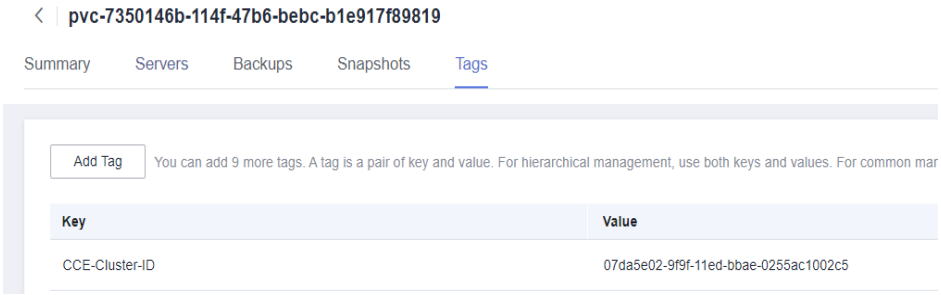
- Add the tag to a cluster.

On the CCE console, click the name of the target cluster to access the cluster console. On the **Cluster Information** page, add the resource tag in the **Other** area.



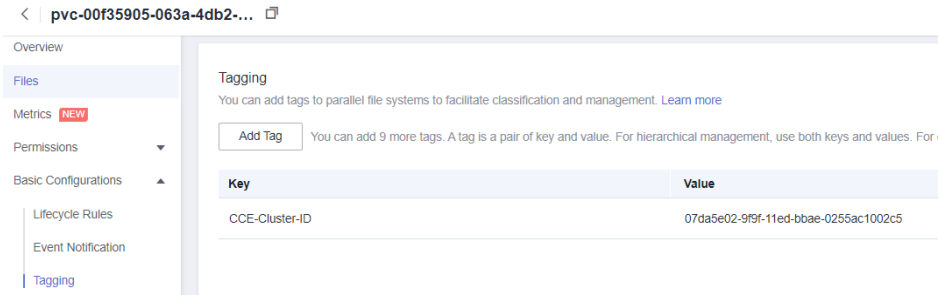
- Add the tag to an EVS disk.

  On the EVS console, click the name of the target disk to go to the details page. On the **Tags** tab, add a tag.



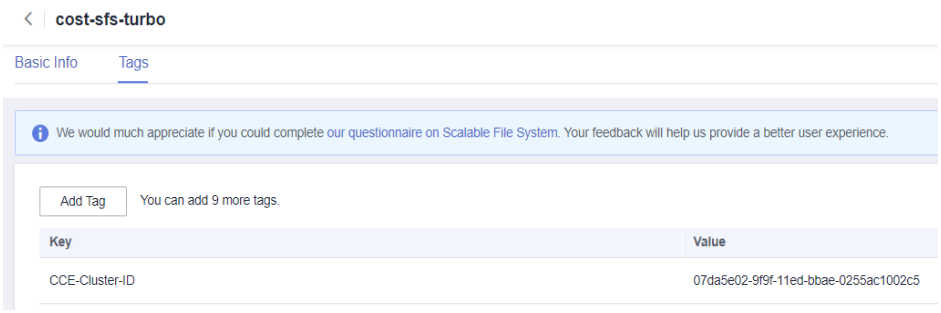
- Add the tag to an OBS bucket.

  On the OBS console, click the name of the target bucket to go to the details page. Choose **Basic Configurations** > **Tagging** and add a tag.



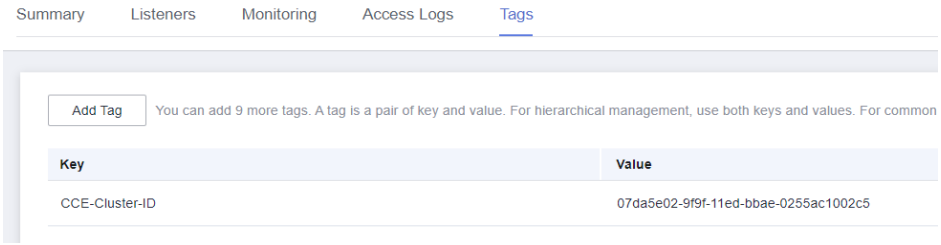
- Add the tag to an SFS Turbo file system.

  On the SFS console, click the name of the target SFS Turbo file system to go to the details page. On the page displayed, click the **Tags** tab and add a tag.



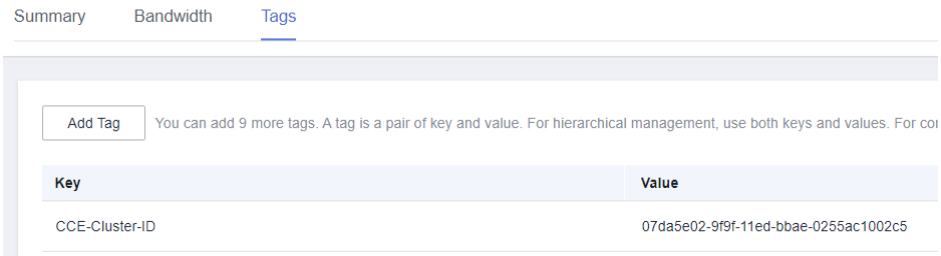
- Add the tag to a load balancer.

  On the ELB console, click the name of the target load balancer to go to the details page. On the page displayed, click the **Tags** tab and add a tag.



- Add the tag to an EIP.

  On the EIP console, click the name of the target EIP to go to the details page. Click the **Tags** tab and add a tag.



Step 3 Analyze the cluster's costs.

On the **Cost Analysis** page, choose **CCE-Cluster-ID** and the ID of the desired cluster from the drop-down list.

Figure 9-15 Analyzing costs

Click **OK**.

Figure 9-16 Viewing the cluster's costs

Service Type	Accrued Total	Forecasted Total **	Aug 2023
Total cost(¥)	53.08	--	53.08
Elastic Cloud Serve...	30.44	--	30.44
Scalable File Servic...	17.50	--	17.50
Elastic Volume Ser...	5.14	--	5.14
Virtual Private Clou...	0.00	--	0.00
Object Storage Ser...	0.00	--	0.00
Elastic Load Balanc...	0.00	--	0.00

----End

9.9 Creating a CCE Turbo Cluster Using a Shared VPC

Shared VPC Overview

A shared VPC allows you to share your VPC resources with other accounts through the Resource Access Manager (RAM) service. For example, tenant A can share its VPC and subnets with tenant B. After tenant B accepted the sharing, tenant B can view the shared subnets and the shared VPC to which the shared subnets belong. Tenant B can use the shared subnets and VPC to create resources, such as CCE Turbo clusters. For details, see **VPC Sharing Overview**.

Application Scenarios

An enterprise organizes accounts in an orderly and centralized manner based on its organization structure or service form. Resources are managed in a unified manner and shared with other members to avoid repeated configurations. Unified security and O&M management makes it easy to configure and audit security policies.

For example, an enterprise IT account, the resource owner, creates a VPC and subnets and shares multiple subnets with other accounts.

- Account A is an enterprise service account and uses the shared subnet 1 to create resources.
- Account B is an enterprise service account and uses the shared subnet 2 to create resources.

Constraints

- Only CCE Turbo clusters support shared VPCs.
- Clusters created using a shared VPC do not support shared load balancers and NAT gateways.

- Clusters created using a shared VPC do not support SFS, OBS, and SFS Turbo storage volumes.
- If a CCE Turbo cluster has been created using a shared VPC, the owner of the shared VPC should not turn off the VPC sharing. Otherwise, the CCE Turbo cluster will malfunction.

Procedure

After account A shares a VPC with account B, account B can select the shared VPC and shared subnets when creating a CCE Turbo cluster.

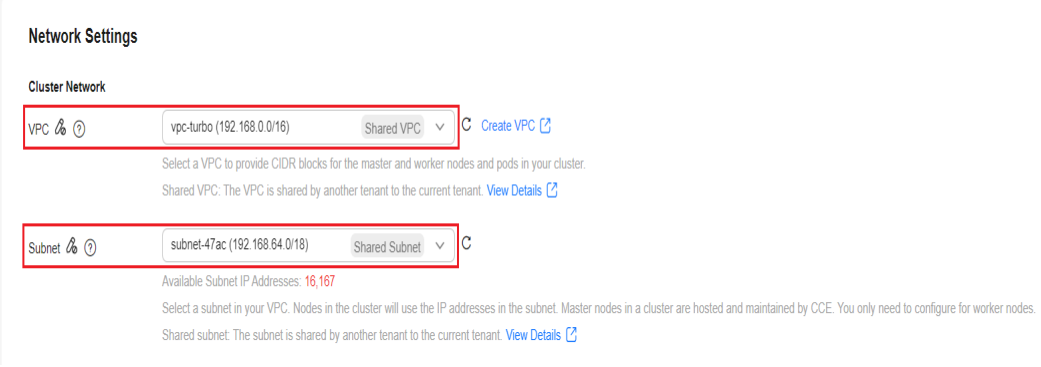
Step 1 (For account A) Use RAM to create a shared VPC and specify account B as the resource user. For details, see **Creating a Resource Share**.

After the resource sharing is created, RAM sends an invitation to account B. Account B can access and use the shared resources only after accepting the invitation.

Step 2 (For account B) Log in to the CCE console and create a CCE Turbo cluster.

Select the VPC shared by account A when configuring network for the cluster. For details about other configurations, see **Buying a CCE Cluster**.

Figure 9-17 Selecting a shared VPC



----End

9.10 Protecting a CCE Cluster Against Overload

As services grow, the Kubernetes cluster scales up, putting more pressure on the control plane. If the control plane cannot handle the load, clusters may fail to provide services. This document explains the symptoms, impact, and causes of cluster overload, as well as how CCE clusters can protect against overload. It also provides recommended measures for protecting against overload.

What Is Cluster Overload?

An overloaded cluster can cause delays in Kubernetes API responses and increase the resource usage on master nodes. In severe cases, the APIs may fail to respond, master nodes may become unusable, and the entire cluster may malfunction.

When a cluster is overloaded, both the control plane and the services that rely on it are impacted. The following lists some scenarios that may be affected:

- Kubernetes resource management: Creating, deleting, updating, or obtaining Kubernetes resources may fail.
- Kubernetes distributed leader selection: In distributed applications based on Kubernetes Leases, leaders may restart due to lease renewal request timeout.

  NOTE

  For example, if the lease renewal of the controller component of the NPD add-on fails, an active/standby switchover is triggered. This means that the active instance will restart, and the standby instance will take over services, ensuring that there is no impact on services.
- Cluster management: When a cluster is severely overloaded, it may become unavailable. In this case, cluster management operations, such as creating or deleting nodes, cannot be performed.

Common causes of cluster overload are as follows:

- The cluster resource data volume is too large.

  etcd and kube-apiserver are two core components of the cluster control plane. etcd serves as the background database that stores all cluster data, while kube-apiserver acts as the entry point for processing requests. kube-apiserver caches cluster data to lessen the burden on etcd, and other core components in the cluster also cache various resources and monitor changes to these resources.

  However, if the cluster resource data volume is too large, the control plane resource usage remains high, leading to overload when the resource data volume exceeds the bearing capability.
- A large amount of data is obtained from a client. For example, a large number of LIST requests are initiated or a single LIST request is sent to obtain a large amount of data.

  Assume that a client uses field selectors to obtain pod data in a cluster and needs to obtain data from etcd (although the client can also get data from the kube-apiserver cache). Data in etcd cannot be obtained by field, so kube-apiserver must get all pod data from etcd, replicate, and serialize structured pod data, and then respond to the client request.

  When the client sends a LIST request, it may need to be processed by multiple control plane components, resulting in a larger amount of data to be processed and a more complex data type. As a result, when the client gets a large amount of data, resource usages on etcd and API server remain high. If the bearing capability is exceeded, the cluster becomes overloaded.

CCE Overload Control

- **Overload control**: CCE clusters have supported overload control since v1.23, which reduces the number of LIST requests outside the system when the control plane experiences high resource usage pressure. To use this function, enable overload control for your clusters. For details, see **Enabling Overload Control for a Cluster**.
- **Optimized processes on LIST requests**: Starting from CCE clusters of v1.23.8-r0 and v1.25.3-r0, processes on LIST requests have been optimized. Even if a client does not specify the **resourceVersion** parameter, kube-apiserver responds to requests based on its cache to avoid additional etcd queries and ensure that the response data is up to date. Additionally, namespace indexes

are now added to the kube-apiserver cache. This means that when a client requests a specified resource in a specified namespace, it no longer needs to obtain resources belonging to the namespace based on full data. This effectively reduces the response delay and control plane memory overhead.

- **Refined traffic limiting policy on the server**: The API Priority and Fairness (APF) feature is used to implement fine-grained control on concurrent requests. For details, see **API Priority and Fairness**.

Suggestions

This section describes measures and suggestions you can take to prevent clusters from being overloaded.

Upgrading the Cluster Version

As the CCE cluster version evolves, new overload protection features and optimizations are regularly introduced. It is recommended that you promptly upgrade your clusters to the latest version. For details, see **Upgrading a Cluster**.

Enabling Overload Control

After overload control is enabled, concurrent LIST requests outside the system will be dynamically controlled based on the resource demands received by master nodes to ensure the stable running of the master nodes and the cluster.

For details, see **Cluster Overload Control**.

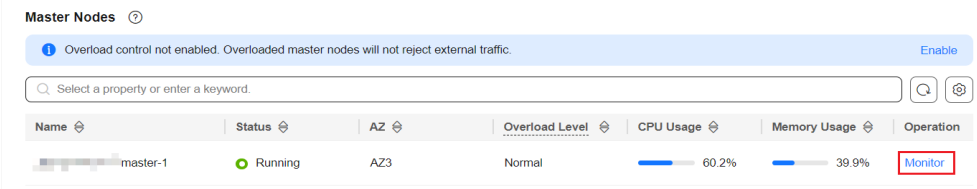
Enabling Observability

Observability is crucial for maintaining the reliability and stability of clusters. By using monitoring, alarms, and logs, administrators can gain a better understanding of the clusters' performance, promptly identify any issues, and take corrective action in a timely manner.

Monitoring configurations

- You can check the monitoring information about master nodes on the **Overview** page of the CCE cluster console.

  Figure 9-18 Viewing master node monitoring information

- You can also use Prometheus to monitor the metrics of master node components, especially the memory usage, resource quantity, QPS, and request latency of kube-apiserver. For details, see **Monitoring Metrics of Master Node Components Using Prometheus**.

Alarm configurations

Alarms are an additional feature of monitoring. Alarms are generated to administrators in a timely manner when a cluster experiences malfunctions,

allowing for prompt resolution of any issues. You can configure alarms for metrics such as memory usage, resource quantity, QPS, and request latency of kube-apisever as needed. For details, see **Configuring Custom Alarms on CCE**.

NOTE

Monitoring metrics such as resource quantity, QPS, and request latency do not have a fixed boundary between normal and abnormal metrics due to variations in service scenarios. As a result, these metrics are considered normal as long as they do not impact service stability. Typical alarm thresholds cannot be defined. To address this, you can observe metric data when services are running stably and configure appropriate alarm thresholds based on the normal fluctuation range of resource usage. Alternatively, you can use the changes of metric data in a unit of time as the alarm detection object.

Logging configurations

Kubernetes logs allow you to locate and rectify faults. The kube-apiserver component logs contain details about client requests, such as the request source, processing time, and reasons for any exceptions. These logs are useful for tracing the source of issues and analyzing problems related to overload. For details, see **Collecting Control Plane Component Logs**.

Controlling Data Volume of Resources

When the resource data volume in a cluster is too large, it can negatively impact etcd performance, including data read and write latency. Additionally, if the data volume of a single type of resource is too large, the control plane consumes a significant number of resources when a client requests all the resources. To avoid these issues, it is recommended that you keep both the etcd data volume and the data volume of a single type of resources under control.

Table 9-7 Recommended maximum etcd data volume for different cluster scales

Cluster Scale	50 Nodes	200 Nodes	1,000 Nodes	2,000 Nodes
Total etcd data capacity	500Mi	1Gi	4Gi	8Gi
etcd data volume of a single type of resources	50Mi	100Mi	400Mi	800Mi

Clearing Unused Resources

To prevent a large number of pending pods from consuming extra resources on the control plane, it is recommended that you promptly clear up Kubernetes resources that are no longer in use, such as ConfigMaps, Secrets, and PVCs.

Optimizing the Client Access Mode

- To avoid frequent LIST queries, it is best to use the client cache mechanism when retrieving cluster resource data multiple times. It is recommended that you communicate with clusters using informers and listers. For details, see **client-go documentation**.

If a LIST query must be used, you can:

- Obtain needed data from the kube-apiserver cache first and avoid making additional queries on etcd data. For clusters earlier than v1.23.8-r0 and v1.25.3-r0, you can set **resourceVersion** to **0**. In clusters of v1.23.8-r0, v1.25.3-r0, and later versions, CCE has improved the way data is retrieved and ensured that the cached data is up to date. By default, you can access the required data from the cache.
- Accurately define the query scope to avoid retrieving irrelevant data and using unnecessary resources. For example:

```
# client-go Code example for obtaining pods in a specified namespace
k8sClient.CoreV1().Pods("<your-namespace>").List(metav1.ListOptions{})
# kubectl Command example for obtaining pods in a specified namespace
kubectl get pods -n <your-namespace>
```

- Use the more efficient Protobuf format instead of the JSON format. By default, Kubernetes returns objects serialized to JSON with content type **application/json**. This is the default serialization format for the API. However, clients may request the more efficient Protobuf representation of these objects for better performance. For details, see **Alternate representations of resources**.

Changing the Cluster Scale

If the resource usage on the master nodes in a cluster remains high for a long time, for example, the memory usage is greater than 85%, it is recommended that you promptly increase the cluster management scale. This will prevent the cluster from becoming overloaded during sudden traffic surges. For details, see **Changing Cluster Scale**.

NOTE

- The performance of the master nodes improves and their specifications become higher as the management scale of a cluster increases.
- The CCE cluster management scale is the maximum number of nodes that a cluster can manage. It is used as a reference during service deployment planning, and the actual quantity of nodes in use may not reach the maximum number of nodes selected. The actual scale depends on various factors, including the type, quantity, and size of resource objects in the cluster, as well as the number of external accesses to the cluster control plane.

Splitting the Cluster

The Kubernetes architecture has a performance bottleneck, meaning that the scale of a single cluster cannot be expanded indefinitely. If your cluster has 2,000 worker nodes, it is necessary to split the services and deploy them across multiple clusters. If you encounter any issues with splitting a cluster, submit a service ticket for technical support.

Summary

When running services on Kubernetes clusters, their performance and availability are influenced by various factors, including the cluster scale, number and size of resources, and resource access. CCE has optimized cluster performance and availability based on cloud native practices and has developed measures to protect against cluster overload. You can use these measures to ensure that your services run stably and reliably over the long term.

9.11 Managing Costs for a Cluster

The key to optimizing cluster costs is to maximize the utilization of cluster resources and minimize unnecessary expenses. It is important to note that cost optimization goes beyond just reducing resources; it also involves finding a balance between cost optimization and cluster reliability. This section provides a summary of the best practices for cluster cost optimization, which will help you efficiently manage cluster expenses and enhance overall efficiency.

Using Appropriate Cluster Configurations

Before setting up a cluster, it is important to assess the resource needs of your applications. This will help you choose the appropriate cluster type, node instance type, and cluster billing mode, all of which can contribute to building a cost-effective cluster.

Selecting a Cluster Type

CCE provides many cluster types. You can select a proper one based on your service characteristics. The following table lists the differences between these clusters.

Category	CCE Standard	CCE Turbo	CCE Autopilot
Description	An enterprise-level container service on Kubernetes	Hardware-software synergy for extra performance	A Kubernetes-compatible serverless container service
Managed object	Clusters, nodes, and workloads	Clusters, nodes, and workloads	Fully hosted nodes
Cluster scale	On-demand adjustment	On-demand adjustment	Automatic adjustment
Node	Multiple flavors available, custom node creation or deletion	Multiple flavors available, custom node creation or deletion	Automatic, flexible node allocation for containers
Compute	Heterogeneous compute including x86, Arm, and NPUs	Heterogeneous compute including x86, Arm, and NPUs	Heterogeneous compute including x86, Arm, and NPUs
Scheduling	Proprietary Volcano for various scheduling policies and improved task execution efficiency	Hybrid scheduling for improved cluster resource utilization	Intelligent scheduling for starting containers in seconds and automatic load balancing

Category	CCE Standard	CCE Turbo	CCE Autopilot
Network	VPC network overlaid with container network	VPC network and container network flattened into one layer, so there is zero performance loss	VPC network and container network flattened into one layer, so there is zero performance loss
Security	Container network access control based on network policies	Kata Containers that allow containers to run inside lightweight VMs	Dedicated cloud native OS that allows automatic vulnerability fixing

For details, see **Comparison Between Cluster Types**.

Selecting a Node Flavor

ECSs come in various flavors, each offering different computing and storage capabilities. Typically, higher specifications (such as CPU and memory) and specialized features (like GPUs and NPUs) result in higher costs per node. It is important to configure stable, cost-effective ECSs that align with the specific needs of your services.

Selecting a Billing Mode for a Node

Different services have varying resource usage periods and stability requirements. To achieve cost-effectiveness, you can choose the appropriate billing mode based on the service characteristics.

Billing Mode	Description
Yearly/Monthly	Yearly/Monthly is a prepaid mode in which you pay for a service before using it. Your bill is generated based on the required duration you specify in the order. The longer the subscription period, the higher the discount. Yearly/Monthly billing is a good option for long-term, stable services.
Pay-per-use	Pay-per-use is a postpaid billing mode. You pay as you go and just pay for what you use. The prices are calculated by the second but billed every hour. Pay-per-use billing allows you to flexibly adjust resource usage. You neither need to prepare for resources in advance, nor end up with excessive or insufficient preset resources. It is a good option for scenarios where there are sudden traffic bursts, such as e-commerce promotions.

Billing Mode	Description
Spot pricing	Spot pricing is a postpaid billing mode. The prices are adjusted gradually based on long-term trends in supply and demand for spot instance capacity. The prices calculated by the second but billed every hour. You need to set a maximum price you are willing to pay for a spot instance. If inventory resources are insufficient or the market price rises above your maximum price, the spot instance will be reclaimed. **NOTICE** Spot instances are ideal for stateless, cost-sensitive applications that can tolerate interruptions. A spot instance is not recommended for workloads that need to run for a long time or that require high stability.

For details, see **Billing Items**.

Clearing Idle Resources in a Timely Manner

It is a good option to identify and clear idle cloud services or resources in clusters in a timely manner, such as unused ECSs, EVS disks, OBS buckets, ELB load balancers, and EIPs.

Optimizing Resource Configuration for a Workload

Setting resource requests and limits too high leads to resource wastage, while setting them too low affects workload stability. By properly configuring resource requests and limits, cluster resource utilization can be improved, resulting in reduced costs.

Configuring Proper Resource Requests and Limits

To ensure that your workloads have enough resources and to avoid wasting resources due to excessive requests, it is important to configure appropriate requests and limits.

Managing Quotas for a Namespace

Quota management sets limits on the total number of resources that teams and users can use when they share cluster resources. These resources include the number of objects of a specific type created in a namespace, as well as the total number of compute resources like CPUs and memory used by these objects.

This approach help minimize unnecessary resource overhead.

For details, see **Configuring Resource Quotas**.

Configuring Auto Scaling for a Cluster

CCE provides auto scaling in seconds. It automatically adjusts compute resources based on preset policies and your service needs to ensure that the number of

cloud servers or containers increases or decreases with service load. This ensures stable, healthy services, improves cluster resource utilization, and reduces costs.

For details, see **Workload Scaling Rules**.

Enabling Auto Scaling for an Application

CCE provides auto scaling for applications. This feature enables applications that experience traffic surges or periodic peak and off-peak hours to automatically adjust compute resources.

Application scaling on demand (HPA)

Application auto scaling helps dynamically adjust compute resources based on service requirements and policies. It enables quick scale-out during peak hours and scale-in during off-peak hours, optimizing resource utilization and reducing costs.

The following table lists the auto scaling approaches supported by CCE.

Policy Name	Description
HPA	Scales Deployments based on metrics like CPU usage and memory usage. HPA adds cooldown time windows and scaling thresholds for applications based on Kubernetes HPA. HPA applies to scenarios where services experienced fluctuating traffic, many services are deployed, and frequent scaling is required.
CronHPA	Scales Deployment periodically (daily, weekly, monthly, or yearly at a specific time). CronHPA applies to scenarios where the application resource usage changes periodically.

Burst scaling (interconnected with CCI)

In short-term high-load scenarios, besides HPA, pods in a CCE cluster can be scaled to CCI. There is no need to create new nodes, reducing resource consumption caused by scale-out. The CCE Cloud Bursting Engine for CCI add-on must be installed in the cluster. For details, see **Elastic Scaling of CCE Pods to CCI**.

Scaling a Node

Application auto scaling helps dynamically adjust the number of pods based on workload metrics. If there are not enough cluster resources and new pods cannot run properly, you can add more nodes to the cluster.

For details, see **Node Scaling Rules**.

The following table lists auto scaling policies that you can select.

Policy Name	Description
Manual scaling	You can manually scale in or out nodes in a node pool. If the resources of the selected flavor are insufficient or the quota is insufficient, the scale-out will fail.
Auto scaling	CCE Cluster Autoscaler automatically scales in or out nodes in a cluster based on the pod scheduling status and resource usage. It supports multiple scaling modes, such as multi-AZ, multi-pod-specifications, metric triggering, and periodic triggering, to meet the requirements of different node scaling scenarios. • Scale-out: Autoscaler checks all unscheduled pods every 10 seconds and selects a node pool that meets the requirements for scale-out based on the policy you set. • Scale-in: Autoscaler scans all nodes every 10 seconds. If the number of pod requests on a node is less than the custom scale-in threshold (in percentage), Autoscaler will check whether pods on the current node can be migrated to other nodes.

Optimizing Application Scheduling

During cloud native progress, it is important to strike a balance between performance and service quality. This can be achieved by carefully considering the service deployment solutions and architectures. Depending on your specific service scenarios, you can choose an appropriate scheduling solution to optimize resource utilization and manage costs efficiently.

Using Cloud Native Hybrid Deployment

If your service meets the following requirements, it is recommended that you use this capability:

- Nodes are deployed in different clusters. They cannot share compute resources with each other, resulting in an increase in resource fragments.
- The node flavors are not ideal for applications that undergo frequent changes. At first, the node flavors match the application requirements, resulting in a high resource allocation rate. However, as the applications evolve, their resource demands change, causing a significant difference in the ratio of requested resources to node flavors. This leads to a decrease in the allocation rate of node resources and an increase in compute resource fragments.
- There are a large number of reserved resources. Online services experience daily peaks and troughs. To ensure service performance and stability, users apply for resources based on peak usage, which may result in many idle resources in the cluster during certain times.
- Online and offline services are deployed in separate Kubernetes clusters, and resources cannot be shared between them at different time. This means that during off-peak hours for online services, the resources cannot be used by offline services.

The following table lists cloud native hybrid deployment features that can help you improve resource utilization, reduce costs, improve efficiency in the scenarios mentioned earlier.

Feature	Description
Dynamic resource oversubscription	Based on the types of online and offline jobs, Volcano is used to optimize cluster resource utilization by using the requested but unused resources (the difference between the requested and used resources) for resource oversubscription and hybrid deployment. For details, see **Dynamic Resource Oversubscription**.
CPU burst	CPU burst is an elastic traffic limiting mechanism that allows temporarily exceeding the CPU limit to reduce the long-tail response time of services and improve the quality of latency-sensitive services. For details, see **CPU Burst**.
Guaranteed egress network bandwidth	The egress network bandwidth used by online and offline services is balanced to ensure enough network bandwidth for online services. For details, see **Guaranteed Egress Network Bandwidth**.

Enabling Resource Usage-based Scheduling

The Volcano Scheduler is used to improve cluster resource usage. It provides bin packing, descheduling, node pool affinity, and load-aware scheduling policies.

Scheduling Policy	Description
Bin packing	Bin packing is an optimization algorithm that aims to reduce cluster resource fragments. After bin packing is enabled for cluster workloads, the scheduler preferentially schedules pods to nodes with high resource allocation. This reduces resource fragments on each node and improves cluster resource utilization. For details, see **Bin Packing**.
Descheduling	The Volcano Scheduler can remove pods that do not meet the configured policies and reschedule them according to those policies. This helps balance the cluster loads and minimize resource fragmentation. For details, see **Descheduling**.

Scheduling Policy	Description
Node pool affinity	When it comes to scenarios like node pool replacement and rolling node upgrade, it becomes necessary to replace an old node pool with a new one. To prevent the node pool replacement from affecting services, it is recommended that you enable soft affinity, which allows for scheduling service pods to the new node pool. For details, see **Node Pool Affinity**.
Load-aware scheduling	Volcano Scheduler offers CPU and memory load-aware scheduling for pods and preferentially schedules pods to the node with the lightest load to balance node loads. This prevents an application or node failure due to heavy loads on a single node. For details, see **Load-aware Scheduling**.

Enabling Priority-based Scheduling and Preemption

A pod priority indicates the importance of a pod relative to other pods. Volcano supports pod PriorityClasses in Kubernetes. After PriorityClasses are configured, the scheduler preferentially schedules high-priority pods. When cluster resources are insufficient, the scheduler will proactively evict low-priority pods to make it possible to schedule pending high-priority pods. For details, see **Priority-based Scheduling and Preemption**.

The following table lists the types of priority-based scheduling and preemption supported by CCE.

Scheduling Type	Description
Priority-based scheduling	The scheduler preferentially guarantees the running of high-priority pods, but will not evict low-priority pods that are running. Priority-based scheduling is enabled by default and cannot be disabled.
Priority-based preemption	When cluster resources are insufficient, the scheduler will proactively evict low-priority pods to make it possible to schedule pending high-priority pods.

Sharing GPUs

GPU virtualization allows for the separation of compute and GPU memory, optimizing the utilization of GPUs. CCE GPU virtualization leverages the proprietary xGPU virtualization technology to dynamically separate GPU memory and compute. This virtualization solution offers greater flexibility compared to static allocation. While ensuring maximum service stability, you have the freedom to define the number of GPUs to be used, thereby enhancing GPU utilization.

For details, see **GPU Virtualization**.

Enabling AI Performance-based Scheduling

In AI and big data collaborative scheduling scenarios, Volcano Dominant Resource Fairness (DRF) and group can be used to improve training performance and resource utilization.

DRF

DRF is a scheduling algorithm based on the dominant resource of a container group. DRF can be used to enhance the service throughput of a cluster, shorten the overall service execution time, and improve training performance. It is suitable for batch AI training and big data jobs. For details, see **DRF**.

In actual services, limited cluster resources are often allocated to multiple users. Each user has the same rights to obtain resources, but the number of resources they need may be different. It is crucial to fairly allocate resources to each user. A common scheduling algorithm is the max-min fairness share, which allocates resources to meet users' minimum requirements as far as possible and then fairly allocates the remaining resources. The rules are as follows:

- Resources are allocated in order of increasing demand.
- No source gets a resource share larger than its demand.
- Sources with unsatisfied demands get an equal share of the resource.

Gang

Gang scheduling meets the scheduling requirements of "All or nothing" in the scheduling process and avoids the waste of cluster resources caused by arbitrary scheduling of pods. It is mainly used in scenarios that require multi-process collaboration, such as AI and big data scenarios. Gang scheduling effectively resolves pain points such as resource waiting or deadlocks in distributed training jobs, thereby significantly improving the utilization of cluster resources. For details, see **Gang**.

The Gang scheduler algorithm checks whether the number of scheduled pods in a job meets the minimum requirements for running the job. If yes, all pods in the job will be scheduled. If no, the pods will not be scheduled.

It is applicable to the scenarios where multi-process collaboration is required.

- AI scenarios typically involve complex processes. Data ingestion, data analysts, data splitting, trainers, serving, and logging which require a group of containers to work together are suitable for container-based Gang scheduling.
- Multi-thread parallel computing communication scenarios under MPI computing framework are also suitable for Gang scheduling because master and slave processes need to work together.
- Containers in a pod group are highly correlated, and there may be resource contention. The overall scheduling allocation can effectively resolve deadlocks.

  If cluster resources are insufficient, Gang scheduling can significantly improve the utilization of cluster resources.

Enabling NUMA Affinity Scheduling

When working with high-performance computing (HPC), real-time applications, or memory-intensive workloads that require frequent communication between CPUs,

accessing nodes across non-uniform memory access (NUMA) in a cloud native environment can lead to decreased system performance due to increased latency and overhead. Volcano's NUMA affinity scheduling policy resolves the issue by scheduling pods to the worker node that requires the least number of cross-NUMA nodes. This reduces data transmission overheads, optimizes resource utilization, and enhances overall system performance.

Volcano targets to lift the limitation to make scheduler NUMA topology aware so that:

- Pods are not scheduled to the nodes that NUMA topology does not match.
- Pods are scheduled to the most suitable node for NUMA topology.

For details, see **NUMA Affinity Scheduling**.

Configuring Application Scaling Priority Policies

With application scaling priority policies, you have precise control over the scaling priorities of pods on different types of nodes, allowing for optimized resource management. The application scaling priority policies include the following aspects:

- Scale-out: Volcano schedules new pods in a cluster based on preset node priority for scale-out.
- Scale-in: When a workload is specified, Volcano scores the workload based on preset node priority to determine pod deletion sequence during scale-in.

If the default scaling priority policy is applied, pods will be scheduled first to yearly/monthly nodes during scale-out, followed by pay-per-use nodes and virtual-kubelet nodes (scaling pods to CCI). During scale-in, pods are deleted sequentially from virtual-kubelet nodes (scaling pods to CCI), pay-per-use nodes, and yearly/monthly nodes. You can adjust the scaling priority policies based on your service scenarios. For details, see **Application Scaling Priority Policies**.

Establishing Resource and Cost Monitoring

Cost Insights uses in-house cost profile algorithms to split costs by department, cluster, namespace, or application, based on your bills and cluster resource usage. It allows you to analyze cluster costs and resource usage and identify resource waste for cost optimization. For details, see **Cost Insights**.

10 Networking

10.1 Planning CIDR Blocks for a Cluster

Before creating a cluster on CCE, determine the number of VPCs, number of subnets, container CIDR blocks, and Services for access based on service requirements.

This topic describes the addresses in a CCE cluster in a VPC and how to plan CIDR blocks.

Constraints

To access a CCE cluster through a VPN, ensure that the VPN does not conflict with the VPC CIDR block where the cluster resides and the container CIDR block.

Basic Concepts

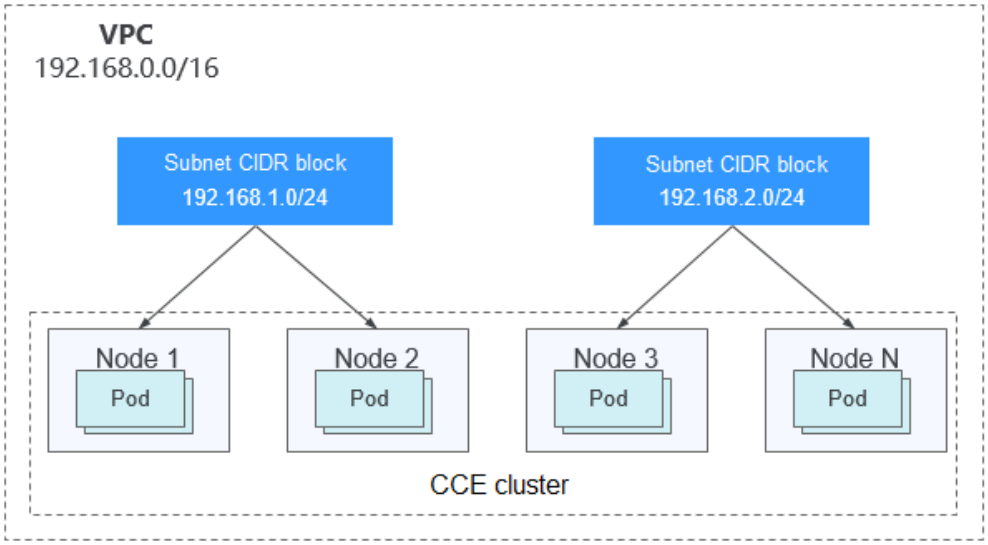
- **VPC CIDR Block**

  Virtual Private Cloud (VPC) enables you to provision logically isolated, configurable, and manageable virtual networks for cloud servers, cloud containers, and cloud databases. You have complete control over your virtual network, including selecting your own CIDR block, creating subnets, and configuring security groups. You can also assign EIPs and allocate bandwidth in your VPC for secure and easy access to your business system.

- **Subnet CIDR Block**

  A subnet is a network that manages ECS network planes. It supports IP address management and DNS. The IP addresses of all ECSs in a subnet belong to the subnet.

Figure 10-1 VPC CIDR block architecture



By default, ECSs in all subnets of the same VPC can communicate with one another, while ECSs in different VPCs cannot communicate with each other.

You can create a peering connection on VPC to enable ECSs in different VPCs to communicate with each other.

- **Container (Pod) CIDR Block**

  Pod is a Kubernetes concept. Each pod has an IP address.

  When creating a cluster on CCE, you can specify the pod (container) CIDR block, which cannot overlap with the subnet CIDR block. For example, if the subnet CIDR block is 192.168.0.0/16, the container CIDR block of the cluster cannot be 192.168.0.0/18 or 192.168.64.0/18 because these addresses are covered by 192.168.0.0/16.

- **Container Subnet** (Only for CCE Turbo Clusters)

  In a CCE Turbo cluster, a container is assigned an IP address from the CIDR block of a VPC. The container subnet can overlap with the subnet CIDR block. Note that the subnet you select determines the maximum number of pods in the cluster.

- **Service CIDR Block**

  Service is also a Kubernetes concept. Each Service has an address. When creating a cluster on CCE, you can specify the Service CIDR block. Similarly, the Service CIDR block cannot overlap with the subnet CIDR block or the container CIDR block. The Service CIDR block can be used only within a cluster.

Single-VPC Single-Cluster Scenarios

CCE Clusters: include clusters in VPC network model and container tunnel network model. **Figure 10-2** shows the CIDR block planning of a cluster.

- VPC CIDR Block: specifies the VPC CIDR block where the cluster resides. The size of this CIDR block affects the maximum number of nodes that can be created in the cluster.
- Subnet CIDR Block: specifies the subnet CIDR block where the node in the cluster resides. The subnet CIDR block is included in the VPC CIDR block.

Different nodes in the same cluster can be allocated to different subnet CIDR blocks.

- Container CIDR Block: cannot overlap with the subnet CIDR block.
- Service CIDR Block: cannot overlap with the subnet CIDR block or the container CIDR block.

Figure 10-2 Network CIDR block planning in single-VPC single-cluster scenarios (CCE cluster)

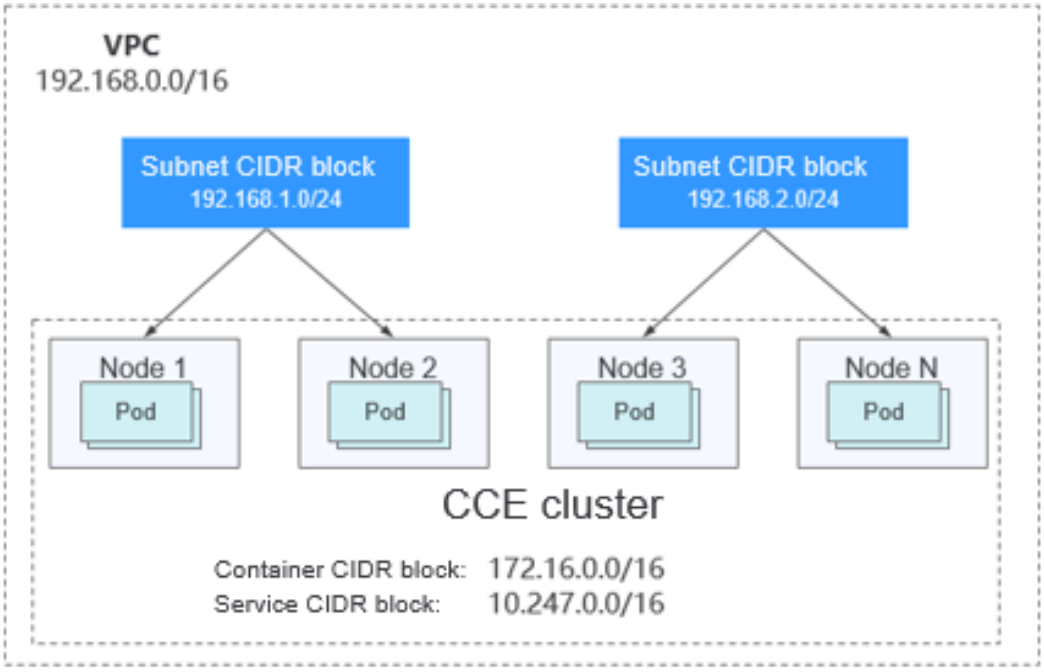
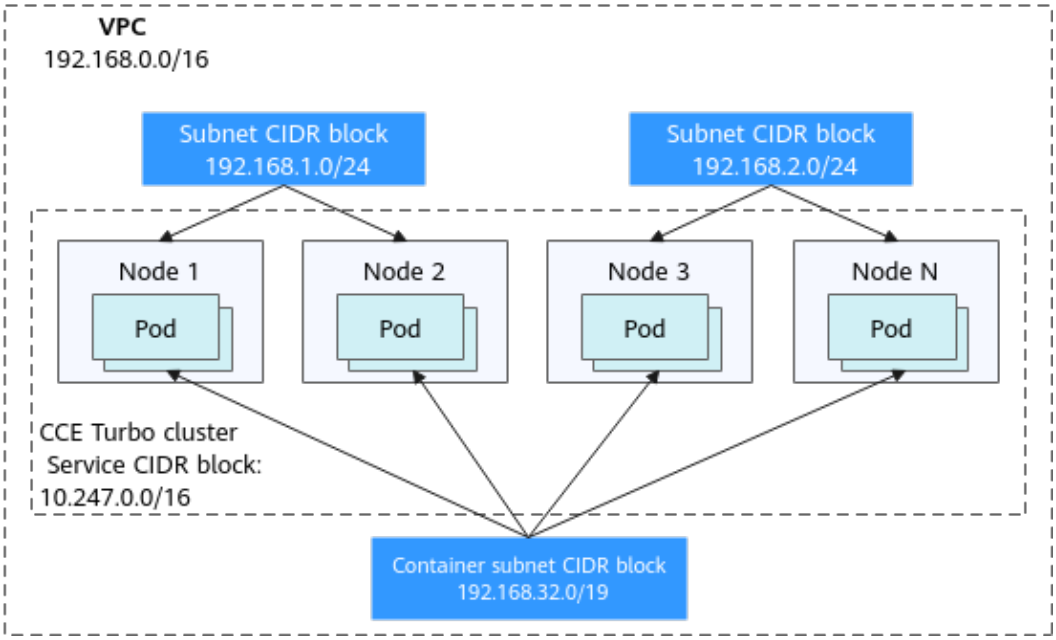


Figure 10-3 shows the CIDR block planning for a **CCE Turbo cluster** (Cloud Native Network 2.0).

- VPC CIDR Block: specifies the VPC CIDR block where the cluster resides. The size of this CIDR block affects the maximum number of nodes that can be created in the cluster.
- Subnet CIDR Block: specifies the subnet CIDR block where the node in the cluster resides. The subnet CIDR block is included in the VPC CIDR block. Different nodes in the same cluster can be allocated to different subnet CIDR blocks.
- Container Subnet CIDR Block: The container subnet is included in the VPC CIDR block and can overlap with the subnet CIDR block or even be the same as the subnet CIDR block. Note that the container subnet size determines the maximum number of containers in the cluster because IP addresses in the VPC are directly allocated to containers. Set a larger IP address segment for the container subnet to prevent insufficient container IP addresses.
- Service CIDR Block: cannot overlap with the subnet CIDR block or the container CIDR block.

Figure 10-3 Network CIDR block planning in single-VPC single-cluster scenarios (CCE Turbo cluster)



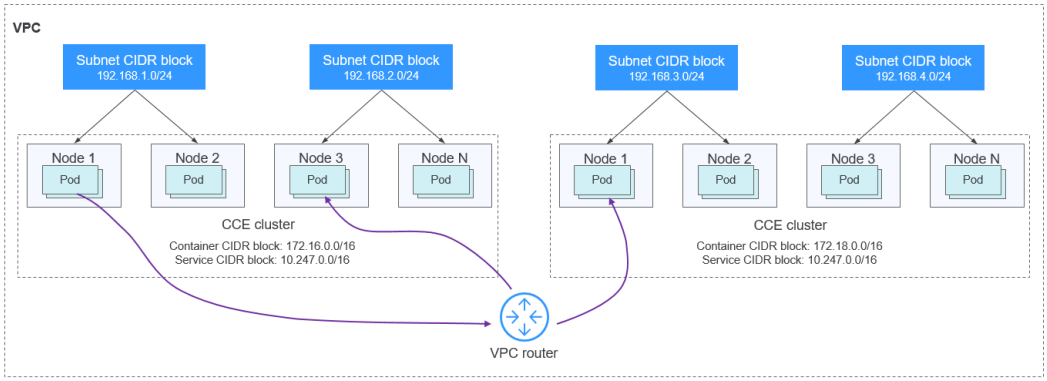
Single-VPC Multi-Cluster Scenarios

VPC network model

Pod packets are forwarded through VPC routes. CCE automatically configures a routing table on the VPC routes to each container CIDR block. The network scale is limited by the VPC route table. **Figure 10-4** shows the CIDR block planning of the cluster.

- VPC CIDR Block: specifies the VPC CIDR block where the cluster resides. The size of this CIDR block affects the maximum number of nodes that can be created in the cluster.
- Subnet CIDR Block: The subnet CIDR block in each cluster cannot overlap with the container CIDR block.
- Container CIDR Block: If multiple VPC network model clusters exist in a single VPC, the container CIDR blocks of all clusters cannot overlap because the clusters use the same routing table. In this case, if the node security group allows container CIDR block from the peer cluster, pods in one cluster can directly access pods in another cluster through the pod IP addresses.
- Service CIDR Block: can be used only in clusters. Therefore, the Service CIDR blocks of different clusters can overlap, but cannot overlap with the subnet CIDR block and container CIDR block of the cluster.

Figure 10-4 VPC network - multi-cluster scenario

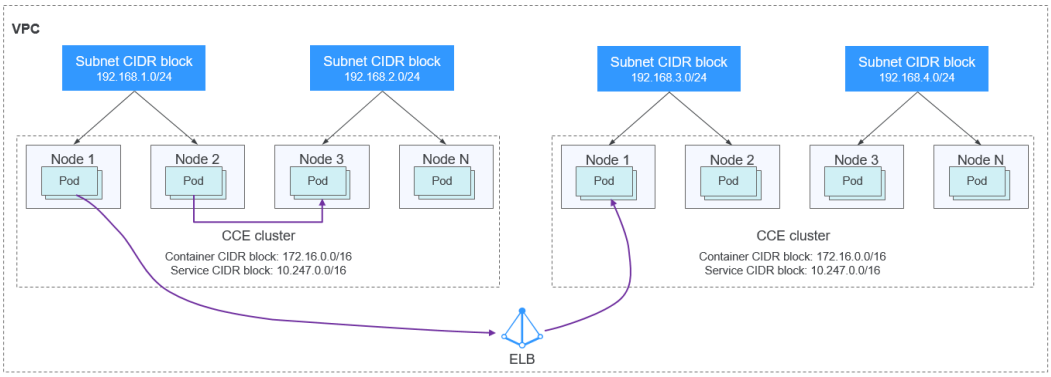


Tunnel network model

Though at some cost of performance, the tunnel encapsulation enables higher interoperability and compatibility with advanced features (such as network policy-based isolation), meeting the requirements of most applications. **Figure 10-5** shows the CIDR block planning of the cluster.

- VPC CIDR Block: specifies the VPC CIDR block where the cluster resides. The size of this CIDR block affects the maximum number of nodes that can be created in the cluster.
- Subnet CIDR Block: The subnet CIDR block in each cluster cannot overlap with the container CIDR block.
- Container CIDR Block: The container CIDR blocks of all clusters can overlap. In this case, pods in different clusters cannot be directly accessed through pod IP addresses. Services are needed for accessing pods in different clusters. The LoadBlancer Services are recommended.
- Service CIDR Block: can be used only in clusters. Therefore, the Service CIDR blocks of different clusters can overlap, but cannot overlap with the subnet CIDR block and container CIDR block of the cluster.

Figure 10-5 Tunnel network - multi-cluster scenario

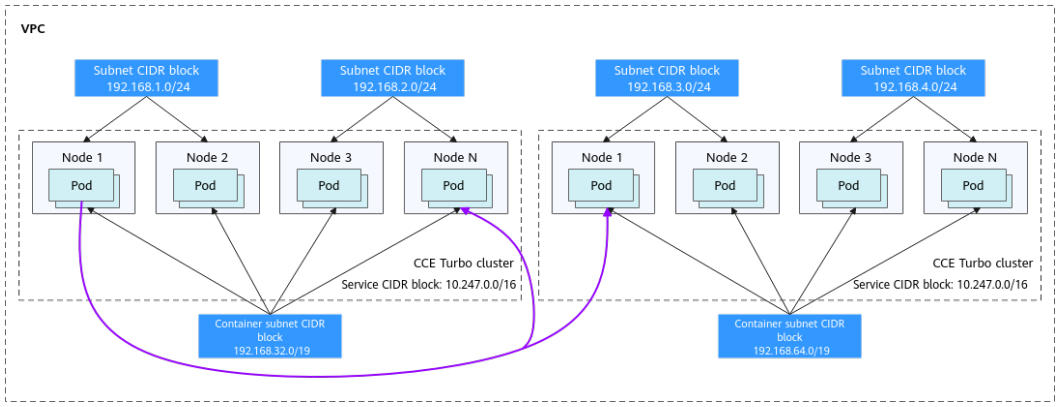


Cloud Native 2.0 network model (CCE Turbo Clusters)

In this mode, container IP addresses are allocated from the VPC CIDR block. ELB passthrough networking is supported to direct access requests to containers. Security groups and multiple types of VPC networks can be bound to deliver high performance.

- VPC CIDR Block: specifies the VPC CIDR block where the cluster resides. In a CCE Turbo cluster, the CIDR block size affects the total number of nodes and containers that can be created in the cluster.
- Subnet CIDR Block: There is no special restriction on the subnet CIDR blocks in CCE Turbo clusters.
- Container Subnet: The CIDR block of the container subnet is included in the VPC CIDR block. Container subnets in different clusters can overlap with each other or overlap with the subnet CIDR block. However, you are advised to stagger the container CIDR blocks of different clusters and ensure that the container subnet CIDR blocks have sufficient IP addresses. In this case, if the ENI security group of the cluster allows the container CIDR block of the peer cluster, pods in different clusters can directly access each other through IP addresses.
- Service CIDR Block: can be used only in clusters. Therefore, the Service CIDR blocks of different clusters can overlap, but cannot overlap with the subnet CIDR block and container subnet CIDR block of the cluster.

Figure 10-6 Cloud Native 2.0 network - multi-cluster scenario



Clusters using different networks

When a VPC contains clusters created with different network models, comply with the following rules when creating a cluster:

- VPC CIDR Block: In this scenario, all clusters are located in the same VPC CIDR block. Ensure that there are sufficient available IP addresses in the VPC.
- Subnet CIDR Block: Ensure that the subnet CIDR block does not overlap with the container CIDR block. Even in some scenarios (for example, coexistence with CCE Turbo clusters), the subnet CIDR block can overlap with the container (subnet) CIDR block. However, this is not recommended.
- Container CIDR Block: Ensure that the container CIDR blocks of clusters in **VPC network model** do not overlap.
- Service CIDR Block: The Service CIDR blocks of all clusters can overlap, but cannot overlap with the subnet CIDR block and container CIDR block of the cluster.

Cross-VPC Cluster Interconnection

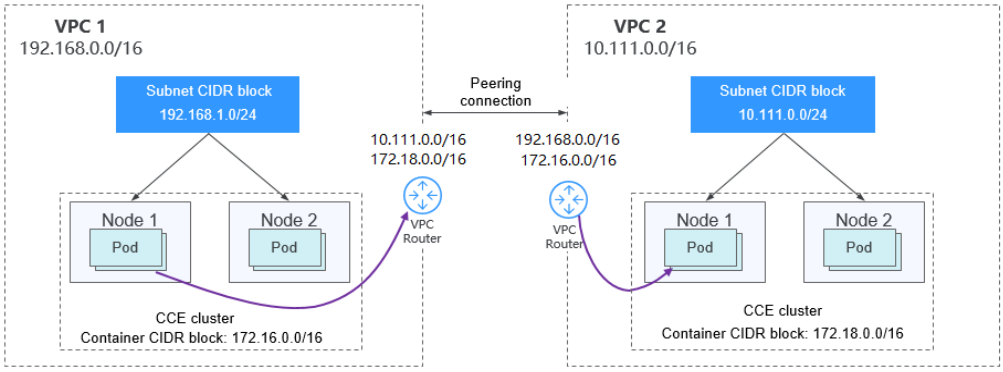
If VPCs cannot communicate with each other, a VPC peering connection is used to ensure communication between VPCs. When two VPC networks are

interconnected, you can configure the packets to be sent to the peer VPC in the route table. For details, see **VPC Peering Connection Overview**.

Clusters using VPC networks

To allow clusters that use VPC networks to access each other across VPCs, add routes to the two ends of the VPC peering after a VPC peering connection is created.

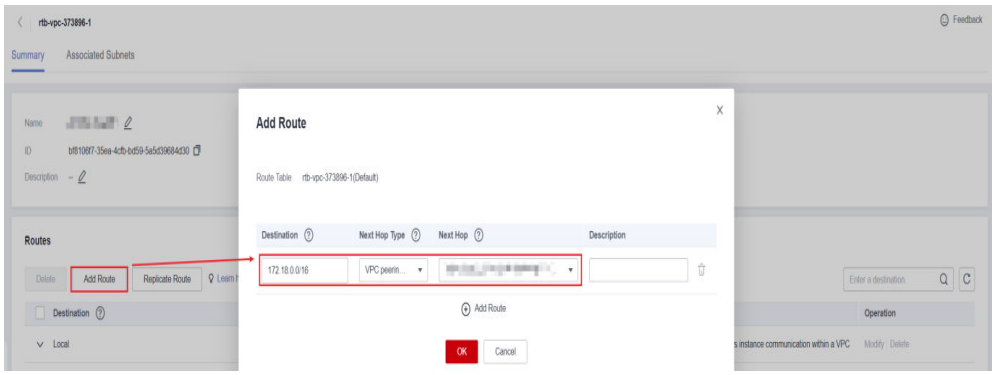
Figure 10-7 VPC network - VPC interconnection scenario



When creating a VPC peering connection between containers across VPCs, pay attention to the following points:

- The VPC to which the clusters belong must not overlap. In each cluster, the subnet CIDR block cannot overlap with the container CIDR block.
- The container CIDR blocks of clusters at both ends cannot overlap, but the Service CIDR blocks can.
- If the request end cluster uses the VPC network, check whether the node security group in the destination cluster allows the container CIDR block of the request end cluster. If yes, pods in one cluster can directly access pods in another cluster through the pod IP address. Similarly, if nodes running in the clusters at the two ends of the VPC peering connection need to access each other, the node security group must allow the VPC CIDR block of the peer cluster.
- You need to add routes for accessing the peer network CIDR block to the VPC routing tables at both ends. For example, you need to add a route for accessing the CIDR block of VPC 2 to the route table of VPC 1, and add a route for accessing VPC 1 to the route table of VPC 2.
  - **Add the VPC CIDR block of the peer cluster**: After the route of the VPC CIDR block is added, a pod in a cluster can access another cluster node. For example, the pod can access the port of a NodePort Service.
  - **Add peer container CIDR block**: After the route of the container CIDR block is added, a pod can directly access pods in another cluster through the container IP addresses.

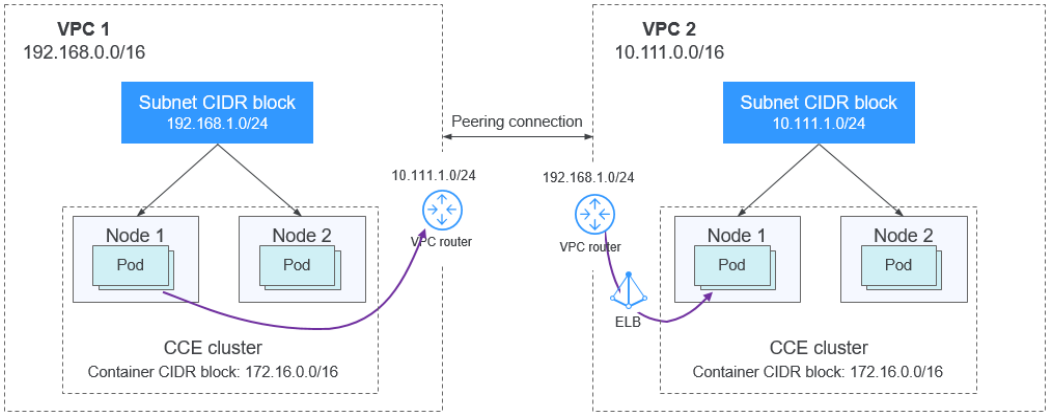
Figure 10-8 Adding the peer container CIDR block to the local route on the VPC console



Clusters using tunnel networks

To allow clusters that use tunnel networks to access each other across VPCs, add routes to the two ends of the VPC peering after a VPC peering connection is created.

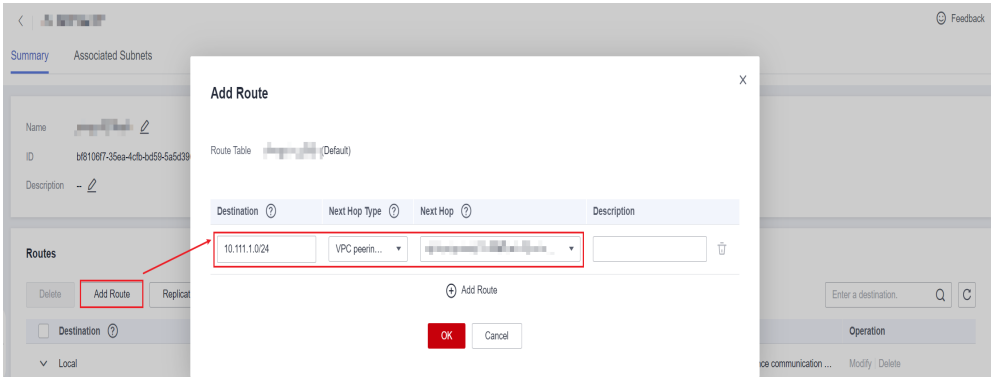
Figure 10-9 Tunnel network - VPC interconnection scenario



Pay attention to the following:

- The VPCs of the peer clusters must not overlap.
- The container CIDR blocks of all clusters can overlap, so do the Service CIDR blocks.
- If the request end cluster uses the tunnel network, check whether the node security group in the destination cluster allows the VPC CIDR block (including the node subnets) of the request end cluster. If yes, nodes in one cluster can access nodes in another cluster. However, pods in different clusters cannot be directly accessed using pod IP addresses. Access between pods in different clusters requires Services. The LoadBlancer Services are recommended.
- The VPC CIDR block route of the peer cluster must be added to the VPC routing tables of both ends. For example, you need to add a route for accessing the CIDR block of VPC 2 to the route table of VPC 1, and add a route for accessing VPC 1 to the route table of VPC 2. After the route of the VPC CIDR block is added, the pod can access another cluster node, for example, accessing the port of a NodePort Service.

Figure 10-10 Adding the subnet CIDR block of the peer cluster node to the local route on the VPC console



Clusters using Cloud Native 2.0 networks (CCE Turbo clusters)

After creating a VPC peering connection, add routes of the VPC peering connection to both ends so that the two VPCs can communicate with each other. Pay attention to the following:

- The VPCs of the clusters at the two ends must not overlap.
- If the request end cluster uses the Cloud Native 2.0 network, check whether the ENI security group (named in the format of *{Cluster name}*-**cce-eni-***{Random ID}*) of the destination cluster allows the VPC CIDR block (including the node subnets and container CIDR block) of the request end cluster. If yes, pods in one cluster can directly access pods in another cluster through the pod IP addresses. Similarly, if nodes in the clusters at the two ends of the VPC peering need to access each other, allow the VPC CIDR block of the peer cluster in the node security group (named in the format of *{Cluster name}*-**cce-node-***{Random ID}*).
- The VPC CIDR block route of the peer cluster must be added to the VPC routing tables of both ends. For example, you need to add a route for accessing the CIDR block of VPC 2 to the route table of VPC 1, and add a route for accessing VPC 1 to the route table of VPC 2. After the route of the VPC CIDR block is added, the pod can access pod IP addresses or nodes in another cluster.

Clusters using different networks

If clusters using different networks need to communicate with each other across VPCs, every one of them may serve as the request end or destination end. Pay attention to the following:

- The VPC CIDR block to which the cluster belongs cannot overlap with the VPC CIDR block of the peer cluster.
- Cluster subnet CIDR blocks cannot overlap with the container CIDR blocks.
- Container CIDR blocks in different clusters cannot overlap with each other.
- If pods or nodes in different clusters need to access each other, the security groups of the clusters on both ends must allow the corresponding CIDR blocks based on the following rules:
  - If the request end cluster uses the VPC network, the node security group of the destination cluster must allow the VPC CIDR block (including the node subnets and container CIDR block) of the request end cluster.

  - If the request end cluster uses the tunnel network, the node security group of the destination cluster must allow the VPC CIDR block (including the node subnets) of the request end cluster.
  - If the request end cluster uses the Cloud Native 2.0 network, the ENI security group and node security group of the destination cluster must allow the VPC CIDR block (including node subnets and container CIDR block) of the request end cluster.
- The VPC CIDR block route of the peer cluster must be added to the VPC routing tables of both ends. For example, you need to add a route for accessing the CIDR block of VPC 2 to the route table of VPC 1, and add a route for accessing VPC 1 to the route table of VPC 2. After the route of the VPC CIDR block is added, the pod can access another cluster node, for example, accessing the port of a NodePort Service.

  If a cluster uses the VPC network, the VPC routing tables at both ends must contain its container CIDR block. After the container CIDR block route is added, the pod can directly access pods in another cluster through the container IP addresses.

VPC-IDC Scenarios

Similar to the VPC interconnection scenario, some CIDR blocks in the VPC are routed to the IDC. The pod IP addresses of CCE clusters cannot overlap with the addresses within these CIDR blocks. To access the pod IP addresses in the cluster in the IDC, configure the route table to the private line VBR on the IDC.

10.2 Selecting a Network Model

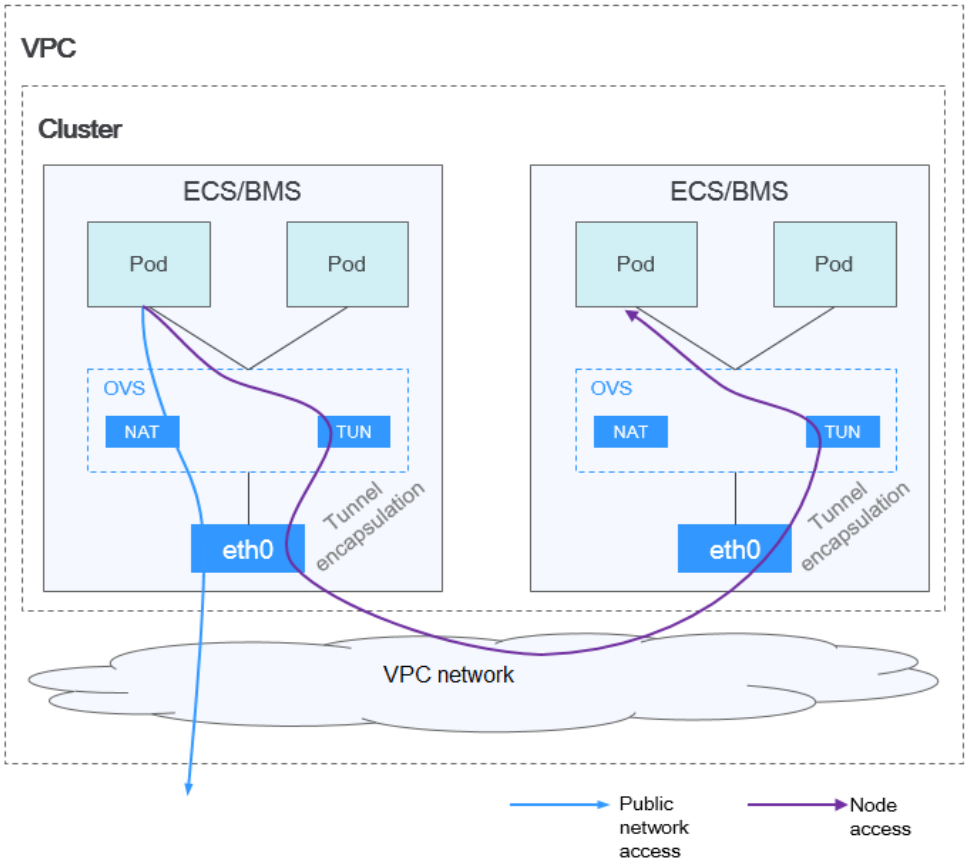
CCE uses proprietary, high-performance container networking add-ons to support the tunnel network, Cloud Native 2.0 network, and VPC network models.

CAUTION

After a cluster is created, the network model cannot be changed. Exercise caution when selecting a network model.

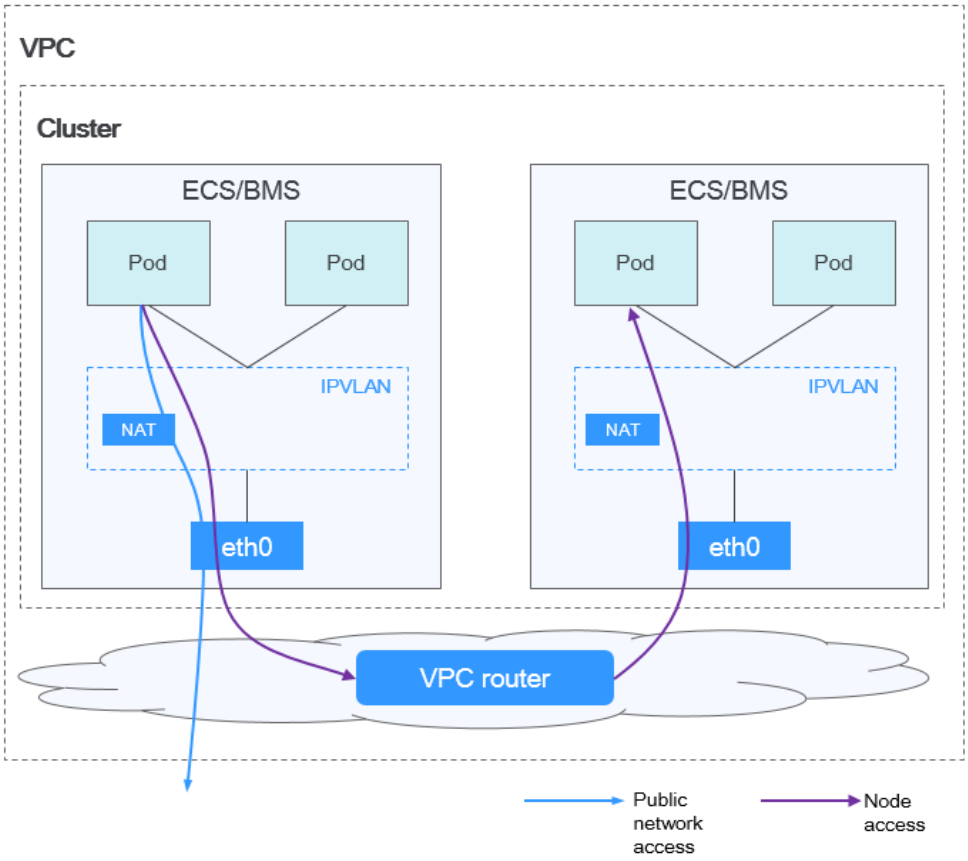
- **Tunnel network**: The container network is an overlay tunnel network on top of a VPC network and uses the VXLAN technology. This network model is applicable when there is no high requirements on performance. VXLAN encapsulates Ethernet packets as UDP packets for tunnel transmission. Though at some cost of performance, the tunnel encapsulation enables higher interoperability and compatibility with advanced features (such as network policy-based isolation), meeting the requirements of most applications.

Figure 10-11 Container tunnel network



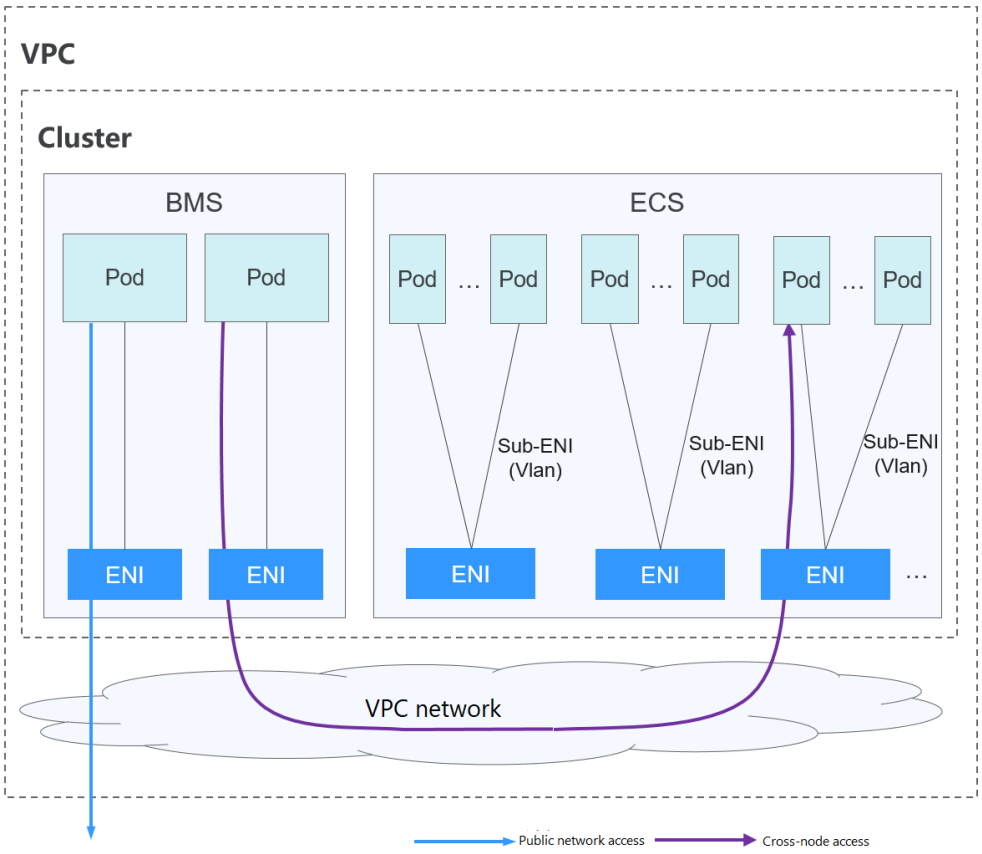
- **VPC network**: The container network uses VPC routing to integrate with the underlying network. This network model is applicable to performance-intensive scenarios. The maximum number of nodes allowed in a cluster depends on the route quota in a VPC network. Each node is assigned a CIDR block of a fixed size. VPC networks are free from tunnel encapsulation overhead and outperform container tunnel networks. In addition, as VPC routing includes routes to node IP addresses and container network segment, container pods in the cluster can be directly accessed from outside the cluster.

Figure 10-12 VPC network



- **Cloud Native Network 2.0**: The container network deeply integrates the elastic network interface (ENI) capability of VPC, uses the VPC CIDR block to allocate container addresses, and supports passthrough networking to containers through a load balancer.

Figure 10-13 Cloud Native 2.0 network



The following table lists the differences between the network models.

Table 10-1 Network model comparison

Dimension	Tunnel Network	VPC Network	Cloud Native Network 2.0
Application scenarios	• Low requirements on performance: As the container tunnel network requires additional VXLAN tunnel encapsulation, it has about 5% to 15% of performance loss when compared with the other two container network models. Therefore, the container tunnel network applies to the scenarios that do not have high performance requirements, such as web applications, and middle-end and back-end services with a small number of access requests. • Large-scale networking: Different from the VPC network that is limited by the VPC route quota, the container tunnel network does not have any restriction	• High performance requirements: As no tunnel encapsulation is required, the VPC network model delivers the performance close to that of a VPC network when compared with the container tunnel network model. Therefore, the VPC network model applies to scenarios that have high requirements on performance, such as AI computing and big data computing. • Small- and medium-scale networks: Due to the limitation on VPC route tables, it is recommended that the number of nodes in a cluster be less than or equal to 1000.	• High performance requirements: Cloud Native Network 2.0 uses VPC networks to construct container networks, eliminating the need for tunnel encapsulation or NAT when containers communicate. This makes Cloud Native Network 2.0 ideal for scenarios that demand high bandwidth and low latency, such as live streaming and e-commerce flash sales. • Large-scale networking: Cloud Native Network 2.0 supports up to 2,000 ECS nodes and 100,000 pods.

Dimension	Tunnel Network	VPC Network	Cloud Native Network 2.0
	on the infrastructure. In addition, the container tunnel network controls the broadcast domain to the node level. The container tunnel network supports a maximum of 2000 nodes.		
Core technology	OVS	IPvlan and VPC route	VPC ENI/sub-ENI
Applicable clusters	CCE standard cluster	CCE standard cluster	CCE Turbo cluster
Container network isolation	Kubernetes native NetworkPolicy for pods	No	Pods support security group isolation.
Interconnecting pods to a load balancer	Interconnected through a NodePort	Interconnected through a NodePort	Directly interconnected using a dedicated load balancer Interconnected using a shared load balancer through a NodePort
Managing container IP addresses	• Separate container CIDR blocks needed • Container CIDR blocks divided by node and dynamically added after being allocated	• Separate container CIDR blocks needed • Container CIDR blocks divided by node and statically allocated (the allocated CIDR blocks cannot be changed after a node is created)	Container CIDR blocks divided from a VPC subnet (You do not need to configure separate container CIDR blocks.)

Dimension	Tunnel Network	VPC Network	Cloud Native Network 2.0
Network performance	Performance loss due to VXLAN encapsulation	No tunnel encapsulation, and cross-node traffic forwarded through VPC routers (The performance is so good that is comparable to that of the host network, but there is a loss caused by NAT.)	Container network integrated with VPC network, eliminating performance loss
Networking scale	A maximum of 2000 nodes are supported.	Suitable for small- and medium-scale networks due to the limitation on VPC route tables. It is recommended that the number of nodes be less than or equal to 1000. Each time a node is added to the cluster, a route is added to the VPC route tables (including the default and custom ones). Evaluate the cluster scale that is limited by the VPC route tables before creating the cluster. For details about route tables, see **Constraints**.	A maximum of 2000 nodes are supported. In a cloud-native network 2.0 cluster, containers' IP addresses are assigned from VPC CIDR blocks, and the number of containers supported is restricted by these blocks. Evaluate the cluster's scale limitations before creating it.

NOTICE

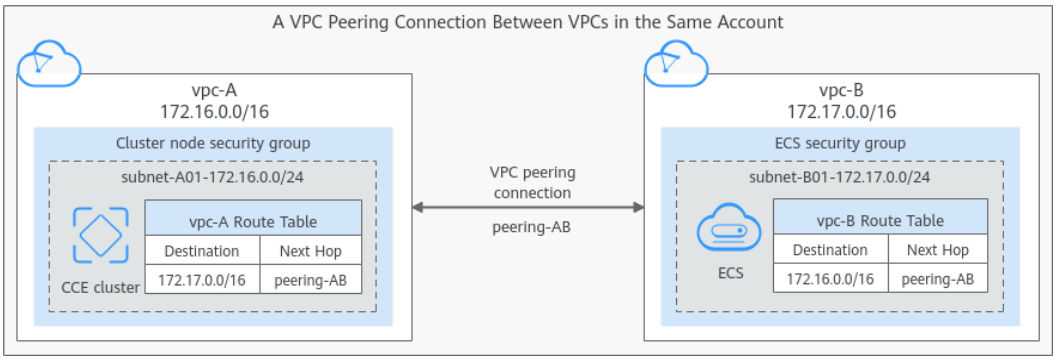
1. The scale of a cluster that uses the VPC network model is limited by the custom routes of the VPC. Therefore, you need to estimate the number of required nodes before creating a cluster.
2. By default, VPC routing network supports direct communication between containers and hosts in the same VPC. If a peering connection policy is configured between the VPC and another VPC, the containers can directly communicate with hosts on the peer VPC. In addition, in hybrid networking scenarios such as Direct Connect and VPN, communication between containers and hosts on the peer end can also be achieved with proper planning.

10.3 Enabling Cross-VPC Network Communications Between CCE Clusters

Application Scenarios

Because services in different VPCs cannot communicate with each other, CCE clusters are unable to communicate across VPCs. To resolve this, a VPC peering connection can be established between two VPCs with different CIDR blocks. This allows clusters in one VPC to access clusters or other services in the other VPC.

Figure 10-14 Example network topology



To enable cross-VPC access, clusters with different network models must communicate with each other across different CIDR blocks. For example, if the local VPC CIDR block of a cluster is 172.16.0.0/16 and the peer VPC CIDR block is 172.17.0.0/16, the routing tables at both ends should be configured as follows.

Cluster Network Model	VPC Route Table Configuration at Both Ends	
	Local VPC Route Table of a Cluster	Peer VPC Route Table
Container tunnel network	The peer VPC CIDR block 172.17.0.0/16 must be added to the destination IP address.	The cluster VPC CIDR block 172.16.0.0/16 must be added to the destination IP address.
VPC network	The peer VPC CIDR block 172.17.0.0/16 must be added to the destination IP address. The container CIDR block of the cluster, for example, 10.0.0.0/16, must be added to the destination IP address.	The cluster VPC CIDR block 172.16.0.0/16 must be added to the destination IP address. The container CIDR block of the cluster, for example, 10.0.0.0/16, must be added to the destination IP address.

Cluster Network Model	VPC Route Table Configuration at Both Ends	
	Local VPC Route Table of a Cluster	Peer VPC Route Table
Cloud Native 2.0 network (for CCE Turbo clusters)	The peer VPC CIDR block 172.17.0.0/16 must be added to the destination IP address.	The cluster VPC CIDR block 172.16.0.0/16 must be added to the destination IP address.

Step 1: Create a VPC Peering Connection

Step 1 Log in to the VPC peering connection console.

Step 2 In the upper right corner of the page, click **Create VPC Peering Connection**.

The **Create VPC Peering Connection** page is displayed.

Step 3 Configure the parameters following instructions.

For details about the parameters, see **Table 10-2**.

Figure 10-15 Creating a VPC peering connection

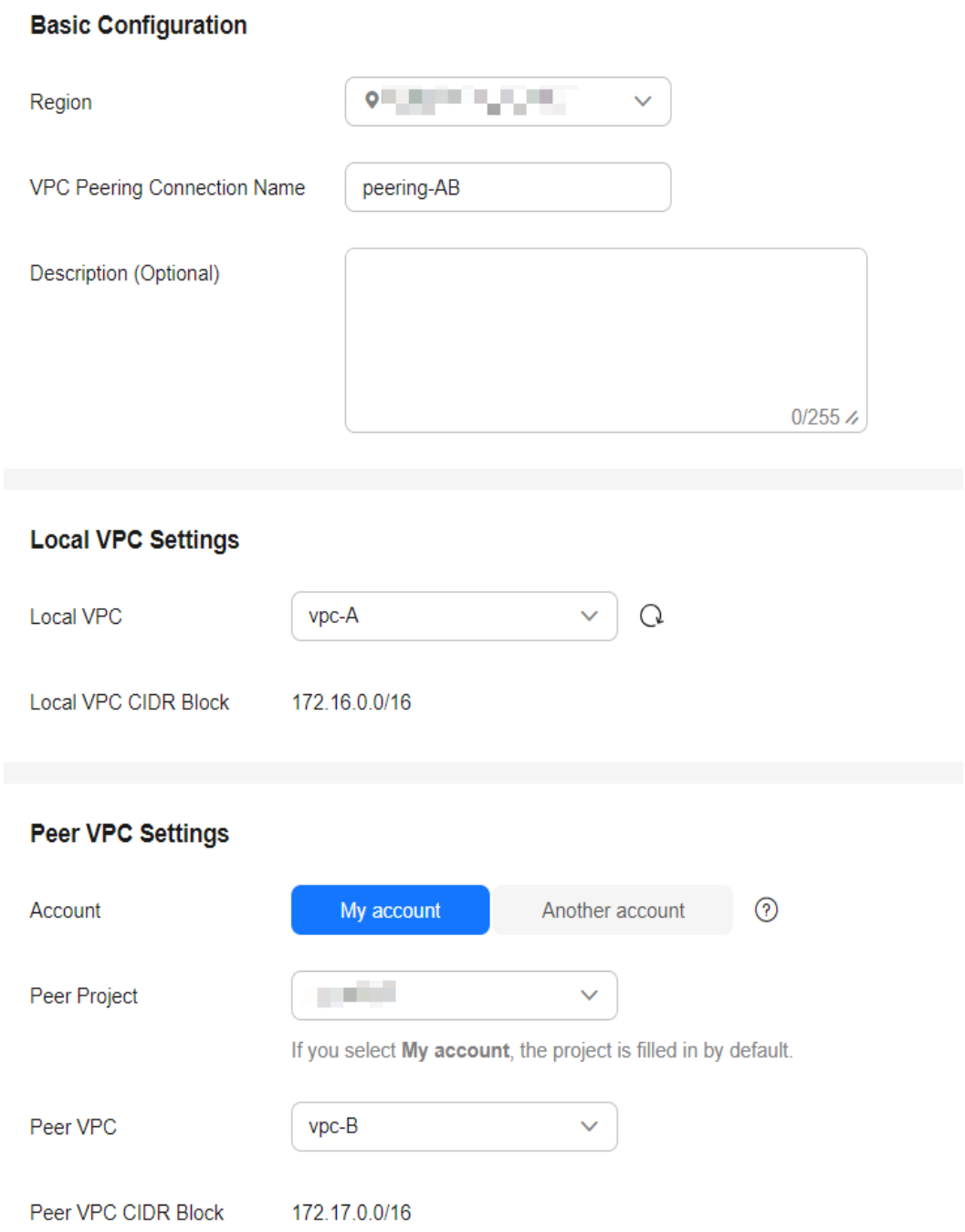


Table 10-2 Parameters for creating a VPC peering connection

Parameter	Description	Example Value
VPC Peering Connection Name	Mandatory. Enter a name for the VPC peering connection. The name can contain a maximum of 64 characters, including letters, digits, hyphens (-), and underscores (_).	peering-AB
Local VPC	Mandatory. VPC at one end of the VPC peering connection. You can select one from the drop-down list.	vpc-A
Local VPC CIDR Block	CIDR block of the selected local VPC	vpc-A CIDR block: 172.16.0.0/16
Account	Mandatory. • **My account**: The local and peer VPCs are from the same account. • **Another account**: The local and peer VPCs are from different accounts.	Current account
Peer Project	The system fills in the corresponding project by default because **Account** is set to **My account**. For example, if vpc-A and vpc-B are in account A and region A, the system fills in the correspond project of account A in region A by default.	None
Peer VPC	This parameter is mandatory if **Account** is set to **My account**. VPC at the other end of the VPC peering connection. You can select one from the drop-down list.	vpc-B
Peer VPC CIDR Block	CIDR block of the selected peer VPC If the local and peer VPCs have overlapping CIDR blocks, the VPC peering connection may not take effect.	vpc-B CIDR block: 172.17.0.0/16

Parameter	Description	Example Value
Description	This parameter is optional. Enter the description of the VPC peering connection in the text box as required.	Use peering-AB to connect vpc-A and vpc-B.

Step 4 Click **Create Now**.

A dialog box for adding routes is displayed.

Step 5 In the displayed dialog box, click **Add Now**. On the displayed page about the VPC peering connection details, go to **Step 2: Add Routes for the VPC Peering Connection** to add a route.

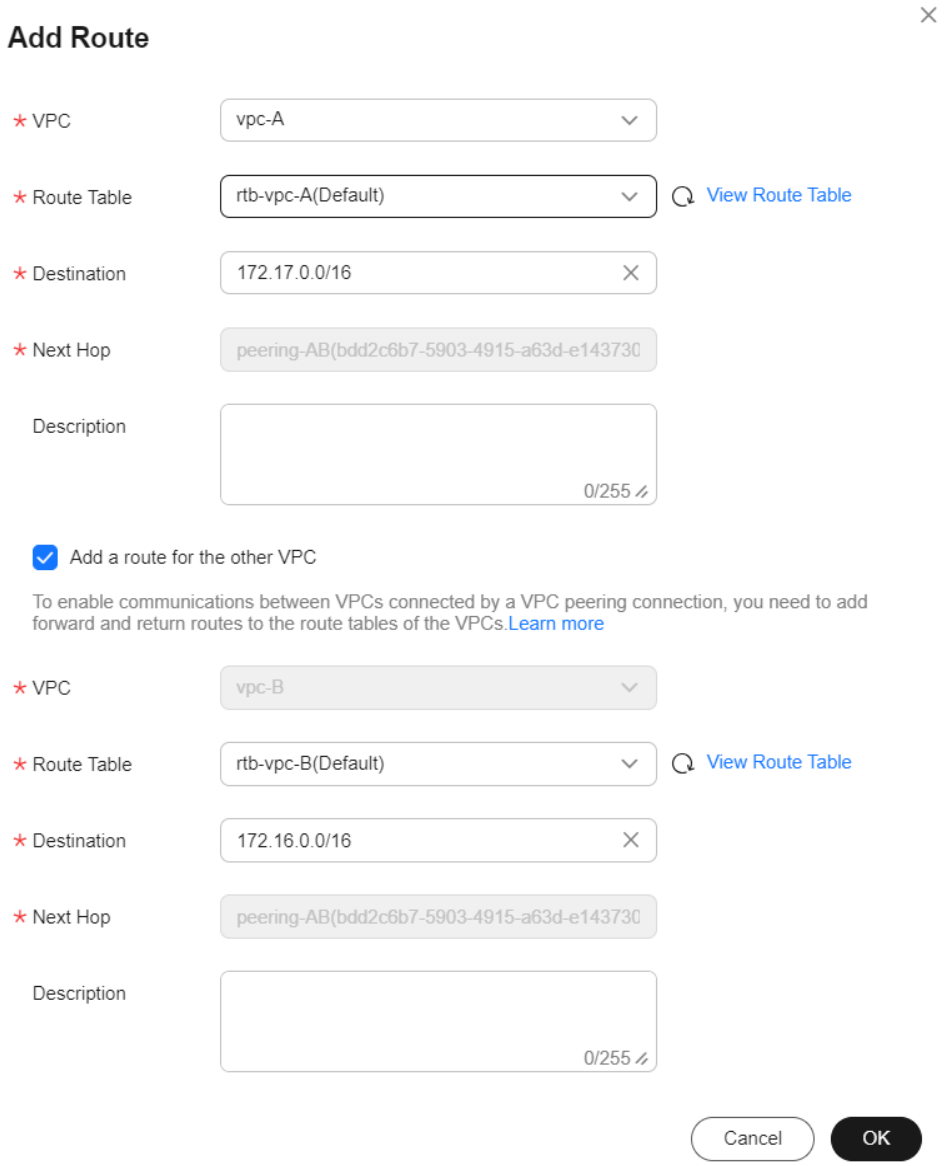
----End

Step 2: Add Routes for the VPC Peering Connection

Step 1 In the lower part of the VPC peering connection details page, click **Add Route**.

The **Add Route** dialog box is displayed.

Figure 10-16 Adding routes for the VPC peering connection



Step 2 Add routes to the VPC route tables following instructions.

Table 10-3 describes the parameters.

Table 10-3 Parameters

Parameter	Description	Example Value
VPC	Select a VPC that is connected by the VPC peering connection.	vpc-A

Parameter	Description	Example Value
Route Table	Select the route table of the VPC. The route will be added to this route table. Each VPC comes with a default route table to control the outbound traffic from the subnets in the VPC. In addition to the default route table, you can also create a custom route table and associate it with the subnets in the VPC. Then, the custom route table controls outbound traffic of the subnets. • If there is only the default route table in the drop-down list, select the default route table. • If there are both default and custom route tables in drop-down list, select the route table associated with the subnet connected by the VPC peering connection.	rtb-vpc-A (Default route table)
Destination	IP address in the VPC at the other end of the VPC peering connection. The value can be VPC CIDR block, subnet CIDR block, or ECS IP address.	vpc-B CIDR block: 172.17.0.0/16
Next Hop	The default value is the current VPC peering connection. You do not need to specify this parameter.	peering-AB
Description	Supplementary information about the route. This parameter is optional. The route description can contain a maximum of 255 characters and cannot contain angle brackets (< or >).	Route from vpc-A to vpc-B
Add a route for the other VPC	If you select this option, you can also add a route for the other VPC connected by the VPC peering connection. To enable communications between VPCs connected by a VPC peering connection, you need to add forward and return routes to the route tables of the VPCs.	Select this option.
VPC	By default, the system selects the other VPC connected by the VPC peering connection. You do not need to specify this parameter.	vpc-B

Parameter	Description	Example Value
Route Table	Select the route table of the VPC. The route will be added to this route table. Each VPC comes with a default route table to control the outbound traffic from the subnets in the VPC. In addition to the default route table, you can also create a custom route table and associate it with the subnets in the VPC. Then, the custom route table controls outbound traffic of the subnets. • If there is only the default route table in the drop-down list, select the default route table. • If there are both default and custom route tables in drop-down list, select the route table associated with the subnet connected by the VPC peering connection.	rtb-vpc-B (Default route table)
Destination	IP address in the VPC at the other end of the VPC peering connection. The value can be VPC CIDR block, subnet CIDR block, or ECS IP address.	vpc-A CIDR block: 172.16.0.0/16
Next Hop	The default value is the current VPC peering connection. You do not need to specify this parameter.	peering-AB
Description	Supplementary information about the route. This parameter is optional. The route description can contain a maximum of 255 characters and cannot contain angle brackets (< or >).	Route from vpc-B to vpc-A.

NOTICE

If the cluster network model in the local VPC is a VPC network, follow the preceding steps to add the CIDR block of the cluster container to the route tables at both ends as the **destination IP address**. In this example, the destination IP address is 10.0.0.0/16.

Step 3 Click **OK**.

You can check the routes in the route list.

----End

Follow-Up Operations

If a cluster needs to access services in other VPCs, **it is important to verify if those cloud services permit access outside the VPC**. This may involve adding a trustlist or security group to enable access to certain services. In the case of a cluster using the VPC network model, you must allow the container CIDR block to pass the destination ends.

For example, if a cluster using the VPC network model needs to access an ECS in a different VPC, you must allow the VPC CIDR block where the cluster is located and its container CIDR block to pass through the ECS security group. This ensures that nodes and containers in the cluster can access the ECS.

10.4 Implementing Network Communications Between Containers and IDCs Using VPC and Direct Connect

Application Scenarios

With VPC and Direct Connect, the container CIDR block (172.56.0.0/16) and IDC CIDR block (10.1.123.0/24) can communicate with each other in the cluster using the VPC network model.

Figure 10-17 Example network topology

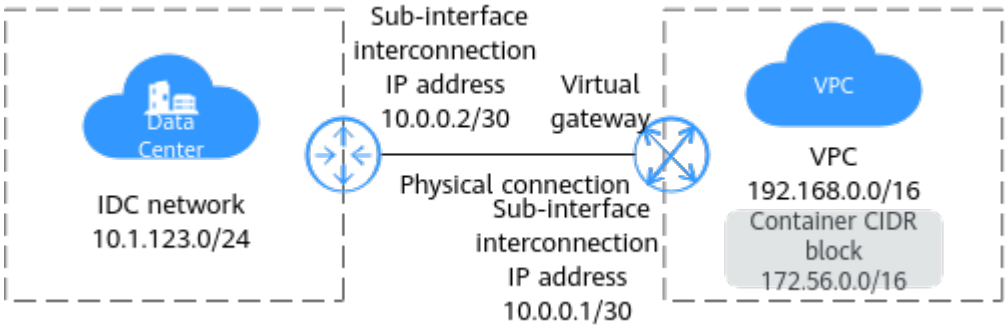


Table 10-4 Address information

Networking	CIDR Block
User's IDC network	10.1.123.0/24
Remote and local gateways (addresses for interconnection)	Huawei Cloud: 10.0.0.1/30 User: 10.0.0.2/30
VPC	192.168.0.0/16
Container CIDR block	172.56.0.0/16

Prerequisites

An IDC is available, and the Direct Connect service has been applied for.

Procedure

Step 1 Create a connection.

1. Log in to the management console, click  in the upper left corner, and select the desired region and project. Click  at the upper left corner and choose **Networking** > **Direct Connect** in the expanded list.
2. In the navigation pane on the left of the console, choose **Direct Connect** > **Connections**. On the displayed page, click **Create Connection**.
3. Enter the equipment room details and select the Direct Connect location and port based on **Table 10-5**.

Table 10-5 Parameters required for creating a cloud connection

Parameter	Description
Billing Mode	Specifies how you are charged. Currently, only **Yearly/Monthly** is supported.
Region	Specifies the region where the connection is deployed. You can change the region in the upper left corner of the console.
Connection Name	Specifies the name of your connection.
Location	Specifies the Direct Connect location where your leased line can be connected to.
Carrier	Specifies the carrier that provides the leased line.
Port Type	Specifies the type of the port used by the connection. There are four types of ports: 1GE, 10GE, 40GE, and 100GE.
Leased Line Bandwidth	Specifies the bandwidth of the connection in the unit of Mbit/s. This is the bandwidth of the leased line you have purchased from the carrier.
Equipment Room Address	Specifies the address of your equipment room. The address must be specific to the floor your equipment room is on, for example, XX Equipment Room, XX Building, No. XX, Huajing Road, Pudong District, Shanghai.
Tag	Identifies the connection. A tag consists of a key and a value. You can add 10 tags to a connection. **NOTE** If a predefined tag has been created on TMS, you can directly select the corresponding tag key and value. For details about predefined tags, see **Predefined Tag Overview**.
Description	Provides supplementary information about the connection.

Parameter	Description
Required Duration	Specifies how long the connection will be used.
Auto-renew	Specifies whether to automatically renew the connection to ensure service continuity. It is recommended that you set the auto-renewal period to be the same as the required duration. If the required duration is three months, the system automatically renews the subscription for every three months.
Enterprise Project	Centrally manages cloud resources and members by project.

4. Click **Confirm Configuration**.
5. Confirm the order and click **Pay Now**.
6. Click **Confirm**.

Step 2 Create a virtual gateway.

1. Choose **Direct Connect** > **Virtual Gateways**, and click **Create Virtual Gateway** on the right. Add the VPC CIDR block and the container CIDR block in the VPC network model.

Figure 10-18 Creating a virtual gateway

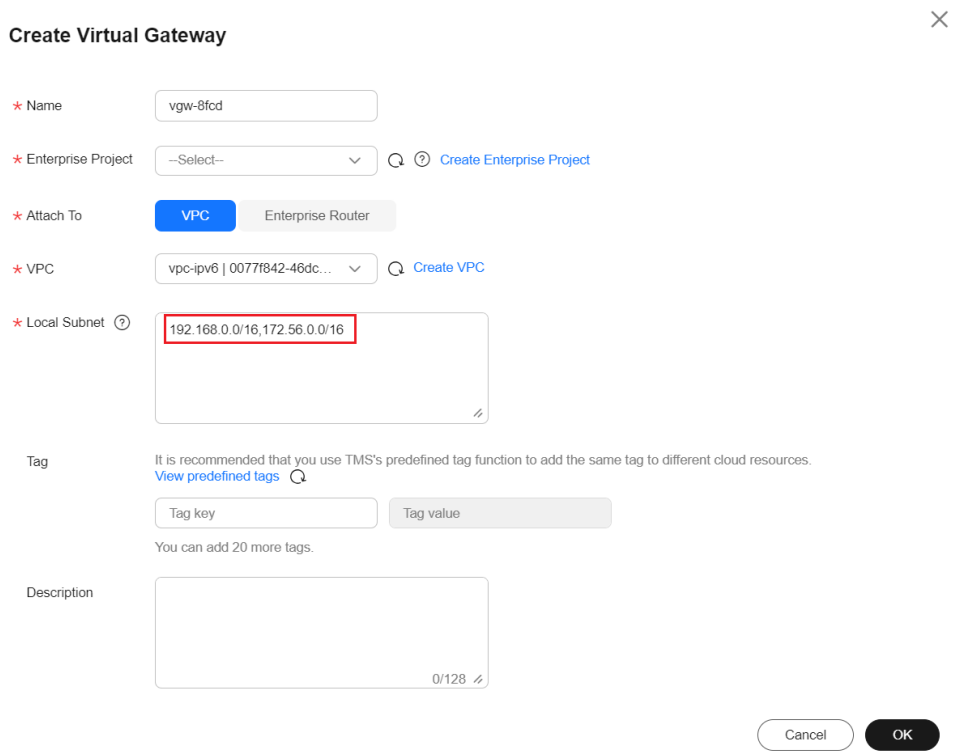


Table 10-6 Virtual gateway parameters

Parameter	Description
Name	Specifies the virtual gateway name. You can enter 1 to 64 characters.
Enterprise Project	Centrally manages cloud resources and members by project.
Attach To	Select **VPC**.
VPC	Specifies the VPC you want to access using the connection.
Local Subnet	Specifies the CIDR blocks of subnets in the VPC to connect to the on-premises network. In this example, the cluster uses the VPC network model. Enter the VPC CIDR block (192.168.0.0/16) and container CIDR block (172.56.0.0/16). For clusters using the container tunnel network and Cloud Native 2.0 Network models, you only need to enter the VPC CIDR block.
Description	Provides supplementary information about the virtual gateway. The description can contain a maximum of 128 characters.

2. Click **OK**.

   When the virtual gateway status changes **Normal**, the virtual gateway has been created.

Step 3 Create a virtual interface.

1. Choose **Direct Connect** > **Virtual Interfaces**, and click **Create Virtual Interface** on the right.
2. Configure the parameters based on **Table 10-7**.

Figure 10-19 Creating a virtual interface

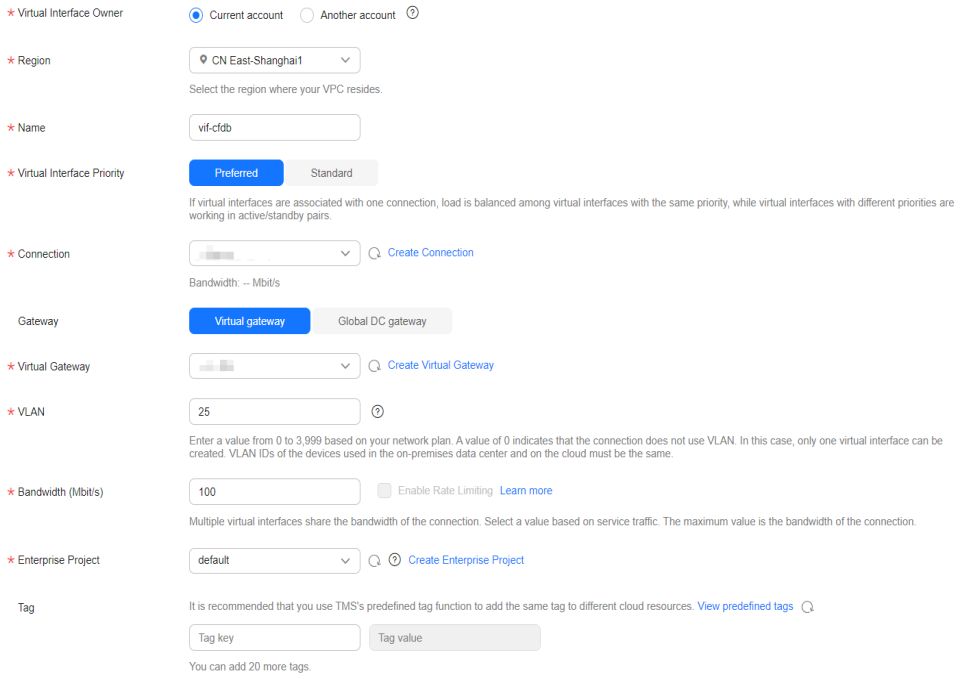


Table 10-7 Parameters required for creating a virtual interface

Parameter	Description
Region	Specifies the region where the connection is deployed. You can change the region in the upper left corner of the console.
Name	Specifies the virtual interface name. You can enter 1 to 64 characters.
Connection	Specifies the connection you use to connect your data center to the cloud.
Virtual Gateway	Specifies the virtual gateway that the virtual interface connects to.
VLAN	Specifies the VLAN of the virtual interface. Configure the VLAN if you create a connection on your own. The VLAN for a hosted connection will be allocated by the carrier or partner. You do not need to configure the VLAN.
Bandwidth	Specifies the bandwidth that can be used by the virtual interface in the unit of Mbit/s. The bandwidth cannot exceed that of the connection.
Enterprise Project	Centrally manages cloud resources and members by project.

Parameter	Description
Local Gateway	Specifies the IP address for connecting to the cloud. In this example, the IP address is **10.0.0.1/30**.
Remote Gateway	Specifies the IP address for connecting to your on-premises network. The remote gateway must be in the same IP address range as the local gateway. Generally, a subnet with a 30-bit mask is recommended. In this example, the IP address is **10.0.0.2/30**.
Remote Subnet	Specifies the subnets of your on-premises network. If multiple remote subnets are available, use commas (,) to separate them. In this example, the IP address is **10.1.123.0/24**.
Routing Mode	Specifies the routing mode. Two options are available, **Static** and **BGP**. If there are two or more connections, select BGP routing.
BGP ASN	Specifies the ASN of the BGP peer. This parameter is mandatory when you select BGP routing.
BGP MD5 Authentication Key	Specifies the password used to authenticate the BGP peer using MD5. This parameter is mandatory when BGP routing is selected, and the parameter values on both gateways must be the same. The key contains 8 to 255 characters and must contain at least two types of the following characters: – Uppercase letters – Lowercase letters – Digits – Special characters ~!, .:;-_"(){}[]/@#$ %^&*+|=
Description	Provides supplementary information about the virtual interface.

3. Click **Create Now**. When the status of the virtual interface changes to **Normal**, the virtual interface has been created.
4. Ping the IP address of a server in the VPC from your data center to test network connectivity.

   Now your environment can connect to the cloud and access the desired VPC.

   NOTE

   After creating a virtual interface, configure your devices and security group rules to allow access on and off the cloud.

Step 4 Test the connectivity.

1. Run the **traceroute** command to check whether the IDC host can communicate with the container.
   a. If the route is normal, Direct Connect has a return route.
   b. If the IDC route to the cloud gateway of Direct Connect is abnormal, check whether the route settings at both ends of Direct Connect are correct.
2. If the IP address cannot be tracerouted, try the ping or telnet operation. Before pinging the address, ensure that the ICMP policy has been enabled for the security group if the target is an ECS.

----End

10.5 Enabling a CCE Cluster to Resolve Domain Names on Both On-Premises IDCs and HUAWEI CLOUD

10.5.1 Solution Overview

Background

Microservices are increasingly used to deploy applications. When microservices access each other, they need to resolve domain names.

When you have on-premises IDCs with internal domain names configured, and you have deployed containerized applications on both these IDCs and cloud, you need to enable the containers and nodes in CCE clusters to resolve domain names of both the IDC and cloud.

Suppose you have reconstructed one of your applications using microservices. You run the application management backend in a CCE cluster, deploy the content moderation service in the on-premises IDC, and use the image recognition service on Huawei Cloud. The VPC where CCE resides is connected to the IDC through a private line. **Figure 10-20** shows the deployment architecture.

When a user accesses this application, the following interaction is involved between different microservices:

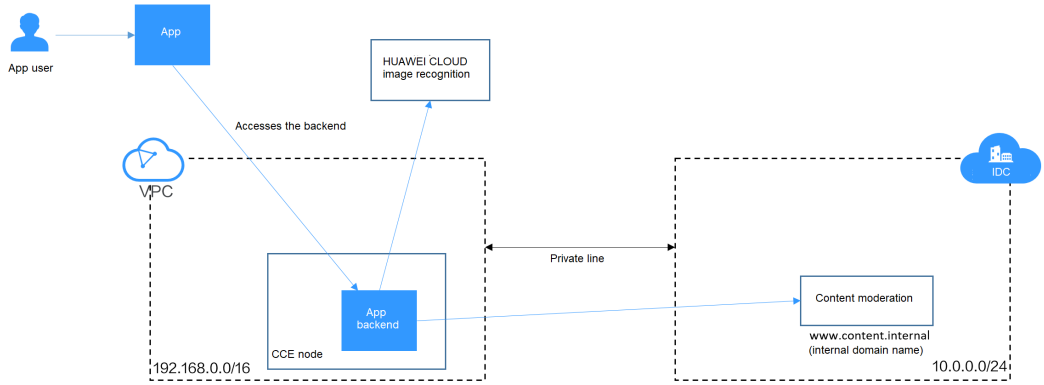
- The CCE cluster uses the Huawei Cloud DNS server, by default, to access the image recognition service.
- The CCE cluster uses the internal DNS server of the IDC to access the content moderation service deployed in the IDC.

In this case, the CCE cluster must be able to use both the Huawei Cloud DNS server and the internal DNS server of the IDC. If the DNS server on the CCE node points to that of the IDC, the domain name of Huawei Cloud cannot be resolved. If the IP address of the IDC internal domain name is added to the **hosts** file, the configuration of the CCE node needs to be updated in real time when the IDC internal service IP changes. This is difficult to implement and may cause the CCE node to be unavailable.

NOTE

The content moderation and image recognition services are used only as examples.

Figure 10-20 Application deployment architecture



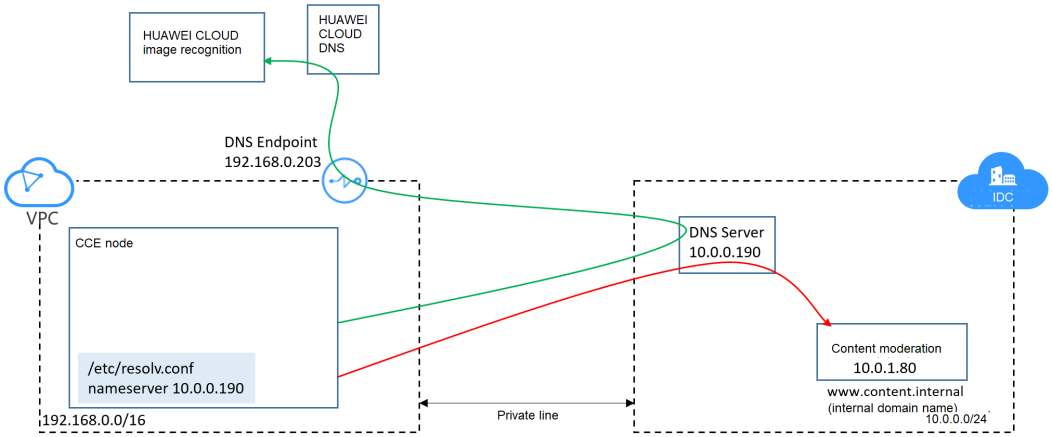
This section provides a solution for CCE clusters to resolve domain names of both on-premises IDCs and Huawei Cloud.

Solution 1: Using the DNS Endpoint for Cascading Resolution

You can use the VPC endpoint service to create a DNS endpoint cascaded with the IDC DNS server, so that nodes and containers in the CCE cluster can use the IDC DNS server for domain name resolution.

- If the Huawei Cloud domain name needs to be resolved, the request is forwarded to the DNS endpoint, and the Huawei Cloud DNS server is used to resolve the address and return the result.
- If the IDC domain name needs to be resolved, the IDC DNS server directly resolves the address and returns the result.

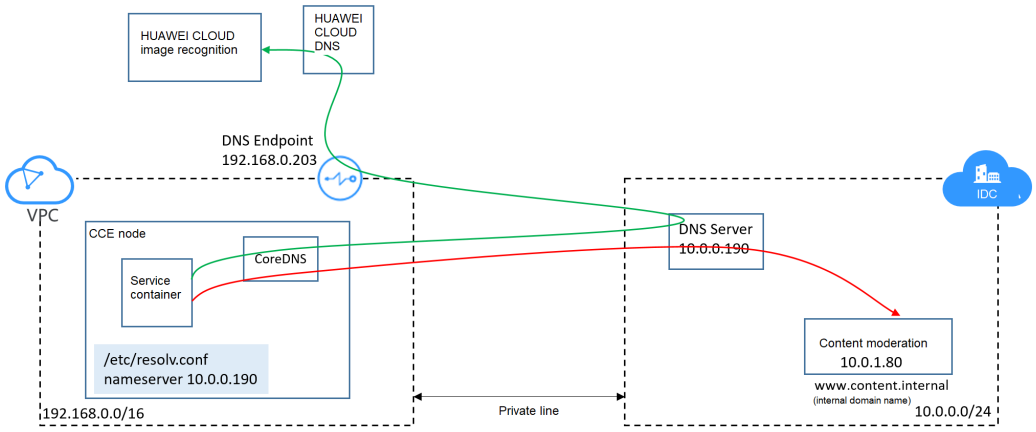
Figure 10-21 Accessing both the Huawei Cloud domain name and external domain name (for nodes)



For domain name resolution in a container, you can set the DNS policy to **ClusterFirst** when creating a pod. In this way, the domain name resolution requests of the container are directly sent to CoreDNS.

- If a cluster-internal domain name needs to be resolved, CoreDNS directly returns the resolution result.
- If an external domain name needs to be resolved, CoreDNS forwards the request to the IDC DNS server for resolution.

Figure 10-22 Accessing both the Huawei Cloud domain name and external domain name (for containers)

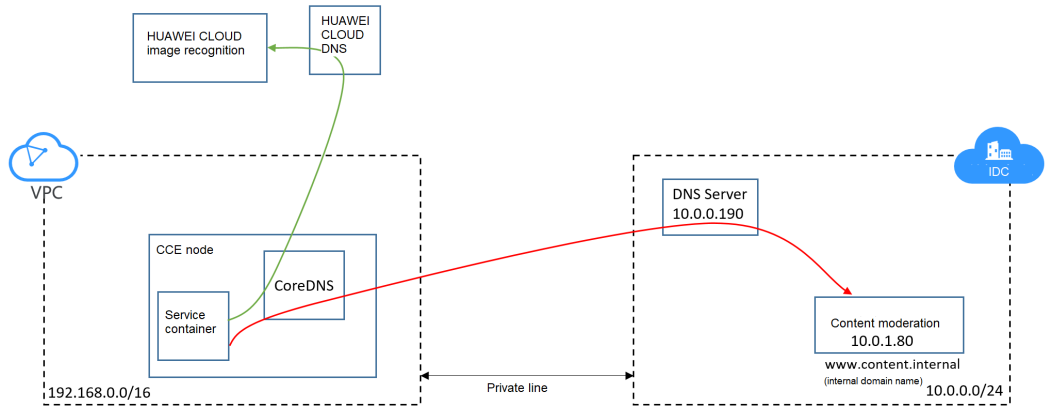


Solution 2: Changing the CoreDNS Configurations

Set the DNS policy to **ClusterFirst** when creating a pod so that the domain name resolution requests of containers are directly sent to CoreDNS.

- If a cluster-internal domain name needs to be resolved, CoreDNS directly returns the resolution result.
- If an external domain name needs to be resolved, CoreDNS forwards the request to the IDC DNS server for resolution.
- If a container accesses a Huawei Cloud internal domain name, the domain name is resolved by the internal DNS server of Huawei Cloud.

Figure 10-23 Domain name resolution in solution 2



Solution Comparison

Solution	Advantage	Disadvantage
Using the DNS endpoint for cascading resolution	External domain names can be resolved for containers and nodes in a CCE cluster.	An external DNS server is required to forward the requests for resolving internal domain names of Huawei Cloud, resulting in performance loss.
Changing the CoreDNS configuration	No external DNS server is required to forward the requests for resolving internal domain names of Huawei Cloud. Therefore, there is no performance loss.	• External domain names cannot be resolved on CCE cluster nodes. • The configuration will be lost if CoreDNS is upgraded or rolled back, and you need to reconfigure CoreDNS.

10.5.2 Solution 1: Using a DNS Endpoint for Cascading Resolution

Prerequisites

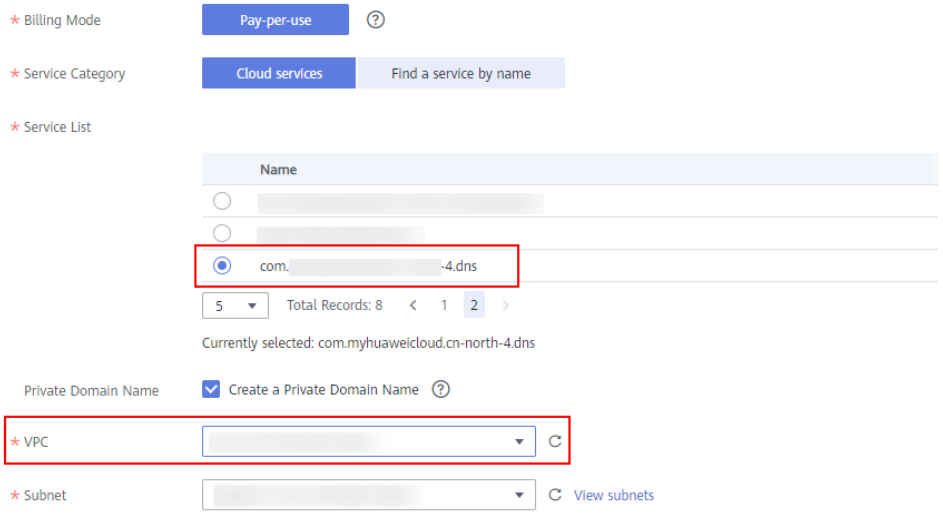
The VPC where the CCE cluster is deployed has been connected to the on-premises IDC through a private line (Direct Connect) or other channels. The IDC can access the IP addresses in the VPC CIDR block and CCE cluster container CIDR block. For details about how to create a Direct Connect connection, see **Getting Started with Direct Connect**.

Procedure

Step 1 Create a DNS endpoint in the VPC where the CCE cluster is deployed.

1. Access the **VPC Endpoint** page on the network console.
2. Click **Buy VPC Endpoint** in the upper right corner.
3. Select the DNS service and VPC where the CCE cluster is deployed.

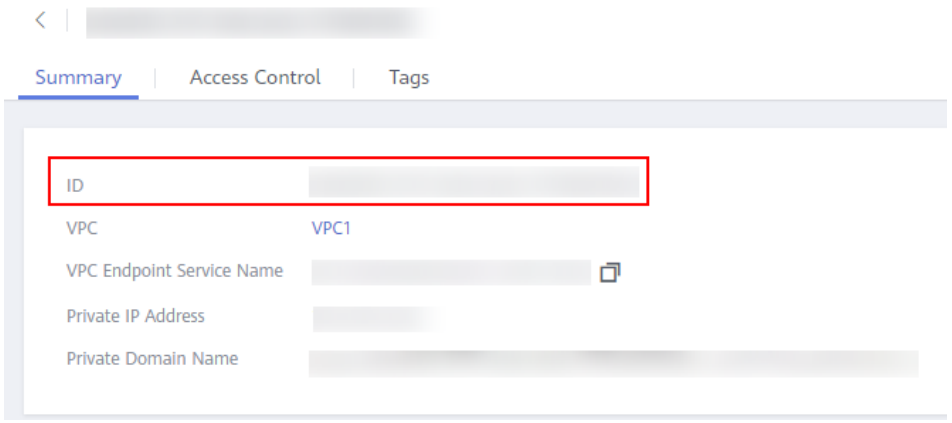
Figure 10-24 Creating a DNS endpoint



4. Click **Next** and then **Submit**.

   After the creation is complete, you can view the IP address of the DNS endpoint on its details page.

Figure 10-25 IP address of the DNS endpoint



Step 2 Configure cascading on the IDC DNS server.

NOTE

The configuration varies depending on the DNS server. The following configurations are used only as example.

BIND (a commonly used DNS server software) is used for the following demonstration.

In this step, you configure the DNS server to forward the requests of resolving Huawei Cloud internal domain names to the DNS endpoint created in the previous step.

For example, in BIND, you can add the lines marked in red to the **/etc/named.conf** file. **192.168.0.203** is the IP address of the DNS endpoint created in **Step 1**.

```
options {
        listen-on port 53 { any; };
        listen-on-v6 port 53 { ::1; };
```



```
        directory       "/var/named";
        dump-file       "/var/named/data/cache_dump.db";
        statistics-file "/var/named/data/named_stats.txt";
        memstatistics-file "/var/named/data/named_mem_stats.txt";
        recursing-file  "/var/named/data/named.recursing";
        secroots-file   "/var/named/data/named.secroots";
        allow-query     { any; };

        forward first;
        forwarders { 192.168.0.203; };

        .....
};
```

Step 3 Change the DNS configuration of the node in the CCE cluster.

You can use either of the following methods to change the settings.

Method 1:

Change the settings after the node is created.

1. Log in to the worker node of the CCE cluster.
2. In the **/etc/resolv.conf** file, change the value of nameserver to the IP address of the IDC DNS server.

   ```
   # vi /etc/resolv.conf
   nameserver 10.0.0.190
   ```

3. Run the following command to lock the **resolv.conf** file to prevent it from being automatically updated by Huawei Cloud.

   chattr +i /etc/resolv.conf

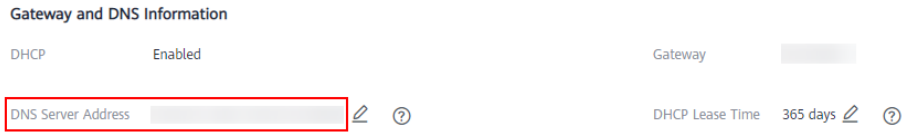
   For details about how to configure DNS, see **Configuring DNS**.

Method 2:

Change the DNS settings of the VPC subnet where the CCE cluster resides. In this way, the IP address of the specified DNS server is used in the **/etc/resolv.conf** file for newly created worker nodes.

Before using this method, ensure that the node can use the IDC DNS server to resolve the Huawei Cloud internal domain name. Otherwise, the node cannot be created. You are advised to commission the DNS server before you change the DNS settings of the VPC subnet.

Figure 10-26 Subnet DNS settings



Step 4 Configure the workload DNS policy.

When creating a workload, you can set **dnsPolicy** to **ClusterFirst** in the YAML file for domain name resolution in containers. This is also the default configuration in Kubernetes. For details about how to configure DNS for workloads, see **DNS Configuration**.

```
apiVersion: v1
kind: Pod
metadata:
```



```
  namespace: default
  name: dns-example
spec:
  containers:
  - name: test
    image: nginx
  dnsPolicy: ClusterFirst
```

----End

Verification

After the configuration is complete, run the **dig** command on the cluster node. The command output shows that the IP address of the server is **10.0.0.190**, which indicates that the domain name is resolved by the IDC DNS server.

```
# dig cce.ap-southeast-1.myhuaweicloud.com

; <<>> DiG 9.9.4-61.1.h14.eulerosv2r7 <<>> cce.ap-southeast-1.myhuaweicloud.com
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 24272
;; flags: qr rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 0, ADDITIONAL: 1

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 4096
;; QUESTION SECTION:
;cce.ap-southeast-1.myhuaweicloud.com. IN    A

;; ANSWER SECTION:
cce.ap-southeast-1.myhuaweicloud.com. 274 IN A       100.125.4.16

;; Query time: 4 msec
;; SERVER: 10.0.0.190#53(10.0.0.190)
;; WHEN: Tue Feb 23 19:16:08 CST 2021
;; MSG SIZE  rcvd: 76
```

Access a domain name of Huawei Cloud from the cluster node. The following output shows that the domain name is resolved to the corresponding IP address.

```
# ping cce.ap-southeast-1.myhuaweicloud.com
PING cce.ap-southeast-1.myhuaweicloud.com (100.125.4.16) 56(84) bytes of data.
```

Create a pod to access the Huawei Cloud domain name. The following output shows that the domain name can be resolved.

```
# kubectl run -i --tty --image tutum/dnsutils dnsutils --restart=Never --rm /bin/sh
If you do not see a command prompt, try pressing Enter.
# ping cce.ap-southeast-1.myhuaweicloud.com
PING cce.ap-southeast-1.myhuaweicloud.com (100.125.4.16) 56(84) bytes of data.
```

10.5.3 Solution 2: Changing the CoreDNS Configurations

Prerequisites

The VPC where the CCE cluster is deployed has been connected to the on-premises IDC through a private line (Direct Connect) or other channels. The IDC can access the IP addresses in the VPC CIDR block and CCE cluster container CIDR block. For details about how to create a Direct Connect connection, see **Getting Started with Direct Connect**.

Procedure

CoreDNS configurations are stored in the ConfigMap named **coredns**. You can find this ConfigMap in the kube-system namespace. Run the following command to view the default configurations.

kubectl get configmap coredns -n kube-system -oyaml

```
kind: ConfigMap
apiVersion: v1
metadata:
  name: coredns
  namespace: kube-system
  selfLink: /api/v1/namespaces/kube-system/configmaps/coredns
  uid: d54ed5df-f4a0-48ec-9bc0-3efc1ac76af0
  resourceVersion: '21789515'
  creationTimestamp: '2021-03-02T09:21:55Z'
  labels:
    app: coredns
    k8s-app: coredns
    kubernetes.io/cluster-service: 'true'
    kubernetes.io/name: CoreDNS
    release: cceaddon-coredns
data:
  Corefile: |-
    .:5353 {
        bind {$POD_IP}
        cache 30
        errors
        health {$POD_IP}:8080
        kubernetes cluster.local in-addr.arpa ip6.arpa {
          pods insecure
          upstream /etc/resolv.conf
          fallthrough in-addr.arpa ip6.arpa
        }
        loadbalance round_robin
        prometheus {$POD_IP}:9153
        forward . /etc/resolv.conf
        reload
    }
```

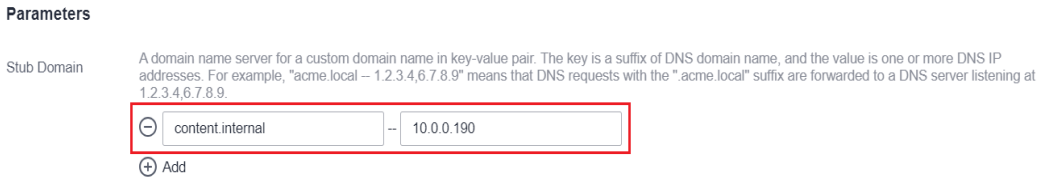
The preceding example shows that all CoreDNS configurations are defined in **Corefile**. By default, resolution requests of any domain name that does not belong to the Kubernetes cluster are directed to the DNS server specified by **forward**. In **forward . /etc/resolv.conf**, the first period (.) indicates all domain names, and **/etc/resolv.conf.** indicates the DNS server of the node.

If a specific external domain name needs to be resolved, you can add an extra configuration item. For example, if you want to forward the requests of resolving the domain name **content.internal** to the DNS server whose IP address is 10.0.0.190, perform the following operations to add configurations in **Corefile**.

Step 1 Log in to the CCE console and click the cluster name to access the cluster console.

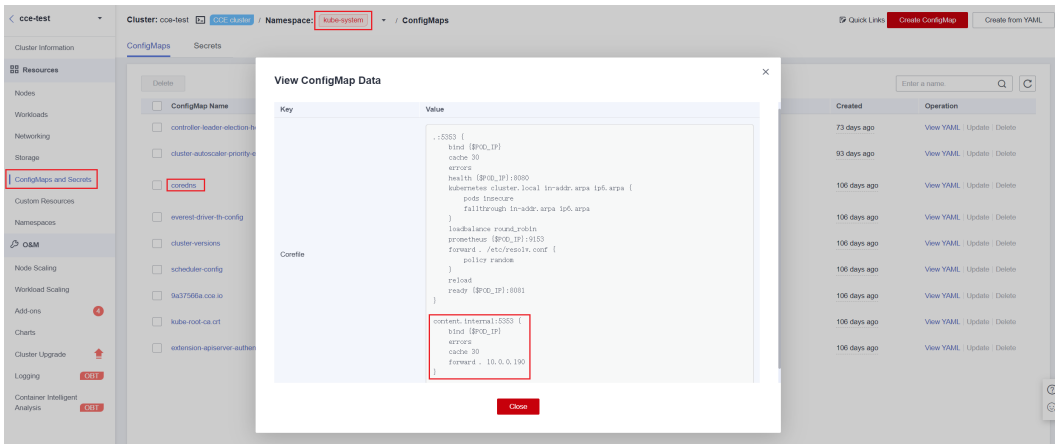
Step 2 In the navigation pane, choose **Add-ons**. Then, click **Edit** under **CoreDNS**.

Step 3 Add a stub domain in the **Parameters** area. A stub domain is a key-value pair. The key is a DNS suffix domain name, and the value is a DNS IP address or a group of DNS IP addresses. In this example, set the key-value pair to **content.internal --10.0.0.190**.



Step 4 Click **OK**.

Step 5 Choose **ConfigMaps and Secrets** in the navigation pane. In the **kube-system** namespace, view the coredns configuration data to check whether the update is successful.



Corresponding Corefile content:

```
.:5353 {
    bind {$POD_IP}
    cache 30
    errors
    health {$POD_IP}:8080
    kubernetes cluster.local in-addr.arpa ip6.arpa {
        pods insecure
        fallthrough in-addr.arpa ip6.arpa
    }
    loadbalance round_robin
    prometheus {$POD_IP}:9153
    forward . /etc/resolv.conf {
        policy random
    }
    reload
    ready {$POD_IP}:8081
}
content.internal:5353 {
    bind {$POD_IP}
    errors
    cache 30
    forward . 10.0.0.190
}
```

For details about other CoreDNS configurations, see **Customizing DNS Service**.

----End

Verification

Create a pod to access the IDC domain name. The following output shows that the domain name can be resolved.


```
web-terminal-568c6566df-c9jhl:~# kubectl run -i --tty --image tutum/dnsutils dnsutils --restart=Never --
rm /bin/sh
If you don't see a command prompt, try pressing enter.
# ping www.content.internal
PING www.content.internal (10.0.1.80) 56(84) bytes of data.
64 bytes from 10.0.1.80: icmp_seq=1 ttl=64 time=1.08 ms
64 bytes from 10.0.1.80: icmp_seq=2 ttl=64 time=0.337 ms
```

Access a Huawei Cloud domain name. The following output shows that the domain name can be resolved.

```
# ping cce.ap-southeast-1.myhuaweicloud.com
PING cce.ap-southeast-1.myhuaweicloud.com (100.125.4.16) 56(84) bytes of data.
```

Access the IDC domain name on the cluster node. The domain name cannot be pinged, indicating that the CoreDNS configurations do not affect the domain name resolution of the node.

10.6 Implementing Sticky Session Through Load Balancing

Concepts

Sticky sessions ensure continuity and consistency when you access applications. If a load balancer is deployed between a client and backend servers, connections may be forwarded to different servers for processing. Sticky sessions can resolve this issue. After sticky session is enabled, requests from the same client will be continuously distributed to the same backend server through load balancing.

For example, in most online systems that require user identity authentication, a user needs to interact with the server for multiple times to complete a session. These interactions require continuity. If sticky session is not configured, the load balancer may allocate certain requests to different backend servers. Since user identity has not been authenticated on other backend servers, interaction exceptions such as a user login failure may occur.

Therefore, select a proper sticky session type based on the application environment.

Table 10-8 Sticky session types

OSI Layer	Listener Protocol and Networking	Sticky Session Type	Scenarios Where Sticky Sessions Become Invalid
Layer 4	TCP- or UDP-compliant Services	**Source IP address**: The source IP address of each request is calculated using the consistent hashing algorithm to obtain a unique hashing key, and all backend servers are numbered. The system allocates the client to a particular server based on the generated key. This allows requests from the same IP address are forwarded to the same backend server.	• Source IP addresses of the clients have changed. • Requests from the clients exceed the session stickiness duration.
Layer 7	HTTP- or HTTPS-compliant ingresses	• **Load balancer cookie**: The load balancer generates a cookie after receiving a request from the client. All subsequent requests with the cookie will be routed to the same backend server. • **Application cookie**: The application deployed on the backend server generates a cookie after receiving the first request from the client. All subsequent requests with the same cookie will be routed to the same backend server.	• If requests sent by the clients do not contain a cookie, sticky sessions will not take effect. • Requests from the clients exceed the session stickiness duration.

NOTE

When creating a load balancer, configure sticky sessions by setting **kubernetes.io/elb.lb-algorithm** to **ROUND_ROBIN** or **kubernetes.io/elb.lb-algorithm** to **LEAST_CONNECTIONS**. If you set **kubernetes.io/elb.lb-algorithm** is to **SOURCE_IP**, source IP address-based sticky sessions are supported. In this case, you do not need to configure sticky sessions again.

Layer 4 Sticky Sessions for Services

In Layer 4 mode, source IP address-based sticky sessions can be enabled, where hash routing is performed based on the client IP address.

Enabling Layer 4 Sticky Session in a CCE Standard Cluster

In a CCE standard cluster, to enable source IP address-based sticky session for a Service, ensure the following conditions are met:

1. **Service Affinity** of the Service must be set to **Node-level**, where the **externalTrafficPolicy** value of the Service must be **Local**.
2. Anti-affinity has been enabled on the backend applications of the Service to prevent all pods from being deployed on the same node.

Procedure

Step 1 Create an Nginx workload.

Set the number of pods to 3 and configure podAntiAffinity.

```
kind: Deployment
apiVersion: apps/v1
metadata:
  name: nginx
  namespace: default
spec:
  replicas: 3
  selector:
    matchLabels:
      app: nginx
  template:
    metadata:
      labels:
        app: nginx
    spec:
      containers:
        - name: container-0
          image: 'nginx:perl'
          resources:
            limits:
              cpu: 250m
              memory: 512Mi
            requests:
              cpu: 250m
              memory: 512Mi
      imagePullSecrets:
        - name: default-secret
      affinity:
        podAntiAffinity:                # Pod anti-affinity
          requiredDuringSchedulingIgnoredDuringExecution:
            - labelSelector:
                matchExpressions:
                  - key: app
                    operator: In
                    values:
                      - nginx
              topologyKey: kubernetes.io/hostname
```

Step 2 Create a LoadBalancer Service, for example, using an existing load balancer. The following shows an example YAML file for configuring source IP address-based sticky sessions:

```
apiVersion: v1
kind: Service
metadata:
  name: svc-example
  namespace: default
  annotations:
    kubernetes.io/elb.class: union
    kubernetes.io/elb.id: *****
    kubernetes.io/elb.lb-algorithm: ROUND_ROBIN      # Weighted round robin allocation policy
    kubernetes.io/elb.session-affinity-mode: SOURCE_IP    # Enable source IP address-based sticky session.
```

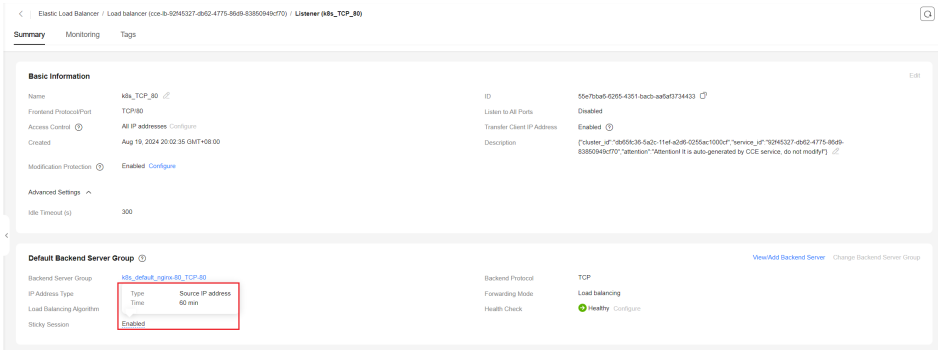


```
spec:
  selector:
    app: nginx
  externalTrafficPolicy: Local    # Node level Service affinity
  ports:
    - name: cce-service-0
      targetPort: 80
      nodePort: 32633
      port: 80
      protocol: TCP
  type: LoadBalancer
```

Step 3 Check whether the Layer 4 sticky session function is enabled.

1. Log in to the ELB console, locate the row containing the target load balancer, and click the listener name.
2. Check whether the sticky session function is enabled in the backend server group.

Figure 10-27 Enabling Layer 4 sticky session



----End

Enabling Layer 4 Sticky Session in a CCE Turbo Cluster

In a CCE Turbo cluster, enabling source IP address-based sticky session for a Service relies on the load balancer type.

- When a dedicated load balancer is used, passthrough networking is allowed between the load balancer and pods, and pods function as the backend server group of the load balancer. Therefore, you do not need to configure Service affinity or application anti-affinity when enabling source IP address-based sticky session for the Service.
- If a shared load balancer is used, sticky session cannot be enabled.

Procedure

- **For dedicated load balancers**

  The following shows an example YAML file for configuring source IP address-based sticky sessions for a Service that uses an existing load balancer:

```
apiVersion: v1
kind: Service
metadata:
  name: svc-example
  namespace: default
  annotations:
```



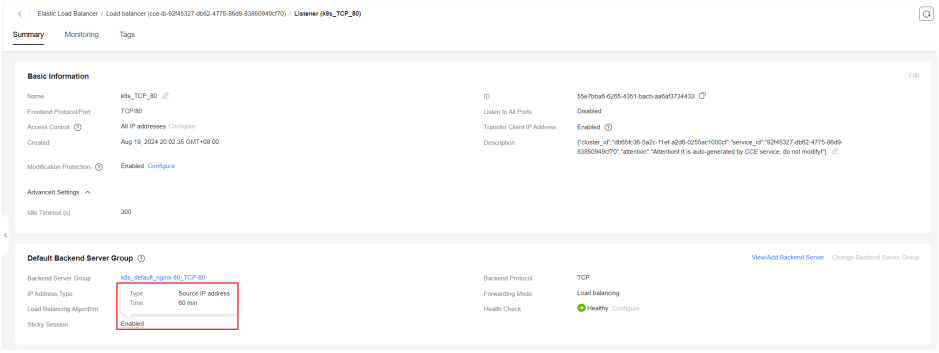
```
    kubernetes.io/elb.class: performance
    kubernetes.io/elb.id: *****
    kubernetes.io/elb.lb-algorithm: ROUND_ROBIN      # Weighted round robin allocation policy
    kubernetes.io/elb.session-affinity-mode: SOURCE_IP     # Enable source IP address-based sticky
session.
spec:
  selector:
    app: nginx
  externalTrafficPolicy: Cluster      # In CCE Turbo clusters, Service affinity does not need to be
configured if a dedicated load balancer is used.
  ports:
    - name: cce-service-0
      targetPort: 80
      nodePort: 32633
      port: 80
      protocol: TCP
  type: LoadBalancer
```

Verify that the Layer 4 sticky session function is enabled.

a. Log in to the ELB console, locate the row containing the target load balancer, and click the listener name.

b. Check whether the sticky session function is enabled in the backend server group.

Figure 10-28 Enabling Layer 4 sticky session



Layer 7 Sticky Sessions for Ingresses

In Layer 7 mode, sticky sessions can be enabled using HTTP cookies or application cookies.

Enabling Layer 7 Sticky Session in a CCE Standard Cluster

To enable cookie-based sticky session on an ingress, ensure the following conditions are met:

1. **Service Affinity** of the ingress must be set to **Node-level**, where the **externalTrafficPolicy** value of the Service must be **Local**.
2. Anti-affinity must be enabled for the ingress workload to prevent all pods from being deployed on the same node.

Procedure

Step 1 Create an Nginx workload.

Set the number of pods to 3 and configure podAntiAffinity.


```
kind: Deployment
apiVersion: apps/v1
metadata:
  name: nginx
  namespace: default
spec:
  replicas: 3
  selector:
    matchLabels:
      app: nginx
  template:
    metadata:
      labels:
        app: nginx
    spec:
      containers:
        - name: container-0
          image: 'nginx:perl'
          resources:
            limits:
              cpu: 250m
              memory: 512Mi
            requests:
              cpu: 250m
              memory: 512Mi
      imagePullSecrets:
        - name: default-secret
      affinity:
        podAntiAffinity:                  # Pod anti-affinity
          requiredDuringSchedulingIgnoredDuringExecution:
            - labelSelector:
                matchExpressions:
                  - key: app
                    operator: In
                    values:
                      - nginx
              topologyKey: kubernetes.io/hostname
```

Step 2 Create a Service for the workload. This section uses a NodePort Service as an example.

Configure sticky sessions during the creation of a Service. An ingress can access multiple Services, and each Service can have different sticky sessions.

```
apiVersion: v1
kind: Service
metadata:
  name: nginx
  namespace: default
  annotations:
    kubernetes.io/elb.lb-algorithm: ROUND_ROBIN      # Weighted round robin allocation policy
    kubernetes.io/elb.session-affinity-mode: HTTP_COOKIE      # HTTP cookie
    kubernetes.io/elb.session-affinity-option: '{"persistence_timeout":"1440"}'   # Session stickiness duration,
in minutes. The value ranges from 1 to 1440.
spec:
  selector:
    app: nginx
  ports:
    - name: cce-service-0
      protocol: TCP
      port: 80
      targetPort: 80
      nodePort: 32633           # Custom node port
  type: NodePort
  externalTrafficPolicy: Local   # Node level Service affinity
```

You can also select **APP_COOKIE**.

NOTICE

Only shared load balancers support application cookie-based sticky sessions. For details, see **What Are the Relationships Between Load Balancing Algorithms and Sticky Session Types?**

```
apiVersion: v1
kind: Service
metadata:
  name: nginx
  namespace: default
  annotations:
    kubernetes.io/elb.lb-algorithm: ROUND_ROBIN      # Weighted round robin allocation policy
    kubernetes.io/elb.session-affinity-mode: APP_COOKIE      # Select APP_COOKIE.
    kubernetes.io/elb.session-affinity-option: '{"app_cookie_name":"test"}'  # Application cookie name
spec:
  selector:
    app: nginx
  ports:
    - name: cce-service-0
      protocol: TCP
      port: 80
      targetPort: 80
      nodePort: 32633            # Custom node port
  type: NodePort
  externalTrafficPolicy: Local   # Node level Service affinity
```

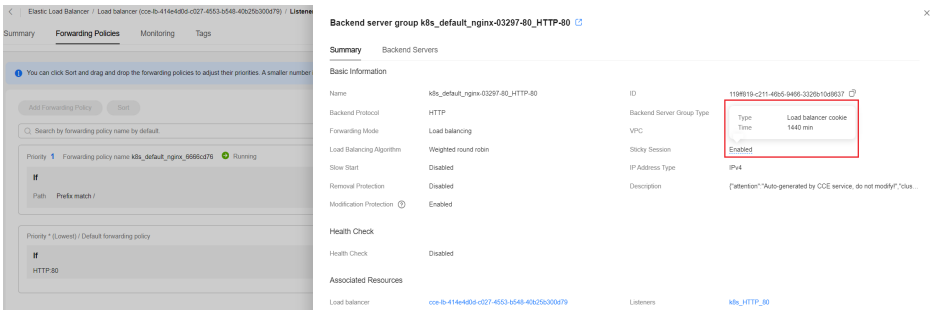
Step 3 Create an ingress and associate it with the Service. The following uses an existing load balancer as an example. For details about how to automatically create a load balancer, see **Using kubectl to Create an ELB Ingress**.

```
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: ingress-test
  namespace: default
  annotations:
    kubernetes.io/elb.class: union
    kubernetes.io/elb.port: '80'
    kubernetes.io/elb.id: *****
spec:
  rules:
  - host: 'www.example.com'
    http:
      paths:
      - path: '/'
        backend:
          service:
            name: nginx     # Service name
            port:
              number: 80
        property:
          ingress.beta.kubernetes.io/url-match-mode: STARTS_WITH
        pathType: ImplementationSpecific
  ingressClassName: cce
```

Step 4 Verify that the Layer 7 sticky session function is enabled.

1. Log in to the ELB console, locate the row containing the target load balancer, and click the listener name.
2. Click the **Forwarding Policies** tab, click the backend server group name, and check whether sticky session is enabled for it.

Figure 10-29 Enabling Layer 7 sticky session



----End

Enabling Layer 7 Sticky Session in a CCE Turbo Cluster

Enable cookie-based sticky session on the ingress.

- When a dedicated load balancer is used, passthrough networking is allowed between the load balancer and pods, and pods function as the backend server group of the load balancer. Therefore, you do not need to configure Service affinity or application anti-affinity when enabling cookie-based sticky session for the ingress.
- If a shared load balancer is used, sticky session cannot be enabled.

Procedure

- **For dedicated load balancers**
  a. Create a Service for the workload. In a CCE Turbo cluster, the ingresses that use a dedicated load balancer must interconnect with ClusterIP Services.

     Configure sticky sessions during the creation of a Service. An ingress can access multiple Services, and each Service can have different sticky sessions.

```
apiVersion: v1
kind: Service
metadata:
  name: nginx
  namespace: default
  annotations:
    kubernetes.io/elb.lb-algorithm: ROUND_ROBIN      # Weighted round robin allocation policy
    kubernetes.io/elb.session-affinity-mode: HTTP_COOKIE      # HTTP cookie
    kubernetes.io/elb.session-affinity-option: '{"persistence_timeout":"1440"}'    # Session
stickiness duration, in minutes. The value ranges from 1 to 1440.
spec:
  selector:
    app: nginx
  ports:
    - name: cce-service-0
      protocol: TCP
      port: 80
      targetPort: 80
      nodePort: 0
  type: ClusterIP
```

  b. Create an ingress and associate it with the Service. The following uses an existing load balancer as an example. For details about how to automatically create a load balancer, see **Using kubectl to Create an ELB Ingress**.

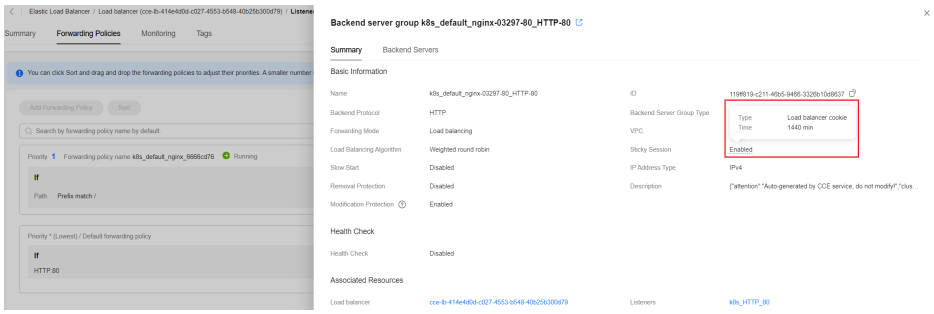

```
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: ingress-test
  namespace: default
  annotations:
    kubernetes.io/elb.class: performance
    kubernetes.io/elb.port: '80'
    kubernetes.io/elb.id: *****
spec:
  rules:
  - host: 'www.example.com'
    http:
      paths:
      - path: '/'
        backend:
          service:
            name: nginx     # Service name
            port:
              number: 80
        property:
          ingress.beta.kubernetes.io/url-match-mode: STARTS_WITH
        pathType: ImplementationSpecific
  ingressClassName: cce
```

c. Verify that the Layer 7 sticky session function is enabled.

   i. Log in to the ELB console, locate the row containing the target load balancer, and click the listener name.

   ii. Click the **Forwarding Policies** tab, click the backend server group name, and check whether sticky session is enabled for it.

Figure 10-30 Enabling Layer 7 sticky session

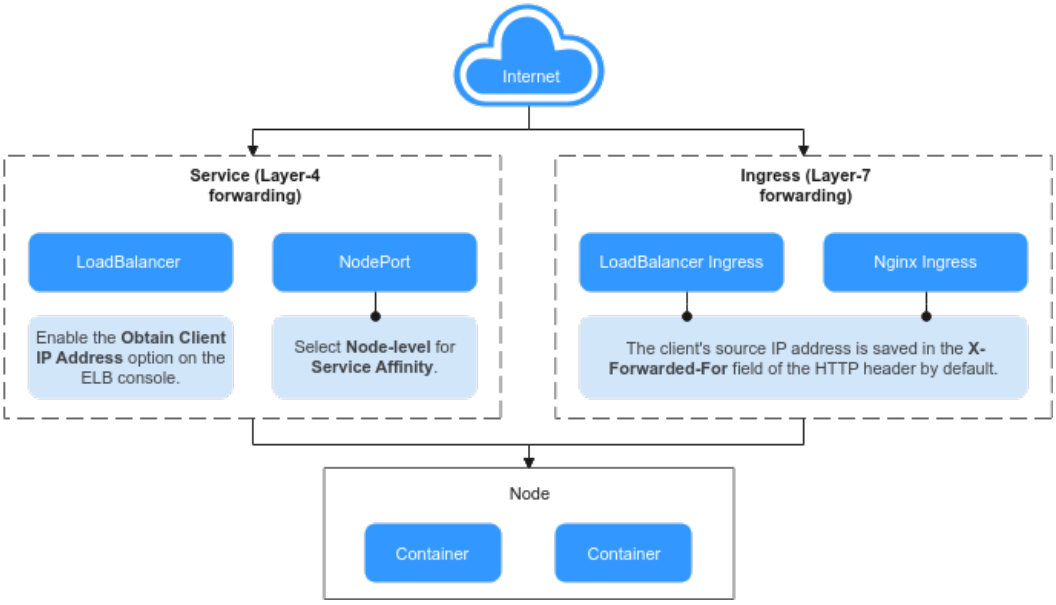


10.7 Obtaining the Client Source IP Address for a Container

When using containers, clients may communicate with them through multiple proxy servers. However, this can cause issues with transferring the clients' source IP addresses to the containers' services. This section describes how to effectively obtain the source IP address of a client in a container based on different network solutions provided by CCE clusters.

Description

Figure 10-31 Obtaining the source IP addresses from the containers



The method for obtaining source client IP addresses may vary with the network settings. The following shows some typical network configurations and their corresponding solutions:

- **Ingress Layer-7 forwarding**: When accessing an application at Layer-7, the client's source IP address is automatically saved in the **X-Forwarded-For** field of the HTTP header. No additional configurations are needed to obtain the client's source IP address.
- **Service Layer-4 forwarding**: The method and principle for obtaining the source IP addresses will depend on the type of Services being used.
  - LoadBalancer Service: A load balancer is used as the traffic entry. Both shared and dedicated load balancers are supported.
    - For a shared load balancer, you need to enable the function of obtaining client IP addresses on the listeners.
    - By default, the function of obtaining client IP addresses is enabled for a dedicated load balancer listener.
  - NodePort Service: Container ports are mapped to node ports, which are used as the entry for external services. The capability of obtaining client source IP addresses depends on the service affinity.
    - In a cluster-level service affinity for a NodePort Service, traffic is forwarded within the cluster, which means the backend containers of the Service cannot access the client's source IP address.
    - In a node-level service affinity for a NodePort Service, the traffic can directly reach the container without any forwarding. This allows the backend containers of the Service to obtain the source IP address of the client.

NOTE

If Istio is used, you can obtain the source IP address by referring to **How Do I Obtain the Actual Source IP Address of a Client After a Service Is Added into Istio?**

Scenarios in Which Source IP Address Can Be Obtained

Due to network model differences, CCE does not allow obtaining source IP addresses in some scenarios, as listed in **Table 10-9**. "-" in the table indicates that this scenario does not exist.

Table 10-9 Scenarios in which source IP addresses can be obtained

Level-1 Category	Level-2 Category	Load Balancer Type	VPC and Container Tunnel Network Models	Cloud Native 2.0 Network Model (CCE Turbo Clusters)	Reference
Layer-7 forwarding (ingress)	ELB	Shared	Supported	Supported	**ELB Ingress**
		Dedicated	Supported	Supported	
	Nginx (connecting to the NGINX Ingress Controller add-on)	Shared	Supported	Not supported	**Nginx Ingress**
		Dedicated	Supported	Supported	This function is enabled by default. No other configuration is required.
Layer-4 forwarding (Service)	LoadBalancer	Shared	Supported	Not supported (supported by workloads that use hostNetwork)	**LoadBalancer**
		Dedicated	Supported	Supported	

Level-1 Category	Level-2 Category	Load Balancer Type	VPC and Container Tunnel Network Models	Cloud Native 2.0 Network Model (CCE Turbo Clusters)	Reference
	NodePort	-	Supported	Not supported (supported by workloads that use hostNetwork)	NodePort

ELB Ingress

For the ELB Ingresses (using HTTP- or HTTPS-compliant), the function of obtaining the source IP addresses of the client is enabled by default. No other operation is required.

A client source IP address is placed in the **X-Forwarded-For** field of the HTTP header by the load balancer. The format is as follows:

```
X-Forwarded-For: <client-source-IP-address>, <proxy-server-1-IP-address>, <proxy-server-2-IP-address>, ...
```

The first IP address obtained from the **X-Forwarded-For** field is the client source IP address.

Nginx Ingress

NOTE

In Cloud Native 2.0 networks (for CCE Turbo clusters), **if a shared load balancer is used, source IP addresses cannot be obtained when an ingress is associated with the NGINX Ingress Controller add-on**. For details, see **Scenarios in Which Source IP Address Can Be Obtained**. To obtain the source IP address, uninstall the NGINX Ingress Controller add-on and use a dedicated load balancer during reinstallation.

- For an Nginx Ingress that uses a dedicated load balancer, transparent transmission of source IP addresses is enabled by default. This means that you can easily obtain the source IP address of the client without any additional configurations.
- For an Nginx Ingress that uses a shared load balancer, perform the following steps to obtain the source IP address of the client:

Step 1 Take the Nginx workload as an example. Before configuring the source IP address, obtain the access logs. **nginx-c99fd67bb-ghv4q** indicates the pod name.

```
kubectl logs nginx-c99fd67bb-ghv4q
```

Information similar to the following is displayed:

```
...
10.0.0.7 - - [17/Aug/2023:01:30:11 +0000] "GET / HTTP/1.1" 200 19 "http://114.114.114.114:9421/"
```



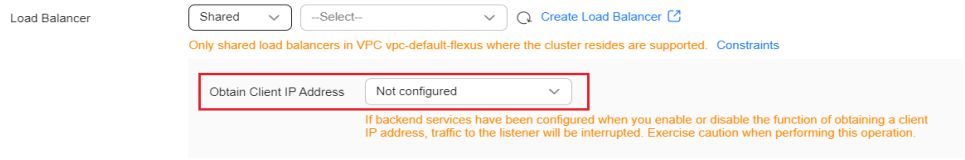
```
"Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/115.0.0.0 Safari/537.36 Edg/115.0.1901.203" "100.125.**.**"
```

100.125..**** specifies the CIDR block of the load balancer, indicating that the traffic is forwarded through the load balancer.

Step 2 Enable **Transfer Client IP Address**. **This operation is required only when shared load balancers are used. For dedicated load balancers, source IP address-based transparent transmission is enabled by default.**

Procedure for clusters of v1.23.17-r0, v1.25.12-r0, v1.27.9-r0, v1.28.7-r0, v1.29.3-r0, and later versions

1. Log in to the CCE console and click the cluster name to access the cluster console.
2. In the navigation pane, choose **Add-ons**. In the right pane, locate **NGINX Ingress Controller** and click **Manage**.
3. Click **Edit** under the installed instance and enable the function of obtaining the client IP address in the load balancer configuration.



4. Click **OK**.

   NOTE

   If backend services have been configured when you enable or disable the function of obtaining a client IP address, traffic will be interrupted. Exercise caution when performing this operation.

Procedure for clusters earlier than v1.23.17-r0, v1.25.12-r0, v1.27.9-r0, v1.28.7-r0, and v1.29.3-r0

1. Click  in the upper left corner of the management console and select a region and a project.
2. Choose **Service List** > **Networking** > **Elastic Load Balance**.
3. On the **Elastic Load Balance** page, click the name of the target load balancer.
4. Click the **Listeners** tab, locate the row containing the target listener, and click **Edit**. If modification protection exists, disable the protection on the basic information page of the listener and try again.
5. Enable **Transfer Client IP Address**.

Figure 10-32 Enabling the function

Step 3 Access the workload again and view the new access log.

```
...
10.0.0.7 - - [17/Aug/2023:02:43:11 +0000] "GET / HTTP/1.1" 304 0 "http://114.114.114.114:9421/" "Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/115.0.0.0 Safari/537.36 Edg/115.0.1901.203" "124.**.**.**"
```

The source IP address of the client is obtained.

----End

NOTE

You can enable WAF for the load balancers used by Nginx Ingress Controllers in clusters, but different WAF modes will affect how Nginx Ingress Controllers obtain the real client IP addresses.

- **Load balancer access in WAF cloud CNAME access mode**

  When using the cloud CNAME access mode, requests go through WAF and are checked for protection before being sent to the load balancer. This means that even if the load balancer has transparent transmission of source IP addresses enabled, the client will receive the back-to-source IP address of WAF. Consequently, the Nginx Ingress Controller is unable to obtain the real client IP address by default. In this case, you can edit the NGINX Ingress Controller add-on and add the following configuration to the add-on parameters:

  ```
  {
      "enable-real-ip": "true",
      "use-forwarded-headers": "true",
      "proxy-real-ip-cidr": <Back-to-source IP address you obtained from WAF>
  }
  ```

- **Load balancer access in the cloud WAF mode**

  This mode is transparent access (non-inline deployment) and supports only dedicated load balancers. In this mode, Nginx Ingress Controllers can obtain the real client IP address by default.

LoadBalancer

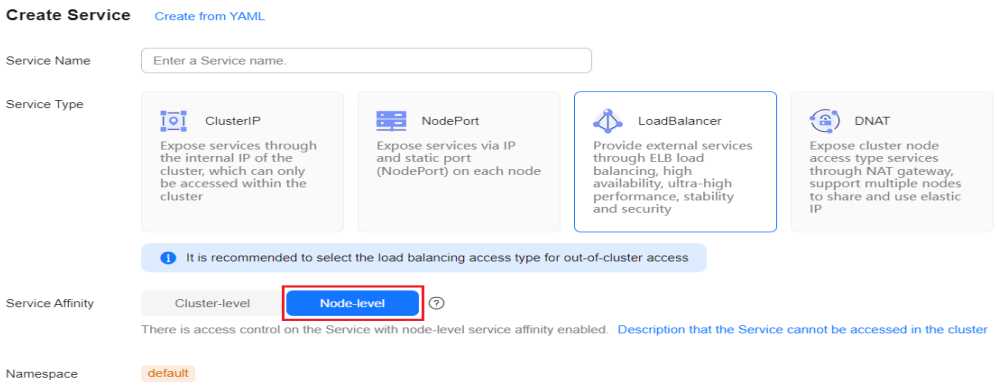
For a LoadBalancer Service, different types of clusters obtain source IP addresses in different scenarios. In some scenarios, source IP addresses cannot be obtained currently. For details, see **Scenarios in Which Source IP Address Can Be Obtained**.

- CCE Clusters (using VPC or Tunnel network): Source IP addresses can be obtained when either a shared or dedicated load balancer is used.
- CCE Turbo Clusters (using the Cloud Native Network 2.0): Source IP addresses can be obtained for dedicated load balancers, and for shared load balancers with hostNetwork enabled.

VPC and Container Tunnel Network Models

To enable the function of obtaining the source IP address on the console, perform the following steps:

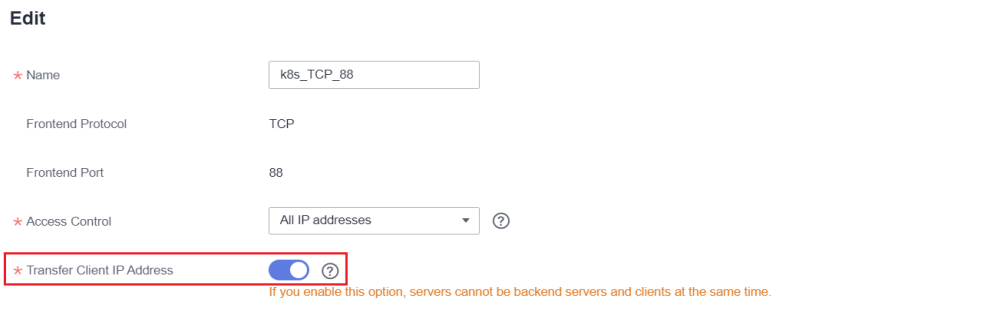
Step 1 When creating a LoadBalancer Service on the CCE console, set **Service Affinity** to **Node-level** instead of **Cluster-level**.



Step 2 Go to the ELB console and enable the function of obtaining the client IP address of the listener corresponding to the load balancer. **Transparent transmission of source IP addresses is enabled for dedicated load balancers by default. You do not need to manually enable this function.**

1. Click  in the upper left corner of the management console and select a region and a project.
2. Choose **Service List** > **Networking** > **Elastic Load Balance**.
3. On the **Elastic Load Balance** page, click the name of the target load balancer.
4. Click the **Listeners** tab, locate the row containing the target listener, and click **Edit**. If modification protection exists, disable the protection on the basic information page of the listener and try again.
5. Enable **Transfer Client IP Address**.

Figure 10-33 Enabling the function



----End

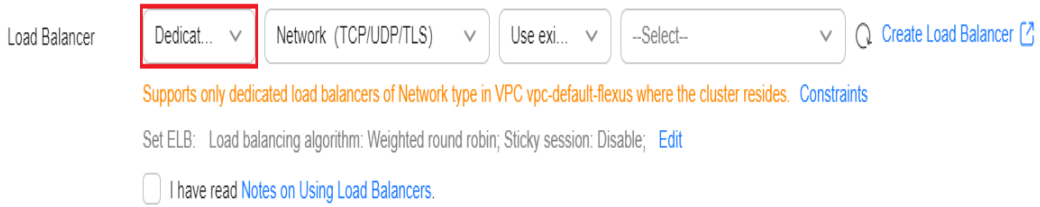
Cloud Native 2.0 Network Model (CCE Turbo Clusters)

When a LoadBalancer Service associated with a shared load balancer is created:

- For workloads with hostNetwork enabled, you can set **Service Affinity** to **Node-level** to obtain the source IP addresses.
- For other workloads, you cannot set **Service Affinity** to **Node-level**, so the source IP addresses cannot be obtained.

Dedicated load balancers are recommended. External access can be directly sent to containers. By default, transparent transmission of source IP addresses is enabled for dedicated load balancers. You do not need to manually enable

Transfer Client IP Address on the ELB console. Instead, you only need to select a dedicated load balancer when creating a LoadBalancer Service on the CCE console.



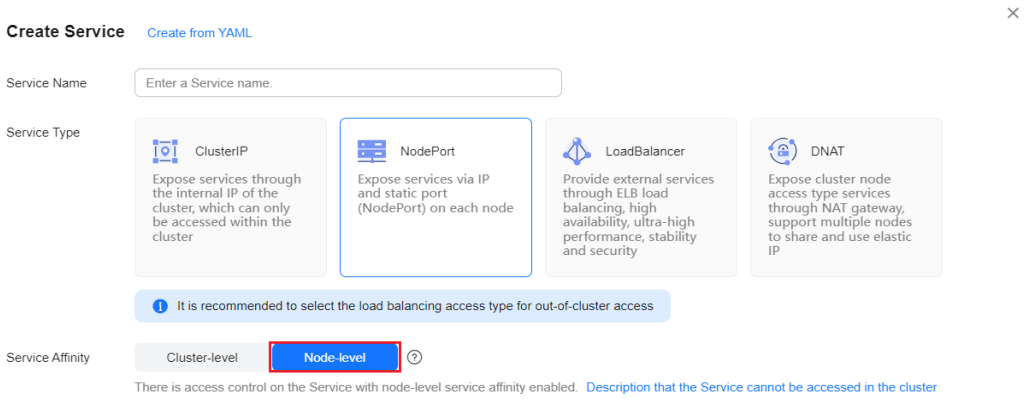
NodePort

Set the service affinity of a NodePort Service to **Node-level** instead of **Cluster-level**. That is, set **spec.externalTrafficPolicy** of the Service to **Local**.

NOTE

In clusters using Cloud Native 2.0 networks, if NodePort Services are used, only workloads with hostNetwork enabled support node-level service affinity. Therefore, only such workloads can obtain source IP addresses.

Figure 10-34 Selecting the node-level affinity



10.8 Increasing the Listening Queue Length by Configuring Container Kernel Parameters

Application Scenarios

By default, the listening queue (backlog) length of **net.core.somaxconn** is set to **128**. If the number of connection requests surpasses this limit during busy services, new requests will be declined. To avoid this issue, you can adjust the kernel parameter **net.core.somaxconn** to increase the length of the listening queue.

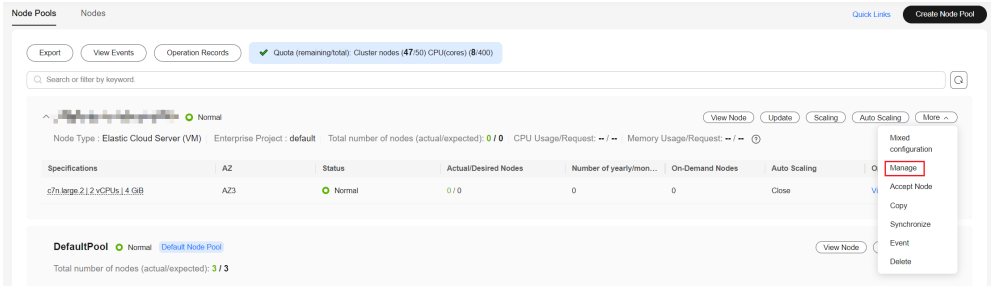
Procedure

Step 1 Modify kubelet configurations.

Modifying the kubelet configurations of a node pool

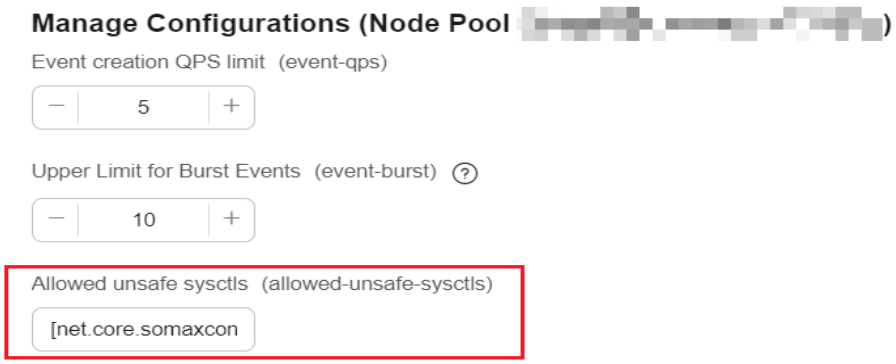
1. Log in to the CCE console and click the cluster name to access the cluster console.
2. Locate the row containing the target node pool and choose **More** > **Manage**.

   Figure 10-35 Managing node pool configurations



3. Modify kubelet configuration parameters and add **[net.core.somaxconn]** to **Allowed unsafe sysctls**.

   Figure 10-36 Modifying kubelet parameters



Modifying the kubelet parameters of a node (not recommended)

1. Log in to the target node.
2. Edit the **/opt/cloud/cce/kubernetes/kubelet/kubelet** file. In versions earlier than 1.15, the file is **/var/paas/kubernetes/kubelet/kubelet**.

   Enable **net.core.somaxconn**.

   ```
   --allowed-unsafe-sysctls=net.core.somaxconn
   ```

   ```
   [root@test-565556-38106 ~]# cat /var/paas/kubernetes/kubelet/kubelet
   DAEMON_ARGS=" --bootstrap-kubeconfig=/var/paas/kubernetes/kubelet/boot.conf --cert-dir=/var/paas/kubernetes/kubelet/pki --rotate
   -certificates=true --network-plugin=cni --cni-conf-dir=/etc/cni/net.d/ --node-ip=192.168.116.149 --provider-id=acb56430-9a20-11e
   9-bf1e-0255ac101f9c --kubeconfig=/var/paas/kubernetes/kubelet/kubeconfig --config=/var/paas/kubernetes/kubelet/kubelet_config.ya
   ml --authentication-token-webhook=true --pod-infra-container-image=cce-pause:2.0 --root-dir=/mnt/paas/kubernetes/kubelet --hostn
   ame-override=192.168.116.149 --allow-privileged=True --v=2 --node-labels="os.name=EulerOS_2.0_SP5,os.version=3.10.0-862.14.0.1.h
   147.eulerosv2r7.x86_64,os.architecture=amd64,failure-domain.beta.kubernetes.io/zone=cn-north-1a,failure-domain.beta.kubernetes.i
   o/region=cn-north-1,kubernetes.io/availablezone=cn-north-1a,failure-domain.beta.kubernetes.io/is-baremetal='false'" --machine_id
   _file=/var/paas/conf/server.conf --cadvisor-port=4194 --allowed-unsafe-sysctls=net.core.somaxconn"
   [root@test-565556-38106 ~]#
   ```

3. Restart kubelet.

   systemctl restart kubelet

   Check the kubelet status.

   systemctl status kubelet

NOTE

After the kubelet parameters of a node are modified, the configurations will be restored if the cluster is upgraded to a later version. Exercise caution when performing this operation.

Step 2 (Required only for clusters earlier than v1.25) Create a pod security policy.

kube-apiserver enables pod security policies for CCE clusters of versions earlier than v1.25. The configurations take effect only after **net.core.somaxconn** is added to **allowedUnsafeSysctls** in the pod security policy. For details about CCE security policies, see **Configuring a Pod Security Policy**.

The following is an example:

```
apiVersion: policy/v1beta1
kind: PodSecurityPolicy
metadata:
  annotations:
    seccomp.security.alpha.kubernetes.io/allowedProfileNames: '*'
  name: sysctl-psp
spec:
  allowedUnsafeSysctls:
  - net.core.somaxconn
  allowPrivilegeEscalation: true
  allowedCapabilities:
  - '*'
  fsGroup:
    rule: RunAsAny
  hostIPC: true
  hostNetwork: true
  hostPID: true
  hostPorts:
  - max: 65535
    min: 0
  privileged: true
  runAsGroup:
    rule: RunAsAny
  runAsUser:
    rule: RunAsAny
  seLinux:
    rule: RunAsAny
  supplementalGroups:
    rule: RunAsAny
  volumes:
  - '*'
```

After creating the pod security policy **sysctl-psp**, configure RBAC permission control for it.

The following is an example:

```
kind: ClusterRole
apiVersion: rbac.authorization.k8s.io/v1
metadata:
  name: sysctl-psp
rules:
  - apiGroups:
      - "*"
    resources:
      - podsecuritypolicies
    resourceNames:
      - sysctl-psp
    verbs:
      - use

---
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRoleBinding
metadata:
  name: sysctl-psp
roleRef:
  kind: ClusterRole
  name: sysctl-psp
  apiGroup: rbac.authorization.k8s.io
```



```
subjects:
- kind: Group
  name: system:authenticated
  apiGroup: rbac.authorization.k8s.io
```

Step 3 Create a workload, configure the kernel parameters, and ensure that the workload is affinity with the node with **net.core.somaxconn** enabled in **Step 1**.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  annotations:
    description: ''
  labels:
    appgroup: ''
  name: test1
  namespace: default
spec:
  replicas: 1
  selector:
    matchLabels:
      app: test1
  template:
    metadata:
      annotations:
        metrics.alpha.kubernetes.io/custom-endpoints: '[{"api":"","path":"","port":"","names":""}]'
      labels:
        app: test1
    spec:
      containers:
        - image: 'nginx:1.14-alpine-perl'
          name: container-0
          resources:
            requests:
              cpu: 250m
              memory: 512Mi
            limits:
              cpu: 250m
              memory: 512Mi
      imagePullSecrets:
        - name: default-secret
      securityContext:
        sysctls:
          - name: net.core.somaxconn
            value: '3000'
      affinity:
        nodeAffinity:
          requiredDuringSchedulingIgnoredDuringExecution:
            nodeSelectorTerms:
              - matchExpressions:
                  - key: kubernetes.io/hostname
                    operator: In
                    values:
                      - 192.168.x.x       # Node name.
```

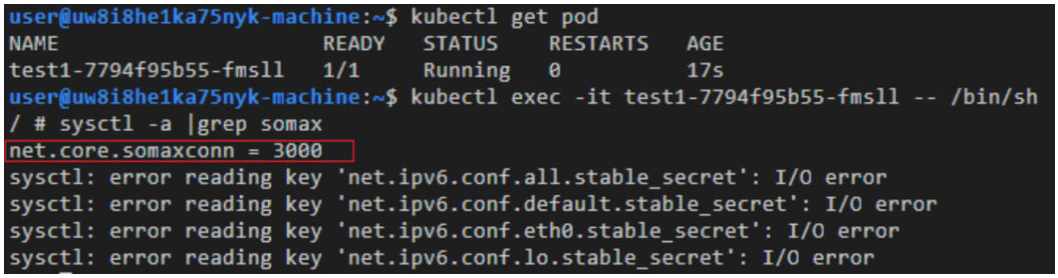
Step 4 Go to the container and check whether the parameter settings take effect.

```
kubectl exec -it <pod name> -- /bin/sh
```

Run the following command in the container to check whether the configuration takes effect:

```
sysctl -a |grep somax
```


Figure 10-37 Viewing the parameter configuration



----End

10.9 Configuring Passthrough Networking for a LoadBalancer Service

Application Scenarios

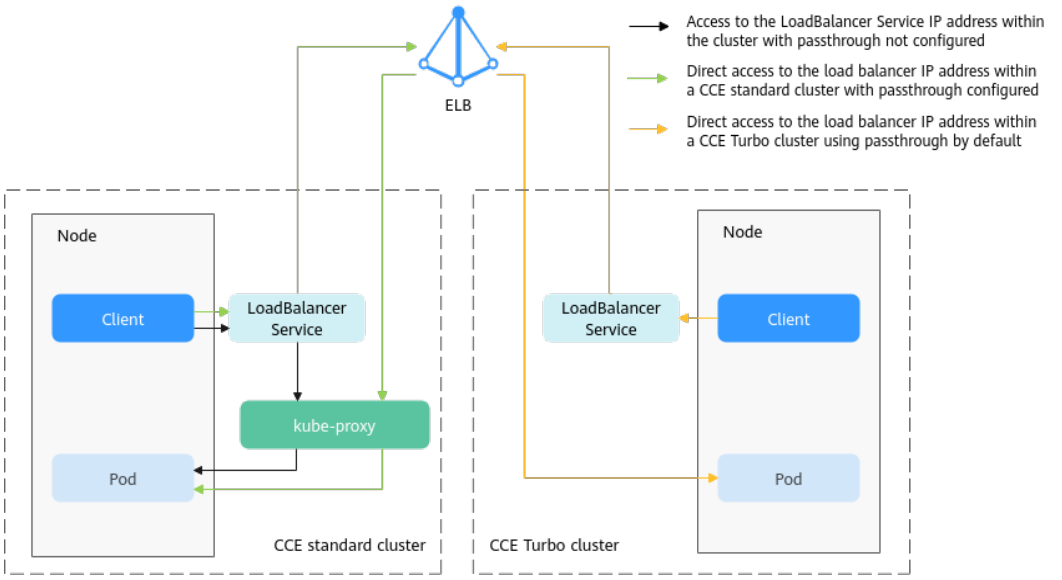
kube-proxy, which is responsible for forwarding intra-cluster traffic, adds the IP addresses of load balancers associated with the LoadBalancer Services to nodes' local forwarding rules by default. When a client from within a cluster accesses the IP address of a load balancer, the traffic is directly forwarded to the destination instead of being forwarded by the load balancer.

If node-level affinity is configured for a Service (with **externalTrafficPolicy** set to **Local**), the Service will forward traffic only to pods on the node that run these pods. When a node or pod accesses another pod in the same cluster, if the node where the client runs does not have the corresponding backend pod, the access may fail.

Solution

CCE supports passthrough networking. You can configure the **kubernetes.io/elb.pass-through** annotation for the LoadBalancer Service so that the load balancer forwards the intra-cluster access to the IP address of the load balancer associated with the Service to backend pods.

Figure 10-38 Passthrough networking illustration



- CCE clusters

  When a LoadBalancer Service is accessed within the cluster, the access is forwarded to the backend pods using iptables/IPVS by default.

  When a LoadBalancer Service (configured with elb.pass-through) is accessed within the cluster, the access is first forwarded to the load balancer, then the nodes, and finally to the backend pods using iptables/IPVS.

- CCE Turbo clusters

  When a client accesses a LoadBalancer Service from within the cluster, passthrough is used by default. In this case, the client directly accesses the load balancer private network IP address and then access a container through the load balancer.

Constraints

- In a CCE standard cluster, after passthrough networking is configured for a dedicated load balancer, the private IP address of the load balancer cannot be accessed from the node where the workload pod resides or other containers on the same node as the workload.
- Passthrough networking is not supported for clusters of v1.15 or earlier.
- In IPVS network mode, the passthrough settings of Services connected to the same load balancer must be the same.
- If node-level (local) service affinity is used, **kubernetes.io/elb.pass-through** is automatically set to **onlyLocal** to enable pass-through.

Procedure

This section describes how to create a Deployment using an Nginx image and create a Service with passthrough networking enabled.

Step 1 Use the kubectl command line tool to connect to the cluster. For details, see **Connecting to a Cluster Using kubectl**.

Step 2 Use the Nginx image to create a Deployment.

Create an **nginx-deployment.yaml** file. The file content is as follows:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx
spec:
  replicas: 2
  selector:
    matchLabels:
      app: nginx
  template:
    metadata:
      labels:
        app: nginx
    spec:
      containers:
      - image: nginx:latest
        name: container-0
        resources:
          limits:
            cpu: 100m
            memory: 200Mi
          requests:
            cpu: 100m
            memory: 200Mi
      imagePullSecrets:
      - name: default-secret
```

Run the following command to deploy the workload:

```
kubectl create -f nginx-deployment.yaml
```

Step 3 Create a LoadBalancer Service and set **kubernetes.io/elb.pass-through** to **true**. For details about how to create LoadBalancer Service, see **LoadBalancer**.

The content of the **nginx-elb-svc.yaml** file is as follows. (In this example, a shared load balancer named **james** is automatically created.)

```
apiVersion: v1
kind: Service
metadata:
  annotations:
    kubernetes.io/elb.pass-through: "true"
    kubernetes.io/elb.class: union
    kubernetes.io/elb.autocreate: '{"type":"public","bandwidth_name":"cce-
bandwidth","bandwidth_chargemode":"bandwidth","bandwidth_size":5,"bandwidth_sharetype":"PER","eip_ty
pe":"5_bgp","name":"james"}'
  labels:
    app: nginx
  name: nginx
spec:
  externalTrafficPolicy: Local
  ports:
  - name: service0
    port: 80
    protocol: TCP
    targetPort: 80
  selector:
    app: nginx
  type: LoadBalancer
```

Step 4 Run the following command to create the Service:

```
kubectl create -f nginx-elb-svc.yaml
```

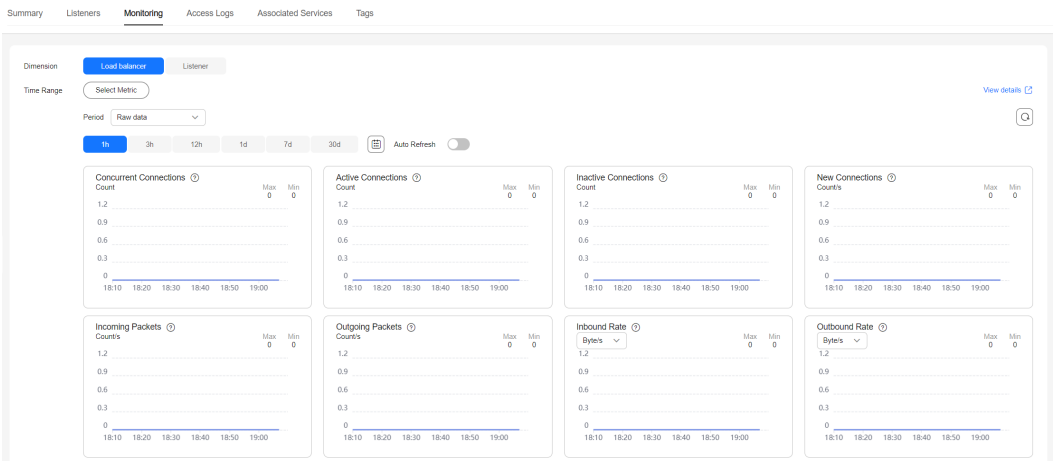
----End

Verification

Step 1 Log in to the ELB console and check the load balancer (named **james** in this example) associated with the Service.

Step 2 Click the load balancer name and click the **Monitoring** tab.

There is 0 connections to the load balancer.



Step 3 Log in to an Nginx container in the cluster using kubectl and access the IP address of the load balancer.

1. Obtain the Nginx containers in the cluster.
   ```
   kubectl get pod
   ```
   Information similar to the following is displayed:
   ```
   NAME                     READY   STATUS    RESTARTS   AGE
   nginx-7c4c5cc6b5-vpncx   1/1     Running   0          9m47s
   nginx-7c4c5cc6b5-xj5wl   1/1     Running   0          9m47s
   ```
2. Log in to an Nginx container container.
   ```
   kubectl exec -it nginx-7c4c5cc6b5-vpncx -- /bin/sh
   ```
3. Access the load balancer IP address.
   ```
   curl **.**.**.**
   ```

Step 4 Wait for a while and check the monitoring data on the ELB console.

If a new access connection is displayed, the access is forwarded by the load balancer as expected.

----End

10.10 Accessing an External Network from a Pod

10.10.1 Accessing the Internet from a Pod

How to Implement

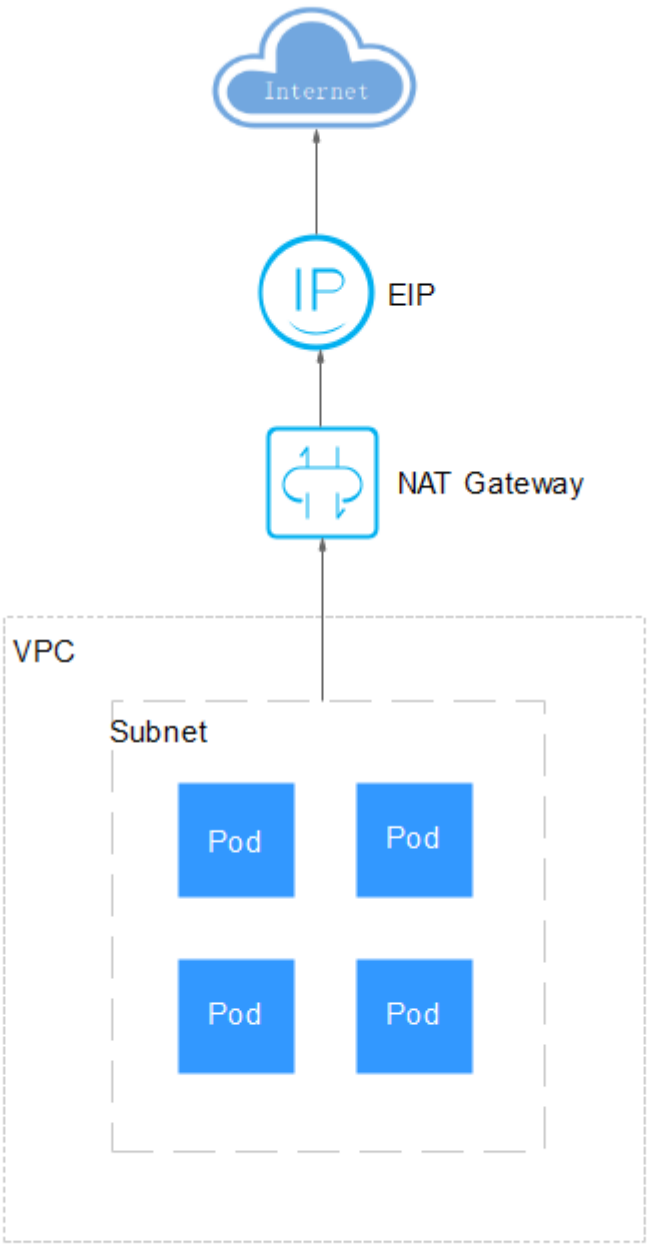
The method of accessing a public network address from a pod varies depending on the network model of the cluster. For details, see **Table 10-10**.

Table 10-10 Methods of accessing a public network address from a pod

Implementation	Tunnel Network	VPC Network	Cloud Native 2.0 Network
Binding an EIP to the node where the container resides	Supported	Supported	Not supported
Binding an EIP to the pod	Not supported	Not supported	Supported **NOTE** Bind an EIP to the pod. For details, see **Configuring a Static EIP for a Pod**.
Accessing the Internet through a NAT gateway	Supported	Supported	Supported

The following uses a CCE Turbo cluster as an example to describe how to use a NAT gateway to access the Internet. The NAT gateway allows containers in a VPC to access the Internet through source network address translation (SNAT), which translates containers' private IP addresses to public IP addresses using the assigned EIP. This allows the containers to use the shared EIP to access the Internet. For details, see **Figure 10-39**. SNAT allows containers in a VPC to access the Internet directly, even without an EIP. However, they cannot receive traffic from the Internet. The NAT gateway provides efficient support for high-concurrency connections and enables public network access. It is well-suited for scenarios with a large volume of requests and connections.

Figure 10-39 How an SNAT rule works



Prerequisites

- A CCE cluster is available. For details, see **Buying a CCE Standard/Turbo Cluster**.
- A pod is available in the cluster. For details, see **Creating a Deployment**.

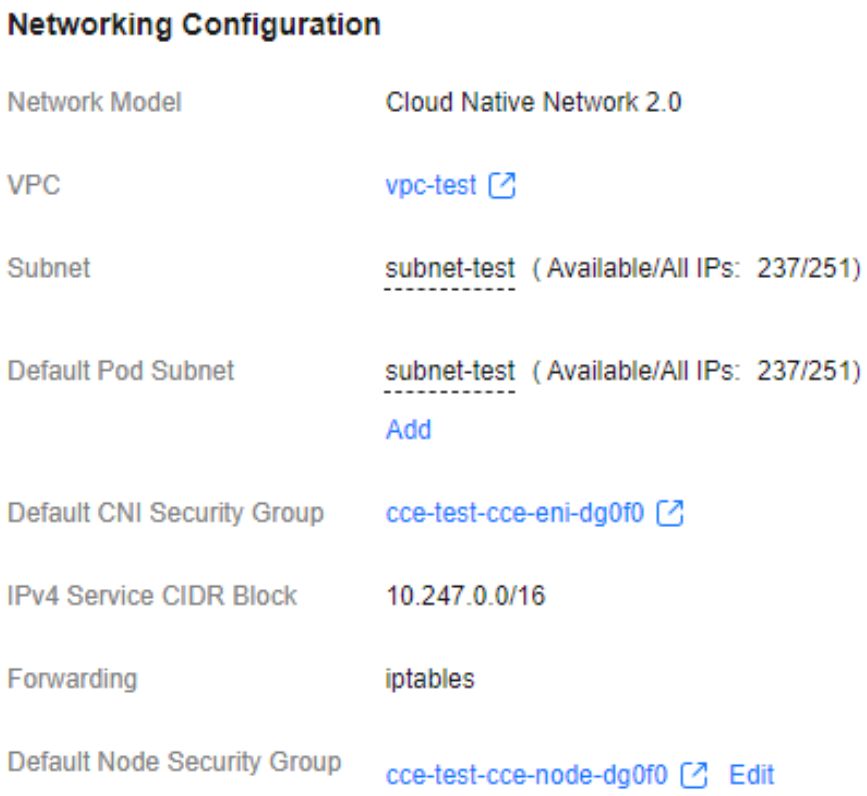
Procedure

To enable a pod to access the Internet, perform the following steps:

Step 1 Check the pod CIDR block.

1. Log in to the management console.
2. Click ☰ in the upper left corner and choose **Containers** > **Cloud Container Engine**.
3. Click the cluster name to access the cluster console. In the navigation pane, choose **Overview**. In the **Networking Configuration** area, check the pod subnet.

Figure 10-40 Pod subnet



Step 2 Check the access from the pod to the Internet. **Log in to the target pod** and run the following command on the CloudShell page:

curl -I *console-intl.huaweicloud.com*

If information similar to the following is displayed, the pod cannot access the Internet:

```
curl: (7) Failed to connect to console-intl.huaweicloud.com port 80: Connection timed out
```

Step 3 Assign an EIP. For details, see **Assigning an EIP**.

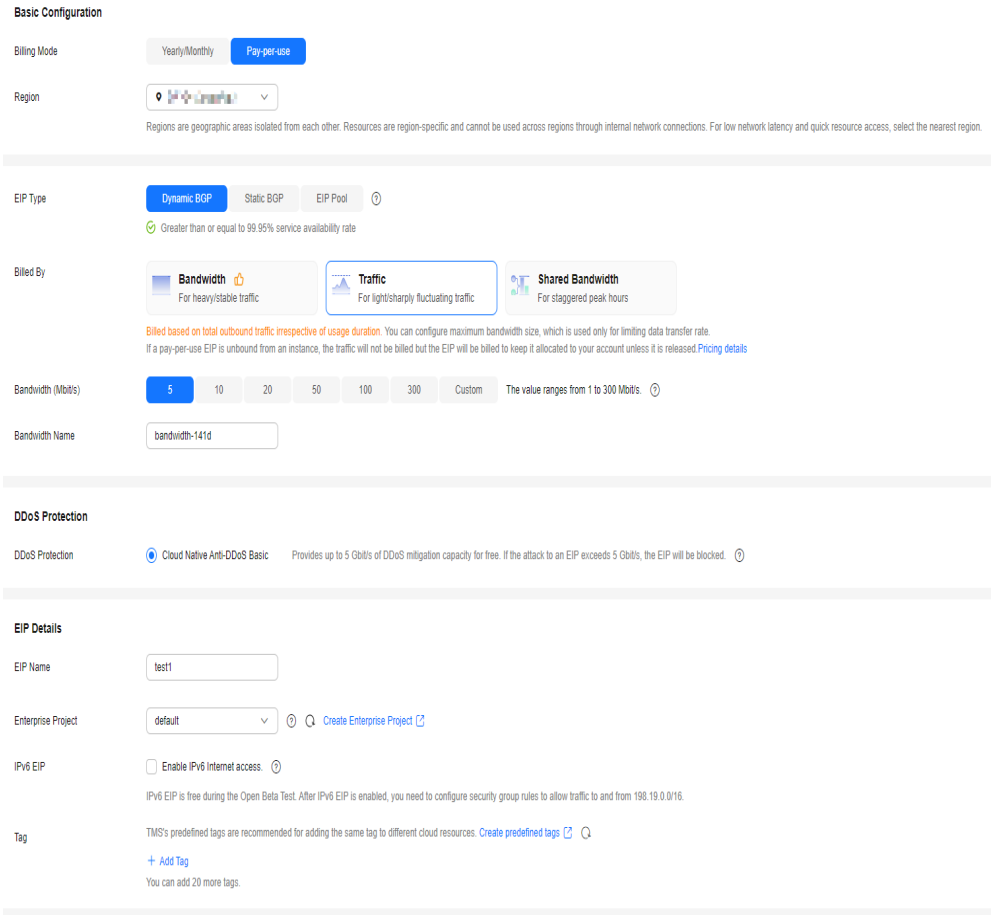
1. Click ⌖ in the upper left corner of the console and select a region.

NOTE

Set **Region** to the one where the target pod is located.

2. Click ☰ in the upper left corner and choose **Networking** > **Elastic IP**.
3. On the **EIPs** page, click **Buy EIP**.
4. Configure parameters as prompted. For details, see **Figure 10-41**.

Figure 10-41 Buying an EIP



Step 4 Buy a NAT gateway. For details, see **Buy a Public NAT Gateway**.

1. Click ☰ in the upper left corner and choose **Networking** > **NAT Gateway**.
2. On the displayed page, click **Buy Public NAT Gateway**.
3. Configure parameters as prompted. Set **VPC** to the one used by the cluster and **Subnet** to the pod subnet. For details, see **Figure 10-42**. When using a CCE Turbo cluster, set **Subnet** to the one where the pod is located. When using a CCE standard cluster, set **Subnet** to the one where the node is located.

Figure 10-42 Buying a NAT gateway

Step 5 Configure an SNAT rule and bind the EIP to the subnet. For details, see **Add an SNAT Rule**.

1. On the page displayed, click the name of the NAT gateway for which you want to add the SNAT rule.
2. On the **SNAT Rules** tab page, click **Add SNAT Rule**.
3. Configure parameters as prompted. For details, see **Figure 10-43**.

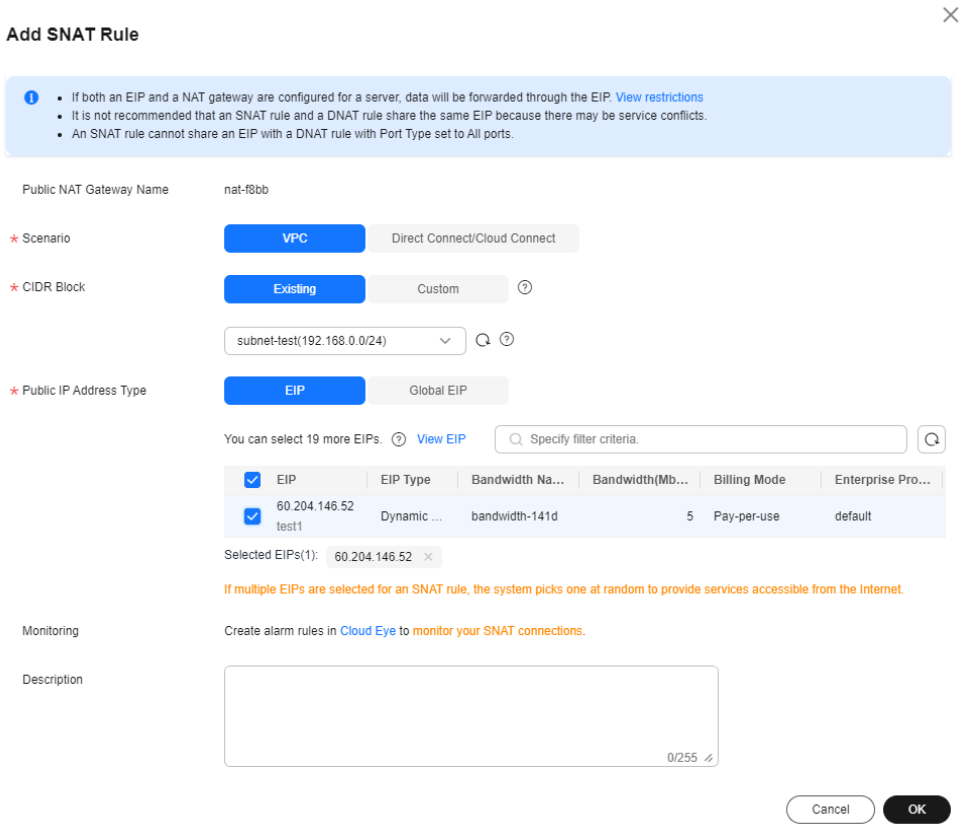
   NOTE

   SNAT rules take effect by CIDR block. When configuring CIDR blocks for different container network models, consider their communication modes. Follow these rules to ensure proper configuration:

   - For a CCE standard cluster using a tunnel or VPC network, select the CIDR block where the node is located, which is the block selected during node creation.
   - For a CCE Turbo cluster using Cloud Native Network 2.0, select the container CIDR block used during cluster creation.

   If there are multiple CIDR blocks, you can create multiple SNAT rules or customize a CIDR block. Make sure that the selected CIDR block includes either the container subnet (for Cloud Native Network 2.0) or the node subnet (for tunnel network and VPC network).

Figure 10-43 Adding an SNAT rule



Step 6 Check whether the pod can access the Internet. **Log in to the target pod** and run the following command on the CloudShell page:

curl -I console-intl.huaweicloud.com

If information similar to the following is displayed, the pod can access the Internet:

```
HTTP/1.1 301 Moved Permanently
Server: CloudWAF
Date: Mon, 19 Aug 2024 12:43:20 GMT
Content-Type: text/html
Connection: keep-alive
Set-Cookie: HWWAFSESID=b4119798a9b29b3c77; path=/
Set-Cookie: HWWAFSESTIME=1724071396374; path=/
...
```

----End

10.10.2 Accessing Cloud Services from a Pod in the Same VPC

The method of accessing cloud services from a pod in the same VPC varies depending on the cluster's network model. For details, see **Table 1 Accessing cloud services from a pod in the same VPC**.

Table 10-11 Accessing cloud services from a pod in the same VPC

Network Model	Description
Tunnel network	Data packets are encapsulated through tunnels in the node network. If the node access permission is limited, you will not be able to access resources from a pod in the same VPC. If you encounter an access failure, verify that the security group of the service you are trying to access allows access from the node where the pod is located.
VPC network	Pod traffic is forwarded through VPC routing. If the container CIDR block is different from the VPC CIDR block of the node, the container cannot directly communicate with other IP addresses in the VPC. To access a service outside the cluster from a pod in the same VPC, you must configure the security group of the accessed service.
Cloud Native Network 2.0	Containers receive IP addresses from VPC CIDR blocks. Container CIDR blocks are part of the VPC subnet where the node is located. Therefore, the containers can directly communicate with other IP addresses in the VPC. If the access failed, check if the security group of the accessed service permits access from the container CIDR block.

Cloud services that communicate with CCE include ECS, ELB, RDS, DCS, Kafka, RabbitMQ, ModelArts, and DDS. To ensure successful communication, make sure your network is configured correctly and verify that the cloud service you want to access allows external access. For example, accessing DCS Redis requires being trustlisted. If you cannot configure the trustlist on the service console, create a service ticket in the target service. The following describes the operations and precautions for accessing an ECS from a pod and an RDS MySQL DB instance from a pod.

Prerequisites

- A CCE cluster is available. For details, see **Buying a CCE Standard/Turbo Cluster**.
- A pod is available in the cluster. For details, see **Creating a Deployment**.

Accessing an ECS from a Pod

The following uses a VPC network cluster as an example to describe how to configure security group rules for seamless access to an ECS in the same VPC. For example, the node CIDR block is 192.168.0.0/24, and the container CIDR block is 172.16.0.0/16.

Step 1 Purchase an ECS. For details, see **Purchasing and Using a Linux ECS**. The ECS and the cluster are in the same region and VPC, and the IP address of the ECS is 192.168.0.28.

Step 2 Log in to the pod. For details, see **Logging In to a Container**. Try to access the ECS from the pod.

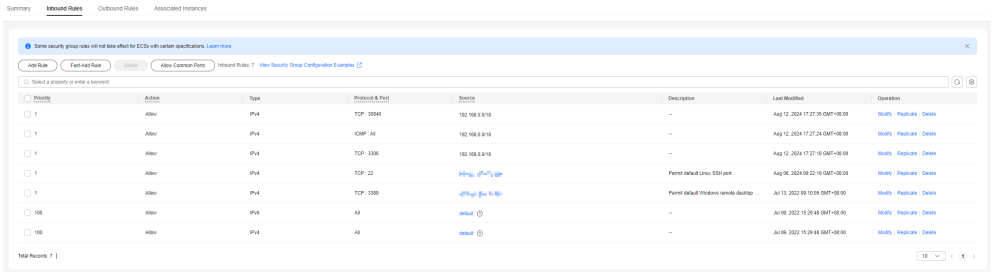
ping *192.168.0.28*

- If the ping command is available, execute it. If the following information is displayed, the access from the pod to the ECS failed:
  ```
  PING 192.168.0.28 (192.168.0.28): 56 data bytes
  --- 192.168.0.28 ping statistics ---
  104 packets transmitted, 0 packets received, 100% packet loss
  ```
- If no ping command is available, add it.
  ```
  ping: command not found
  ```
  The following uses the **Nginx:latest** container as an example to describe how to add a ping command. If the ping command is already available, skip this step.
  a. Ensure that the pod can access the Internet. For details, see **Accessing the Internet from a Pod**.
  b. Update the local software package index.
     apt-get update
  c. Install the **iputils-ping** software package, which provides the ping command.
     apt-get install iputils-ping
  d. Access the ECS again.
     ping *192.168.0.28*
     If the following information is displayed, the ping command has been added:
     ```
     PING 192.168.0.28 (192.168.0.28): 56 data bytes
     --- 192.168.0.28 ping statistics ---
     104 packets transmitted, 0 packets received, 100% packet loss
     ```

Step 3 Add the container CIDR block of the cluster to the inbound rules of the ECS security group so that all pods in the cluster can access the ECS. If you only want to grant access to the ECS from a specific pod in the cluster, you can add the IP address of that pod to the inbound rules of the ECS security group.

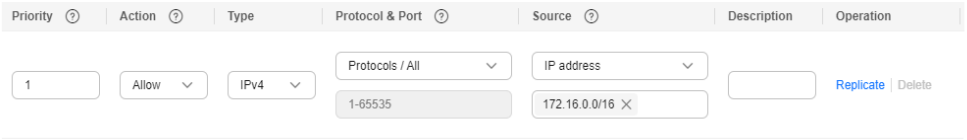
1. On the console homepage, click  in the upper left corner. In the expanded list, choose **Compute > Elastic Cloud Server** and click the target ECS name.
2. Click the **Security Groups** tab. In the left pane of the page, click **Manage Rule**. On the **Inbound Rules** tab page, you can find that the source addresses include the CIDR block 192.168.0.0/18. Within this block, the node CIDR block 192.168.0.0/24 is included, but the container CIDR block 172.16.0.0/16 is not. If a cluster uses a VPC network model, you need to allow both the node and container CIDR blocks in the security group rules of the ECS outside the cluster to access the ECS from a pod. However, for other network models, you only need to allow the node CIDR block in the security group rules of the ECS.

Figure 10-44 Original inbound rules



3. Click **Add Rule** and enter **172.16.0.0/16** in the **Source** text box. For details, see **Figure 10-45**.

Figure 10-45 Adding a rule



Step 4 Check whether the pod can access the ECS outside of the cluster in the same VPC. On the CloudShell page of the pod, run the following command again:

ping *192.168.0.28*

If information similar to the following is displayed, the pod can access the ECS:

```
PING 192.168.0.28 (192.168.0.28): 56 data bytes
64 bytes from 192.168.0.28: seq=0 ttl=64 time=1.412 ms
64 bytes from 192.168.0.28: seq=1 ttl=64 time=1.400 ms
64 bytes from 192.168.0.28: seq=2 ttl=64 time=1.299 ms
64 bytes from 192.168.0.28: seq=3 ttl=64 time=1.283 ms
--- 192.168.0.28 ping statistics ---
4 packets transmitted, 4 packets received, 0% packet loss
```

----End

Accessing a Cloud Service (RDS for MySQL as an Example) from a Pod

The following uses a VPC network cluster as an example to describe how to configure security group rules for seamless access to an RDS for MySQL instance in the same VPC. For example, the node CIDR block is 192.168.0.0/24, and the container CIDR block is 172.16.0.0/16.

Step 1 Buy an RDS for MySQL instance. For details, see **Buying a DB Instance and Connecting to It Using a MySQL Client**. The DB instance and the cluster are in the same region and VPC, and the IP address of the DB instance is 192.168.10.10.

Step 2 Log in to the pod. For details, see **Logging In to a Container**. Try to access the RDS for MySQL instance from the pod.

ping *192.168.10.10*

- If the ping command is available, execute it. If the following information is displayed, the access from the pod to the RDS for MySQL instance failed:


```
PING 192.168.10.10 (192.168.10.10): 56 data bytes
--- 192.168.10.10 ping statistics ---
104 packets transmitted, 0 packets received, 100% packet loss
```

- If no ping command is available, add it.

  ```
  ping: command not found
  ```

  The following uses the **Nginx:latest** container as an example to describe how to add a ping command. If the ping command is already available, skip this step.

  a. Ensure that the pod can access the Internet. For details, see **Accessing the Internet from a Pod**.

  b. Update the local software package index.

     apt-get update

  c. Install the **iputils-ping** software package, which provides the ping command.

     apt-get install iputils-ping

  d. Access the RDS for MySQL instance again.

     ping *192.168.10.10*

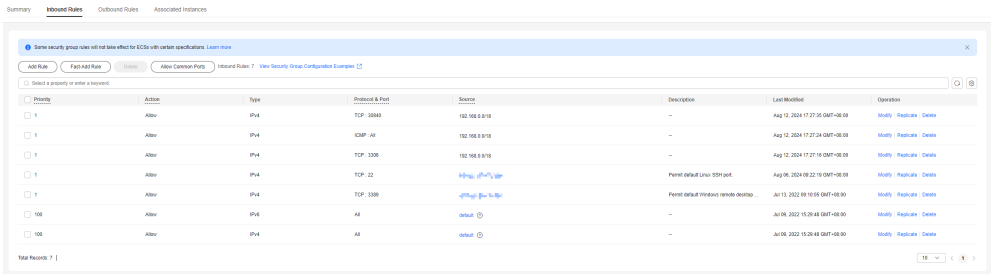
     If the following information is displayed, the ping command has been added:

     ```
     PING 192.168.10.10 (192.168.10.10): 56 data bytes
     --- 192.168.10.10 ping statistics ---
     104 packets transmitted, 0 packets received, 100% packet loss
     ```

Step 3 Add the container CIDR block of the cluster to the inbound rules of the DB instance security group so that all pods in the cluster can access the RDS for MySQL instance. If you only want to grant access to the RDS for MySQL instance from a specific pod in the cluster, you can add the IP address of that pod to the inbound rules of the DB instance security group.

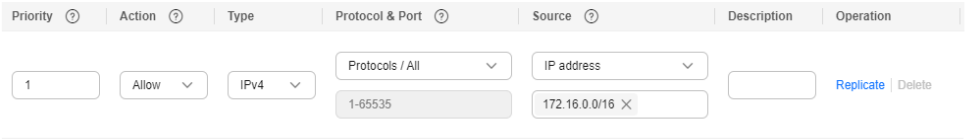
1. On the console homepage, click  in the upper left corner. In the expanded list, choose **Databases > Relational Database Service**. On the **Instances** page, click the DB instance name.
2. In the navigation pane, choose **Connectivity & Security**. In the **Security Group Rules** area, click the target security group rule. On the **Inbound Rules** tab page, you can find that the source addresses include the CIDR block 192.168.0.0/18. Within this block, the node CIDR block 192.168.0.0/24 is included, but the container CIDR block 172.16.0.0/16 is not. If a cluster uses a VPC network model, you need to allow both the node and container CIDR blocks in the security group rules of the RDS for MySQL instance outside the cluster to access the DB instance from a pod. However, for other network models, you only need to allow the node CIDR block in the security group rules of the DB instance.

Figure 10-46 Original inbound rules



3. Click **Add Rule** and enter **172.16.0.0/16** in the **Source** text box. For details, see **Figure 10-47**.

Figure 10-47 Adding a rule



Step 4 Check whether the pod can access the RDS for MySQL instance. On the CloudShell page of the pod, run the following command again:

ping ***192.168.10.10***

If information similar to the following is displayed, the pod can access the DB instance:

```
PING 192.168.10.10 (192.168.10.10): 56 data bytes
64 bytes from 192.168.10.10: seq=0 ttl=64 time=1.412 ms
64 bytes from 192.168.10.10: seq=1 ttl=64 time=1.400 ms
64 bytes from 192.168.10.10: seq=2 ttl=64 time=1.299 ms
64 bytes from 192.168.10.10: seq=3 ttl=64 time=1.283 ms
--- 192.168.10.10 ping statistics ---
4 packets transmitted, 4 packets received, 0% packet loss
```

----End

Troubleshooting a Pod Access Failure

If a pod cannot access the network, rectify the fault by referring to **Table 10-12**. If the fault persists, **submit a service ticket** to contact Huawei Cloud customer service.

Table 10-12 Troubleshooting methods

Check Item	Possible Fault	Solution
Security group rules of the accessed service	One of the following issues may be the cause of the failure: • The security group's inbound rules prevent access to the node CIDR block or container CIDR block. • The security group's inbound rules permit access to the node CIDR block and container CIDR block, but the protocol is incorrectly configured. **NOTICE** Run the **ping** command and use ICMP to test network connectivity. Before doing so, enable the ICMP port in the security group rule.	• For possible cause 1, add a security group rule. For details, see **Adding a Security Group Rule**. • For possible cause 2, change the protocol port in the security group rules. For details, see **Modifying a Security Group Rule**.
Trustlist	The trustlist for the accessed service does not have the node CIDR block and container CIDR block configured.	Add the container and node CIDR blocks to the trustlist. Find more information in the help document for the relevant service.
Domain name resolution	When accessing an external domain name, the pod uses its cluster's domain name resolution to resolve the destination address and accesses the address based on the pod's network policy. However, sometimes the domain name cannot be resolved, resulting in errors. The most common errors are listed below: • Name or service not known • Temporary failure in name resolution • Unable to resolve hostname • DNS resolution failed • Could not resolve MYHOST (nodename nor servname known), where *MYHOST* indicates the domain name that cannot be resolved	Locate the cause of the DNS exception. For details, see **DNS Overview** for troubleshooting.

Check Item	Possible Fault	Solution
Network policy (applicable only to tunnel networks)	If you have configured a network policy for both your tunnel network cluster and the namespace where the pod is located, the network policy may prevent the pod from accessing the destination address.	If so, modify the network policy. For details, see **Configuring Network Policies to Restrict Pod Access**.

10.10.3 Accessing Cloud Services from a Pod in a Different VPC

Pods cannot communicate with each other across VPCs. To resolve this issue, you can use VPC peering to connect two VPCs so that pods in one VPC can access services in the other VPC. The method of setting up cross-VPC connectivity varies depending on the clusters' network types. For details, see **Table 10-13**. In this section, the VPC where the cluster is in is referred to as the cluster VPC, the VPC where the cloud service to be accessed is in is referred to as the destination VPC, and the subnet where the cloud service to be accessed is in is referred to as the destination subnet.

Table 10-13 Cross-VPC access for clusters of different network types

Network Model	Description	Difference
Tunnel network	Data packets are encapsulated through tunnels in the node network. To access cloud services from a pod in a different VPC, ensure that the node subnet can communicate with the destination subnet.	After creating a VPC peering connection between the cluster VPC and the destination VPC, you only need to create a route for the node subnet and the destination subnet.
VPC network	Pod traffic is forwarded through VPC routing. The VPC CIDR block of the cluster cannot overlap with the container CIDR block. When accessing services from a pod in a different VPC, ensure that the node subnet can communicate with the destination subnet and that the container CIDR block can also communicate with the destination subnet.	After creating a VPC peering connection between the cluster VPC and the destination VPC, you need to create a route for the destination subnet, cluster node subnet, and container CIDR block.

Network Model	Description	Difference
Cloud Native Network 2.0	In the Cloud Native 2.0 network model, container IP addresses are directly assigned from the VPC CIDR block. To access cloud services from a pod in a different VPC, ensure that the container subnet can communicate with the destination subnet.	After creating a VPC peering connection between the cluster VPC and the destination VPC, you only need to create a route for the container subnet and the destination subnet.

Cloud services that communicate with CCE include ECS, ELB, RDS, DCS, Kafka, RabbitMQ, ModelArts, and DDS. To ensure successful communication, make sure your network is configured correctly and verify that the cloud service you want to access allows external access. For example, accessing DCS Redis requires being trustlisted. If you cannot configure the trustlist on the service console, create a service ticket in the target service.

This section uses ECS and RDS for MySQL as examples to describe how to implement cross-VPC communication between pods in clusters that use different network models. **Table 10-14** shows the details about the cluster, ECS, and RDS for MySQL network information in the example.

Table 10-14 Network information

Cloud Service	Container Network Model	Network Information
CCE	Container tunnel network (CCE standard cluster)	• Cluster VPC – Name: vpc-demo1 – CIDR block: 192.168.0.0/18 (primary) and 172.1.0.0/24 (secondary) **NOTE** After a VPC is created, if the primary CIDR block is not enough, you can add secondary CIDR blocks to the VPC. For details, see **Adding a Secondary IPv4 CIDR Block to a VPC**. After a secondary CIDR block is added to the VPC, you can create a subnet based on the secondary CIDR block. The subnet can be used in CCE. – Subnet: 192.168.0.0/24, 192.168.60.0/28, and 172.1.0.0/26 • Node subnet: 192.168.0.0/24 • Container CIDR block: 172.18.1.0/24
	VPC network (CCE standard cluster)	• Cluster VPC – Name: vpc-demo1 – CIDR block: 192.168.0.0/18 (primary) and 172.1.0.0/24 (secondary) – Subnet: 192.168.0.0/24, 192.168.60.0/28, and 172.1.0.0/26 • Node subnet: 192.168.0.0/24 • Container CIDR block: 172.18.1.0/24
	Cloud Native 2.0 network (CCE Turbo cluster)	• Cluster VPC – Name: vpc-demo1 – CIDR block: 192.168.0.0/18 (primary) and 172.1.0.0/24 (secondary) – Subnet: 192.168.0.0/24, 192.168.60.0/28, and 172.1.0.0/26 • Node subnet: 192.168.0.0/24 • Container subnet: 192.168.60.0/28

Cloud Service	Container Network Model	Network Information
ECS	N/A	• Destination VPC – Name: vpc-demo2 – CIDR block: 10.1.0.0/16 – Subnet: 10.1.1.0/24 • Subnet where the ECS resides (destination subnet): 10.1.1.0/24 • ECS IP address: 10.1.1.24
RDS for MySQL	N/A	• Destination VPC – Name: vpc-373896-1 – CIDR block: 172.16.0.0/16 – Subnet: 172.16.0.0/24 • Subnet where RDS for MySQL resides (destination subnet): 172.16.0.0/24 • IP address of RDS for MySQL: 172.16.0.167

Prerequisites

- A CCE cluster is available. For details, see **Buying a CCE Standard/Turbo Cluster**.
- A pod is available in the cluster. For details, see **Creating a Deployment**.
- You have an ECS or RDS for MySQL DB instance, which is in the same region as the cluster but in a different VPC. For details about how to purchase an ECS or a DB instance, see **Purchasing and Using a Linux ECS (New Edition)** and **Buying a DB Instance and Connecting to It Using a MySQL Client**.

Accessing Cloud Services from a Pod in a Different VPC

This part describes how to access an ECS or an RDS for MySQL DB instance from a pod in a different VPC.

Accessing an ECS from a Pod

The following describes how to access an ECS from pods that run in clusters that use the tunnel network model, VPC network model, and Cloud Native 2.0 network model, respectively. You can select a method based on your cluster types.

Accessing an ECS from a pod in a CCE standard cluster that uses the tunnel network model

1. Create a VPC peering connection between the cluster VPC and the destination VPC.

a. Switch to the console, click ☰ in the upper left corner, and choose **Networking** > **Virtual Private Cloud** in the expanded list.

b. In the navigation pane, choose **VPC Peering Connections**. In the upper right corner of the displayed page, click **Create VPC Peering Connection**.

c. Configure parameters following instructions. For details about the parameters, see **Table 10-15**.

Figure 10-48 Creating a VPC peering connection

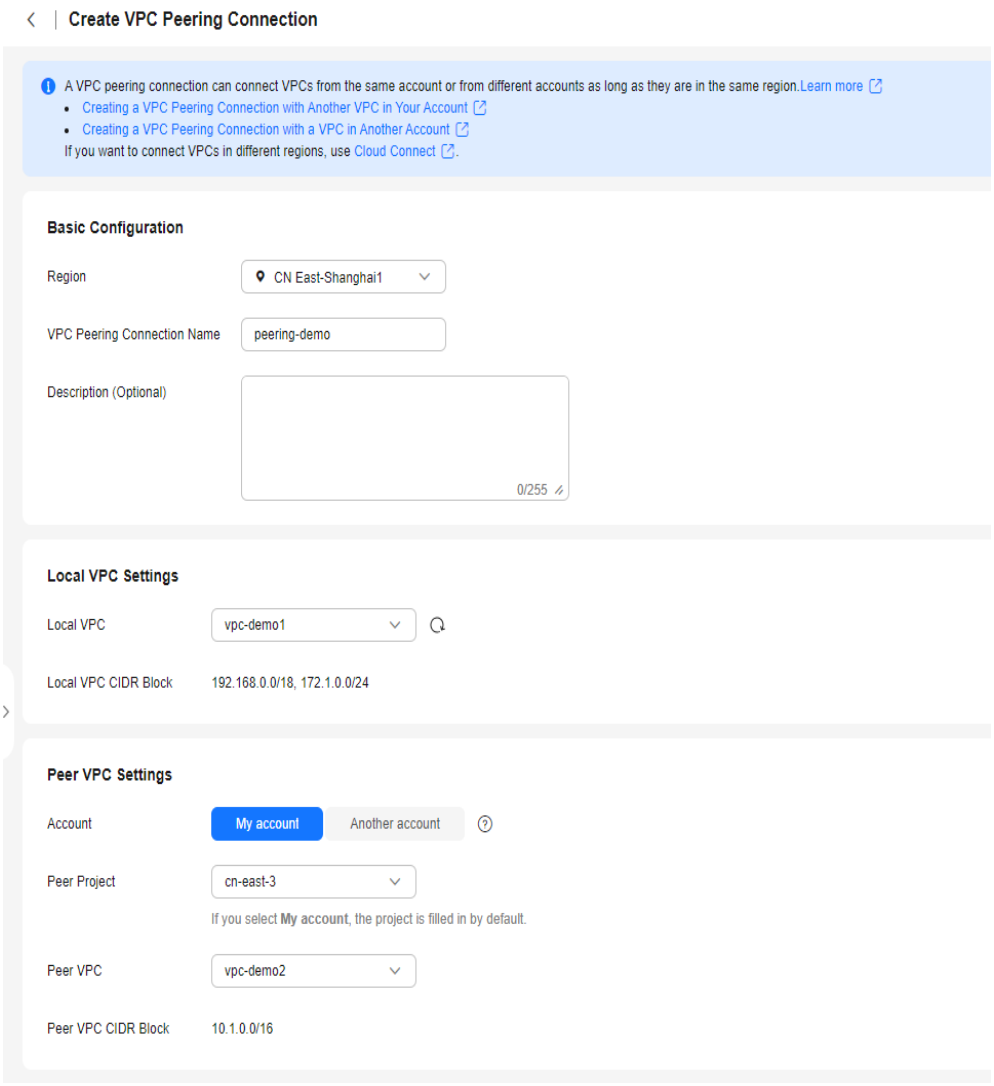


Table 10-15 Parameters for creating a VPC peering connection

Parameter	Description	Example
VPC Peering Connection Name	Mandatory. Enter a name for the VPC peering connection. The name can contain a maximum of 64 characters, including letters, digits, hyphens (-), and underscores (_).	peering-demo
Local VPC	Mandatory. Local-end VPC of the peering connection. You can choose one from the drop-down list.	vpc-demo1
Local VPC CIDR Block	CIDR block of the selected local-end VPC.	192.168.0.0/18 and 172.1.0.0/24
Account	Mandatory. • **My account**: The local and peer VPCs are from the same account. • **Another account**: The local and peer VPCs are from different accounts.	My account
Peer Project	The system fills in the corresponding project by default because **Account** is set to **My account**. For example, vpc-demo1 and vpc-demo2 are both under account A in region A. Then, the system fills in the project of account A in region A by default.	None
Peer VPC	This parameter is mandatory if **Account** is set to **My account**. VPC at the other end of the peering connection. You can choose one from the drop-down list.	vpc-demo2
Peer VPC CIDR Block	CIDR block of the selected peer VPC. **NOTICE** If the local and peer VPCs have overlapping CIDR blocks, the VPC peering connection may not take effect.	10.1.0.0/16

d. After configuring the parameters, click **Create Now**.

2. In the displayed **VPC Peering Connection Created** dialog box, click **Add Now** and add a route for the node subnet and destination subnet. In the **Add Route** dialog box, configure the parameters following instructions. For details about the parameters, see **Table 10-16**.

Figure 10-49 Adding a route for the node subnet and destination subnet

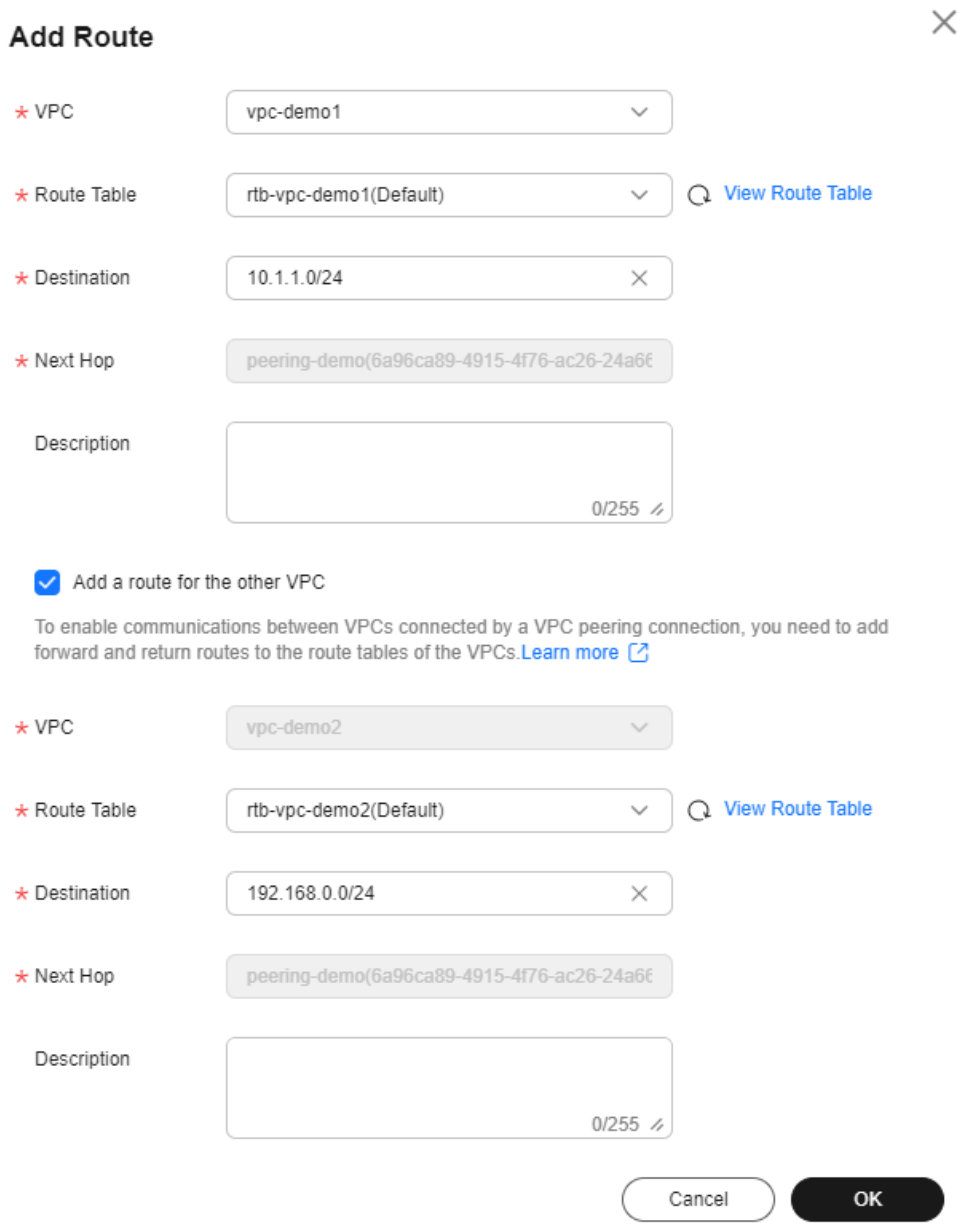


Table 10-16 Parameters for adding a route for the node subnet and destination subnet

Parameter	Description	Example
VPC	Select a VPC that is connected by the VPC peering connection.	vpc-demo1

Parameter	Description	Example
Route Table	Select the route table of the VPC. The route will be added to this route table. Each VPC comes with a default route table that manages the flow of outgoing traffic from the subnets in the VPC. In addition to the default route table, you can create a custom route table and associate it with the subnets in the VPC. Then, the custom route table controls outbound traffic of the subnets. • If there is only the default route table in the drop-down list, select the default route table. • If there are both default and custom route tables in drop-down list, select the route table associated with the subnet connected by the VPC peering connection.	rtb-vpc-demo1 (default route table)
Destination	IP address in the VPC at the other end of the VPC peering connection. The value can be a VPC CIDR block, subnet CIDR block, or ECS IP address.	10.1.1.0/24
Add a route for the other VPC	If you select this option, you can also add a route for the other VPC connected by the VPC peering connection. To allow VPCs connected through VPC peering to communicate, you must include forward and return routes in the VPCs' route tables.	Selected
VPC	By default, the system selects the other VPC connected by the VPC peering connection. You do not need to specify this parameter.	vpc-demo2

Parameter	Description	Example
Route Table	Select the route table of the VPC. The route will be added to this route table. Each VPC comes with a default route table that manages the flow of outgoing traffic from the subnets in the VPC. In addition to the default route table, you can create a custom route table and associate it with the subnets in the VPC. Then, the custom route table controls outbound traffic of the subnets. • If there is only the default route table in the drop-down list, select the default route table. • If there are both default and custom route tables in drop-down list, select the route table associated with the subnet connected by the VPC peering connection.	rtb-vpc-demo2 (default route table)
Destination	IP address in the VPC at the other end of the VPC peering connection. The value can be a VPC CIDR block, subnet CIDR block, or ECS IP address.	192.168.0.0/24

3. Log in to the pod and enter the following code on the CloudShell page of the pod again, where *10.1.1.24* indicates the IP address of the ECS to be accessed: (For details about how to log in to a container, see **Logging In to a Container**.)

```
ping 10.1.1.24
```

NOTE

If the access fails, check whether the traffic from the cluster node subnet is allowed in the inbound rules of the ECS security group. If it is not allowed, you need to add a security group rule and allow the corresponding traffic. For details, see **Adding a Security Group Rule**.

– If a ping command is available and information similar to the following is displayed, cross-VPC access from the pod is successful:

```
PING 10.1.1.24 (10.1.1.24): 56 data bytes
64 bytes from 10.1.1.24: seq=0 ttl=64 time=1.412 ms
64 bytes from 10.1.1.24: seq=1 ttl=64 time=1.400 ms
64 bytes from 10.1.1.24: seq=2 ttl=64 time=1.299 ms
64 bytes from 10.1.1.24: seq=3 ttl=64 time=1.283 ms
--- 10.1.1.24 ping statistics ---
4 packets transmitted, 4 packets received, 0% packet loss
```

– If no ping command is available, add it.

```
ping: command not found
```

The following uses the **Nginx:latest** container as an example to describe how to add a ping command. If the ping command is already available, skip this step.

i. Ensure that the pod can access the Internet. For details, see **Accessing the Internet from a Pod**.

ii. Update the local software package index and install the **iputils-ping** software package that provides the ping command.

```
apt-get update
apt-get install iputils-ping
```

iii. Access the ECS again.

```
ping 10.1.1.24
```

If information similar to the following is displayed, the ping command has been added and the cross-VPC access from the pod is successful:

```
PING 10.1.1.24 (10.1.1.24): 56 data bytes
64 bytes from 10.1.1.24: seq=0 ttl=64 time=1.412 ms
64 bytes from 10.1.1.24: seq=1 ttl=64 time=1.400 ms
64 bytes from 10.1.1.24: seq=2 ttl=64 time=1.299 ms
64 bytes from 10.1.1.24: seq=3 ttl=64 time=1.283 ms
--- 10.1.1.24 ping statistics ---
4 packets transmitted, 4 packets received, 0% packet loss
```

Accessing an ECS from a pod in a CCE standard cluster that uses the VPC network model

1. Create a VPC peering connection between the cluster VPC and the destination VPC.
   a. Switch to the console, click  in the upper left corner, and choose **Networking** > **Virtual Private Cloud** in the expanded list.
   b. In the navigation pane, choose **VPC Peering Connections**. In the upper right corner of the displayed page, click **Create VPC Peering Connection**.
   c. Configure parameters following instructions. For details about the parameters, see **Table 10-17**.

Figure 10-50 Creating a VPC peering connection

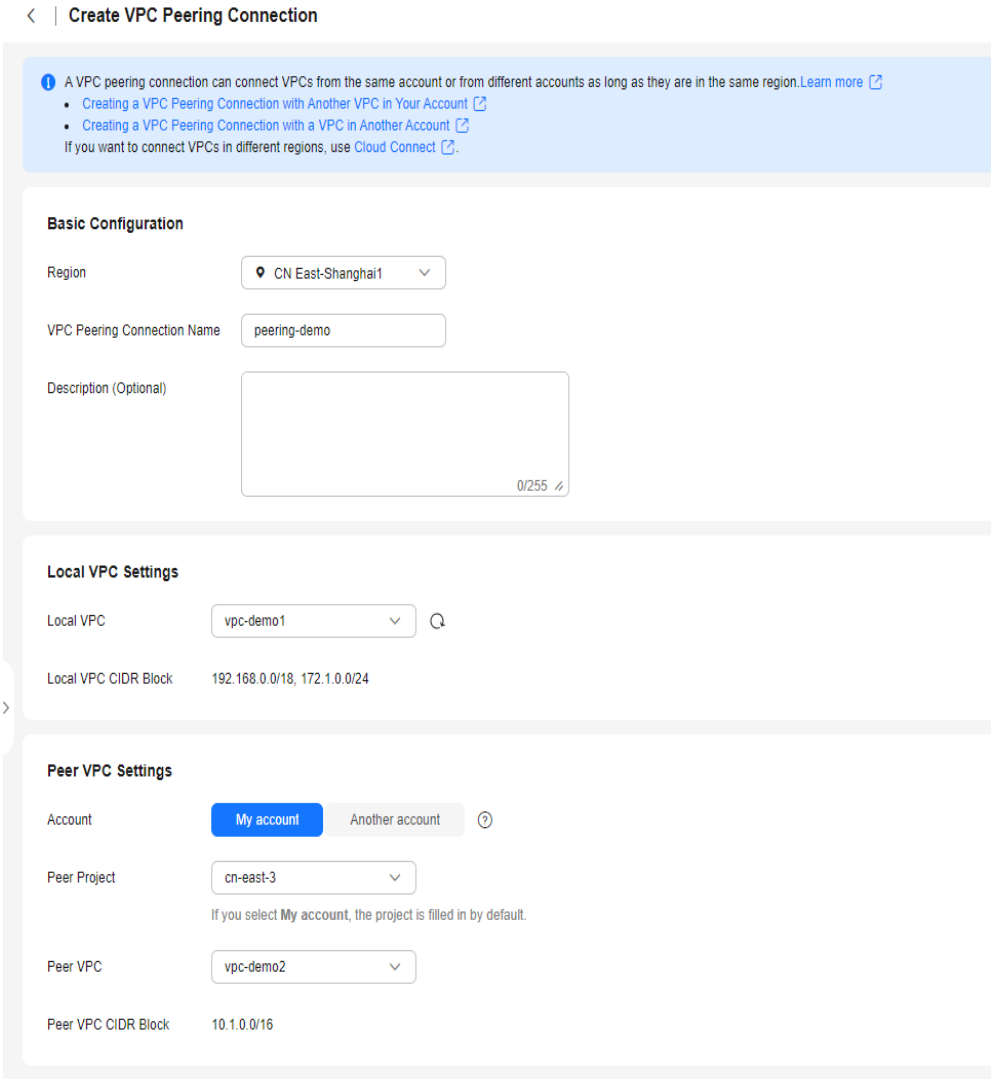


Table 10-17 Parameters for creating a VPC peering connection

Parameter	Description	Example
VPC Peering Connection Name	Mandatory. Enter a name for the VPC peering connection. The name can contain a maximum of 64 characters, including letters, digits, hyphens (-), and underscores (_).	peering-demo
Local VPC	Mandatory. Local-end VPC of the peering connection. You can choose one from the drop-down list.	vpc-demo1

Parameter	Description	Example
Local VPC CIDR Block	CIDR block of the selected local-end VPC.	192.168.0.0/18 and 172.1.0.0/24
Account	Mandatory. • **My account**: The local and peer VPCs are from the same account. • **Another account**: The local and peer VPCs are from different accounts.	My account
Peer Project	The system fills in the corresponding project by default because **Account** is set to **My account**. For example, vpc-demo1 and vpc-demo2 are both under account A in region A. Then, the system fills in the project of account A in region A by default.	None
Peer VPC	This parameter is mandatory if **Account** is set to **My account**. VPC at the other end of the peering connection. You can choose one from the drop-down list.	vpc-demo2
Peer VPC CIDR Block	CIDR block of the selected peer VPC. **NOTICE** If the local and peer VPCs have overlapping CIDR blocks, the VPC peering connection may not take effect.	10.1.0.0/16

d. After configuring the parameters, click **Create Now**.

2. In the displayed **VPC Peering Connection Created** dialog box, click **Add Now** and add a route for the node subnet and destination subnet. In the **Add Route** dialog box, configure the parameters following instructions. For details about the parameters, see **Table 10-18**.

Figure 10-51 Adding a route for the node subnet and destination subnet

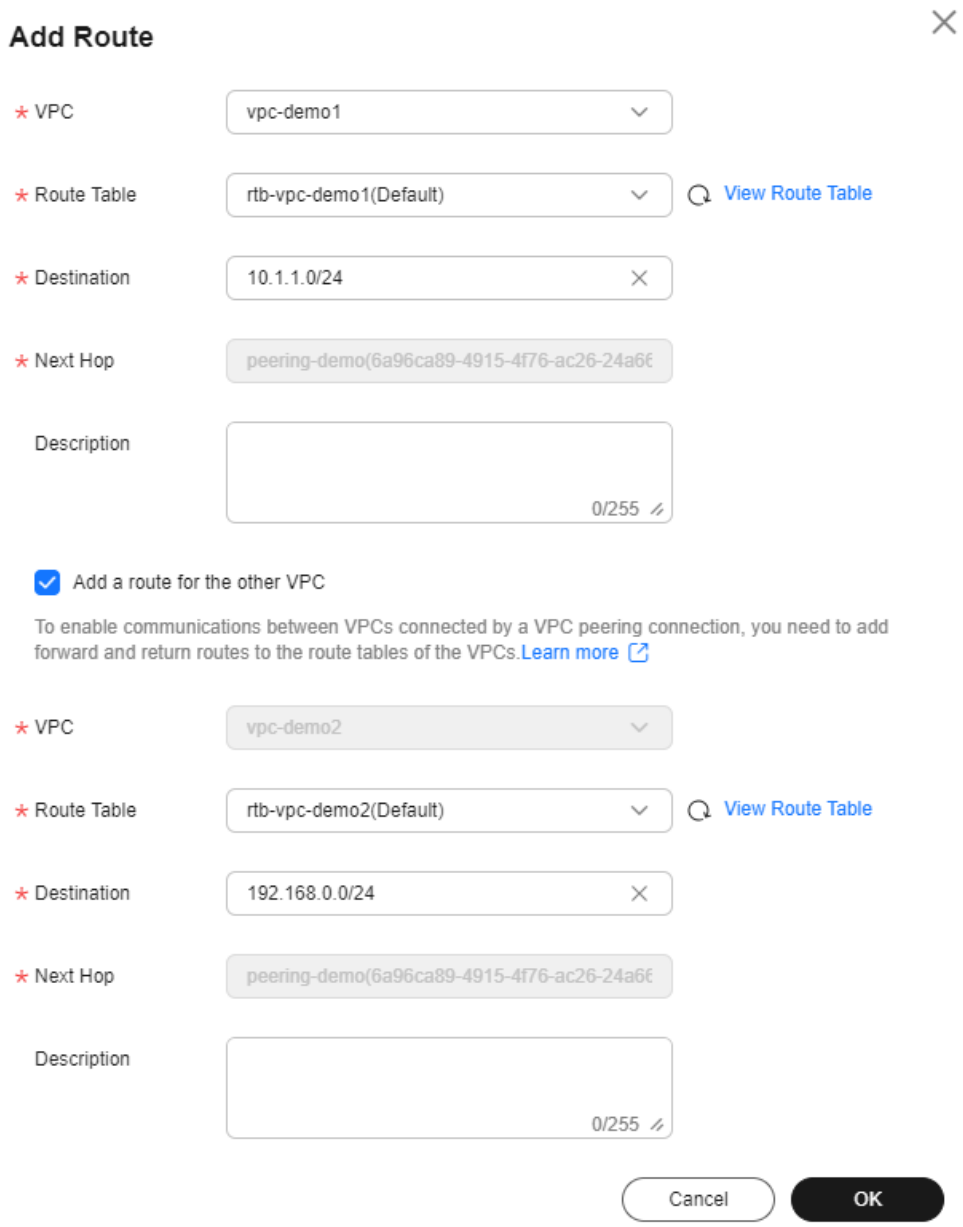


Table 10-18 Parameters for adding a route for the node subnet and destination subnet

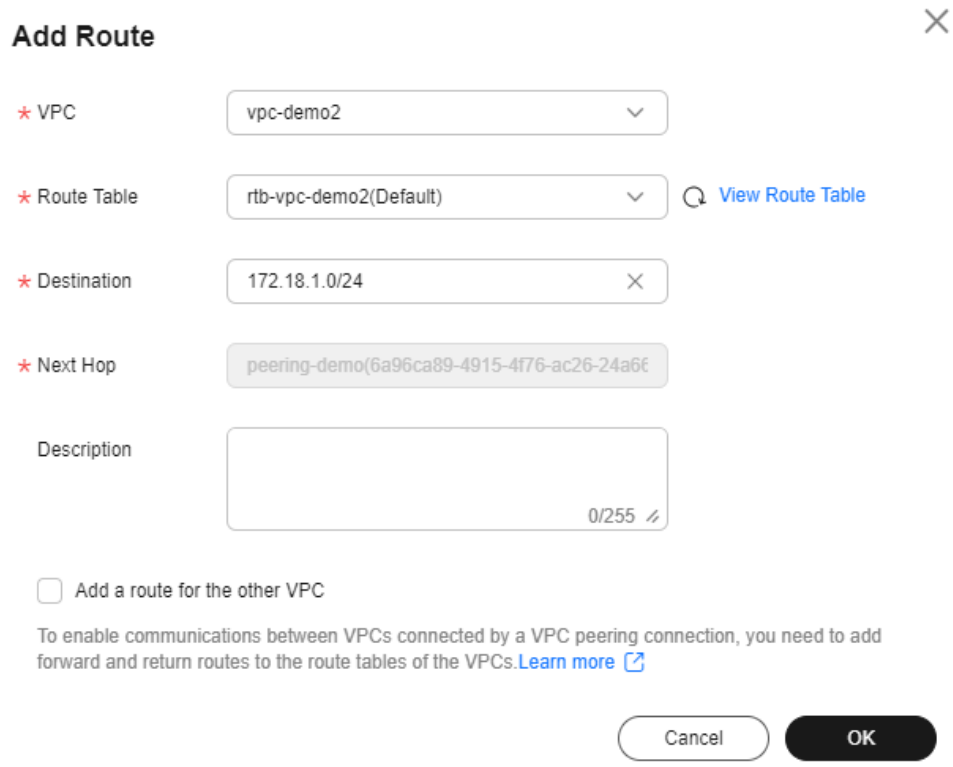
Parameter	Description	Example
VPC	Select a VPC that is connected by the VPC peering connection.	vpc-demo1

Parameter	Description	Example
Route Table	Select the route table of the VPC. The route will be added to this route table. Each VPC comes with a default route table that manages the flow of outgoing traffic from the subnets in the VPC. In addition to the default route table, you can create a custom route table and associate it with the subnets in the VPC. Then, the custom route table controls outbound traffic of the subnets. • If there is only the default route table in the drop-down list, select the default route table. • If there are both default and custom route tables in drop-down list, select the route table associated with the subnet connected by the VPC peering connection.	rtb-vpc-demo1 (default route table)
Destination	IP address in the VPC at the other end of the VPC peering connection. The value can be a VPC CIDR block, subnet CIDR block, or ECS IP address.	10.1.1.0/24
Add a route for the other VPC	If you select this option, you can also add a route for the other VPC connected by the VPC peering connection. To allow VPCs connected through VPC peering to communicate, you must include forward and return routes in the VPCs' route tables.	Selected
VPC	By default, the system selects the other VPC connected by the VPC peering connection. You do not need to specify this parameter.	vpc-demo2

Parameter	Description	Example
Route Table	Select the route table of the VPC. The route will be added to this route table. Each VPC comes with a default route table that manages the flow of outgoing traffic from the subnets in the VPC. In addition to the default route table, you can create a custom route table and associate it with the subnets in the VPC. Then, the custom route table controls outbound traffic of the subnets. • If there is only the default route table in the drop-down list, select the default route table. • If there are both default and custom route tables in drop-down list, select the route table associated with the subnet connected by the VPC peering connection.	rtb-vpc-demo2 (default route table)
Destination	IP address in the VPC at the other end of the VPC peering connection. The value can be a VPC CIDR block, subnet CIDR block, or ECS IP address.	192.168.0.0/24

3. On the current page, click **Add Route** and add a route for the destination VPC and the container CIDR block of the cluster. In the **Add Route** dialog box, set **VPC** to **vpc-demo2** and **Destination** to **172.18.1.0/24**. For details, see **Figure 10-52**.

Figure 10-52 Adding a route to the container CIDR block



4. Log in to the pod and enter the following code on the CloudShell page of the pod again, where *10.1.1.24* indicates the IP address of the ECS to be accessed: (For details about how to log in to a container, see **Logging In to a Container**.)

```
ping 10.1.1.24
```

NOTE

If the access fails, check whether the traffic from the cluster node subnet and container CIDR block is allowed in the inbound rules of the ECS security group. If it is not allowed, you need to add a security group rule and allow the corresponding traffic. For details, see **Adding a Security Group Rule**.

- If a ping command is available and information similar to the following is displayed, cross-VPC access from the pod is successful:

```
PING 10.1.1.24 (10.1.1.24): 56 data bytes
64 bytes from 10.1.1.24: seq=0 ttl=64 time=1.412 ms
64 bytes from 10.1.1.24: seq=1 ttl=64 time=1.400 ms
64 bytes from 10.1.1.24: seq=2 ttl=64 time=1.299 ms
64 bytes from 10.1.1.24: seq=3 ttl=64 time=1.283 ms
--- 10.1.1.24 ping statistics ---
4 packets transmitted, 4 packets received, 0% packet loss
```

- If no ping command is available, add it.

```
ping: command not found
```

The following uses the **Nginx:latest** container as an example to describe how to add a ping command. If the ping command is already available, skip this step.

i. Ensure that the pod can access the Internet. For details, see **Accessing the Internet from a Pod**.

ii. Update the local software package index and install the **iputils-ping** software package that provides the ping command.

```
apt-get update
apt-get install iputils-ping
```

iii. Access the ECS again.

```
ping 10.1.1.24
```

If information similar to the following is displayed, the ping command has been added and the cross-VPC access from the pod is successful:

```
PING 10.1.1.24 (10.1.1.24): 56 data bytes
64 bytes from 10.1.1.24: seq=0 ttl=64 time=1.412 ms
64 bytes from 10.1.1.24: seq=1 ttl=64 time=1.400 ms
64 bytes from 10.1.1.24: seq=2 ttl=64 time=1.299 ms
64 bytes from 10.1.1.24: seq=3 ttl=64 time=1.283 ms
--- 10.1.1.24 ping statistics ---
4 packets transmitted, 4 packets received, 0% packet loss
```

Accessing an ECS from a pod in a CCE Turbo cluster that uses the Cloud Native 2.0 network model

1. Create a VPC peering connection between the cluster VPC and the destination VPC.
   a. Switch to the console, click  in the upper left corner, and choose **Networking** > **Virtual Private Cloud** in the expanded list.
   b. In the navigation pane, choose **VPC Peering Connections**. In the upper right corner of the displayed page, click **Create VPC Peering Connection**.
   c. Configure parameters following instructions. For details about the parameters, see **Table 10-19**.

Figure 10-53 Creating a VPC peering connection

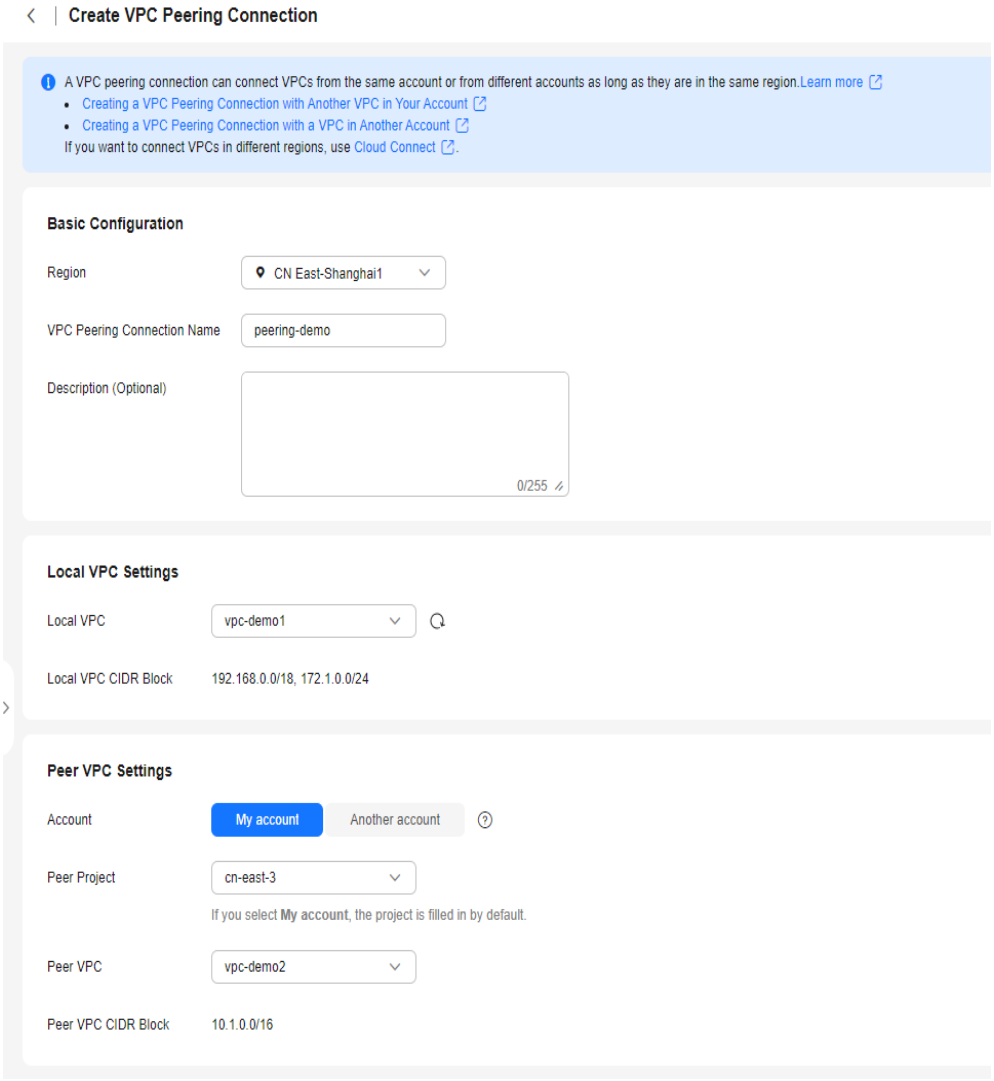


Table 10-19 Parameters for creating a VPC peering connection

Parameter	Description	Example
VPC Peering Connection Name	Mandatory. Enter a name for the VPC peering connection. The name can contain a maximum of 64 characters, including letters, digits, hyphens (-), and underscores (_).	peering-demo
Local VPC	Mandatory. Local-end VPC of the peering connection. You can choose one from the drop-down list.	vpc-demo1

Parameter	Description	Example
Local VPC CIDR Block	CIDR block of the selected local-end VPC.	192.168.0.0/18 and 172.1.0.0/24
Account	Mandatory. • **My account**: The local and peer VPCs are from the same account. • **Another account**: The local and peer VPCs are from different accounts.	My account
Peer Project	The system fills in the corresponding project by default because **Account** is set to **My account**. For example, vpc-demo1 and vpc-demo2 are both under account A in region A. Then, the system fills in the project of account A in region A by default.	None
Peer VPC	This parameter is mandatory if **Account** is set to **My account**. VPC at the other end of the peering connection. You can choose one from the drop-down list.	vpc-demo2
Peer VPC CIDR Block	CIDR block of the selected peer VPC. **NOTICE** If the local and peer VPCs have overlapping CIDR blocks, the VPC peering connection may not take effect.	10.1.0.0/16

2. In the displayed **VPC Peering Connection Created** dialog box, click **Add Now** and add a route for the container subnet and destination subnet. In the **Add Route** dialog box, configure the parameters following instructions. For details about the parameters, see **Table 10-20**.

Figure 10-54 Adding a route for the container subnet and the destination subnet

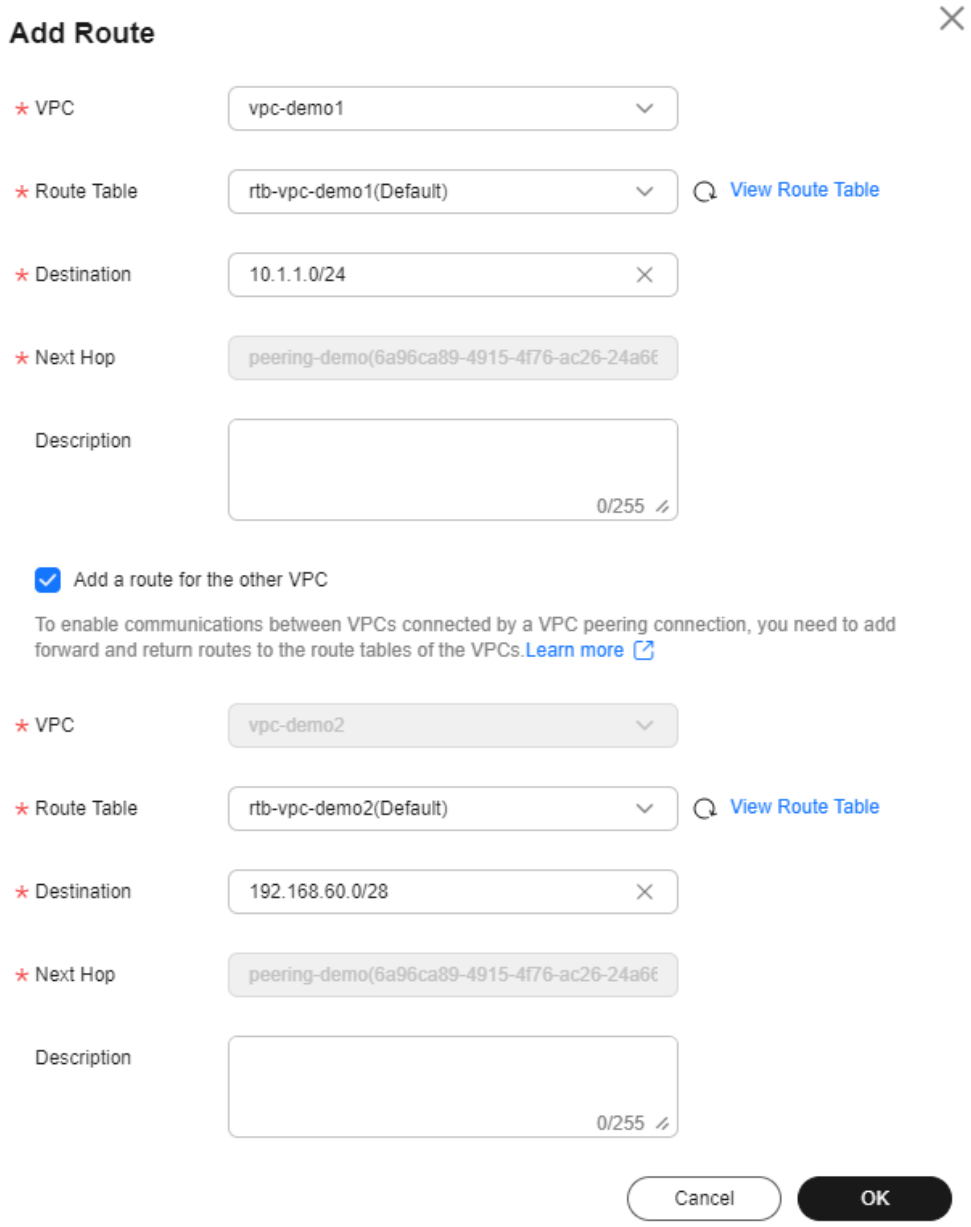


Table 10-20 Parameters for adding a route for the container subnet and destination subnet

Parameter	Description	Example
VPC	Select a VPC that is connected by the VPC peering connection.	vpc-demo1

Parameter	Description	Example
Route Table	Select the route table of the VPC. The route will be added to this route table. Each VPC comes with a default route table that manages the flow of outgoing traffic from the subnets in the VPC. In addition to the default route table, you can create a custom route table and associate it with the subnets in the VPC. Then, the custom route table controls outbound traffic of the subnets. • If there is only the default route table in the drop-down list, select the default route table. • If there are both default and custom route tables in drop-down list, select the route table associated with the subnet connected by the VPC peering connection.	rtb-vpc-demo1 (default route table)
Destination	IP address in the VPC at the other end of the VPC peering connection. The value can be a VPC CIDR block, subnet CIDR block, or ECS IP address.	10.1.1.0/24
Add a route for the other VPC	If you select this option, you can also add a route for the other VPC connected by the VPC peering connection. To allow VPCs connected through VPC peering to communicate, you must include forward and return routes in the VPCs' route tables.	Selected
VPC	By default, the system selects the other VPC connected by the VPC peering connection. You do not need to specify this parameter.	vpc-demo2

Parameter	Description	Example
Route Table	Select the route table of the VPC. The route will be added to this route table. Each VPC comes with a default route table that manages the flow of outgoing traffic from the subnets in the VPC. In addition to the default route table, you can create a custom route table and associate it with the subnets in the VPC. Then, the custom route table controls outbound traffic of the subnets. • If there is only the default route table in the drop-down list, select the default route table. • If there are both default and custom route tables in drop-down list, select the route table associated with the subnet connected by the VPC peering connection.	rtb-vpc-demo2 (default route table)
Destination	IP address in the VPC at the other end of the VPC peering connection. The value can be a VPC CIDR block, subnet CIDR block, or ECS IP address.	192.168.60.0/28

3. Log in to the pod and enter the following code on the CloudShell page of the pod again, where *10.1.1.24* indicates the IP address of the ECS to be accessed: (For details about how to log in to a container, see **Logging In to a Container**.)

```
ping 10.1.1.24
```

NOTE

If the access fails, check whether the traffic from the cluster container subnet is allowed in the inbound rules of the ECS security group. If it is not allowed, you need to add a security group rule and allow the corresponding traffic. For details, see **Adding a Security Group Rule**.

– If a ping command is available and information similar to the following is displayed, cross-VPC access from the pod is successful:

```
PING 10.1.1.24 (10.1.1.24): 56 data bytes
64 bytes from 10.1.1.24: seq=0 ttl=64 time=1.412 ms
64 bytes from 10.1.1.24: seq=1 ttl=64 time=1.400 ms
64 bytes from 10.1.1.24: seq=2 ttl=64 time=1.299 ms
64 bytes from 10.1.1.24: seq=3 ttl=64 time=1.283 ms
--- 10.1.1.24 ping statistics ---
4 packets transmitted, 4 packets received, 0% packet loss
```

– If no ping command is available, add it.

```
ping: command not found
```

The following uses the **Nginx:latest** container as an example to describe how to add a ping command. If the ping command is already available, skip this step.

i. Ensure that the pod can access the Internet. For details, see **Accessing the Internet from a Pod**.

ii. Update the local software package index and install the **iputils-ping** software package that provides the ping command.

```
apt-get update
apt-get install iputils-ping
```

iii. Access the ECS again.

```
ping 10.1.1.24
```

If information similar to the following is displayed, the ping command has been added and the cross-VPC access from the pod is successful:

```
PING 10.1.1.24 (10.1.1.24): 56 data bytes
64 bytes from 10.1.1.24: seq=0 ttl=64 time=1.412 ms
64 bytes from 10.1.1.24: seq=1 ttl=64 time=1.400 ms
64 bytes from 10.1.1.24: seq=2 ttl=64 time=1.299 ms
64 bytes from 10.1.1.24: seq=3 ttl=64 time=1.283 ms
--- 10.1.1.24 ping statistics ---
4 packets transmitted, 4 packets received, 0% packet loss
```

Accessing a Cloud Service (RDS for MySQL as an Example) from a Pod

The following describes how to access an RDS for MySQL DB instance from pods that run in clusters that use the tunnel network model, VPC network model, and Cloud Native 2.0 network model, respectively. You can select a method based on your cluster types.

Accessing an RDS for MySQL DB instance from a pod in a CCE standard cluster that uses the tunnel network model

1. Create a VPC peering connection between the cluster VPC and the destination VPC.

   a. Switch to the console, click ☰ in the upper left corner, and choose **Networking** > **Virtual Private Cloud** in the expanded list.

   b. In the navigation pane, choose **VPC Peering Connections**. In the upper right corner of the displayed page, click **Create VPC Peering Connection**.

   c. Configure parameters following instructions. For details about some of the parameters, see **Table 10-21**.

Figure 10-55 Creating a VPC peering connection

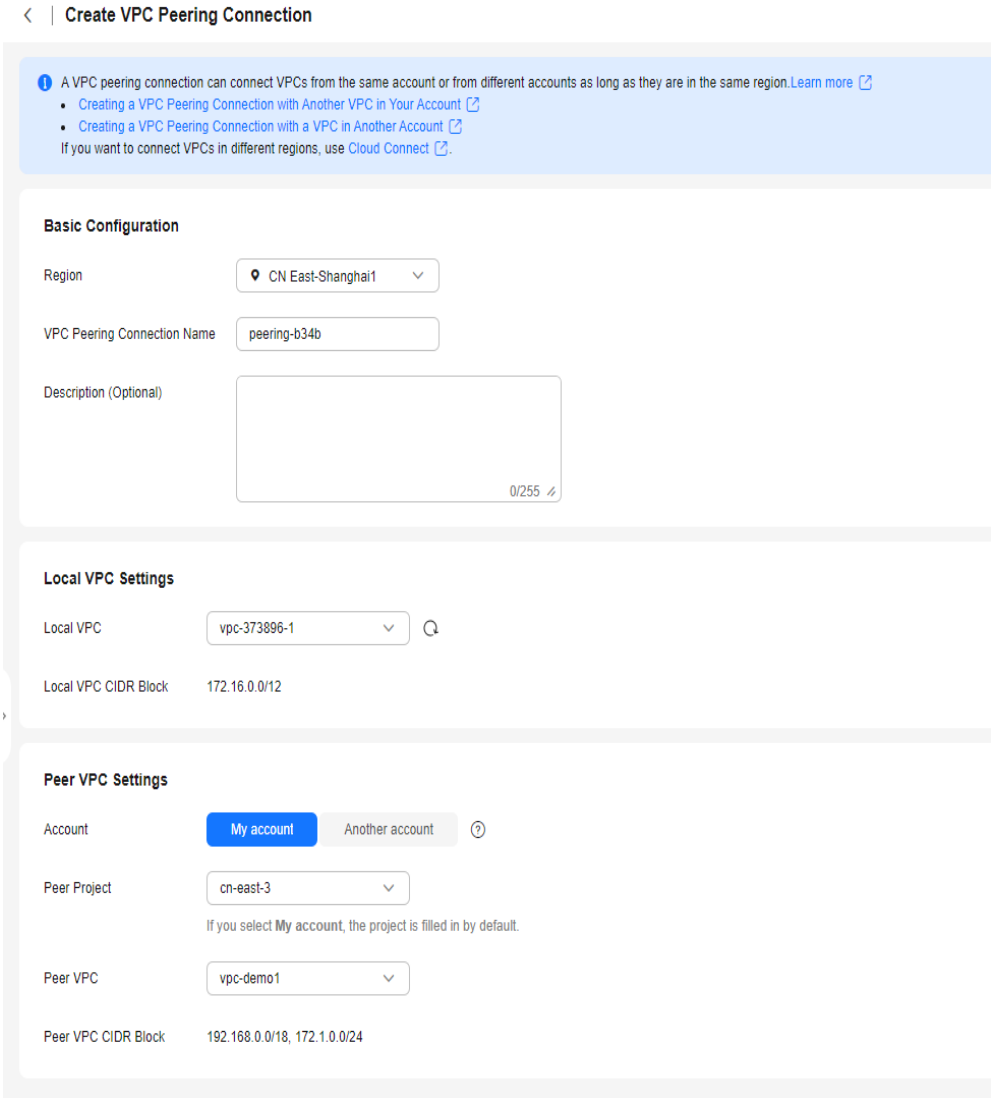


Table 10-21 Parameters for creating a VPC peering connection

Parameter	Description	Example
VPC Peering Connection Name	Mandatory. Enter a name for the VPC peering connection. The name can contain a maximum of 64 characters, including letters, digits, hyphens (-), and underscores (_).	peering-b34b
Local VPC	Mandatory. Local-end VPC of the peering connection. You can choose one from the drop-down list.	vpc-373896-1

Parameter	Description	Example
Local VPC CIDR Block	CIDR block of the selected local-end VPC.	172.16.0.0/12
Account	Mandatory. • **My account**: The local and peer VPCs are from the same account. • **Another account**: The local and peer VPCs are from different accounts.	My account
Peer Project	The system fills in the corresponding project by default because **Account** is set to **My account**. For example, vpc-demo1 and vpc-demo2 are both under account A in region A. Then, the system fills in the project of account A in region A by default.	None
Peer VPC	This parameter is mandatory if **Account** is set to **My account**. VPC at the other end of the peering connection. You can choose one from the drop-down list.	vpc-demo1
Peer VPC CIDR Block	CIDR block of the selected peer VPC. **NOTICE** If the local and peer VPCs have overlapping CIDR blocks, the VPC peering connection may not take effect.	192.168.0.0/18 and 172.1.0.0/24

d. After configuring the parameters, click **Create Now**.

2. In the displayed **VPC Peering Connection Created** dialog box, click **Add Now** and add a route for the node subnet and destination subnet. In the **Add Route** dialog box, configure the parameters following instructions. For details about the parameters, see **Table 10-22**.

Figure 10-56 Adding a route for the node subnet and destination subnet

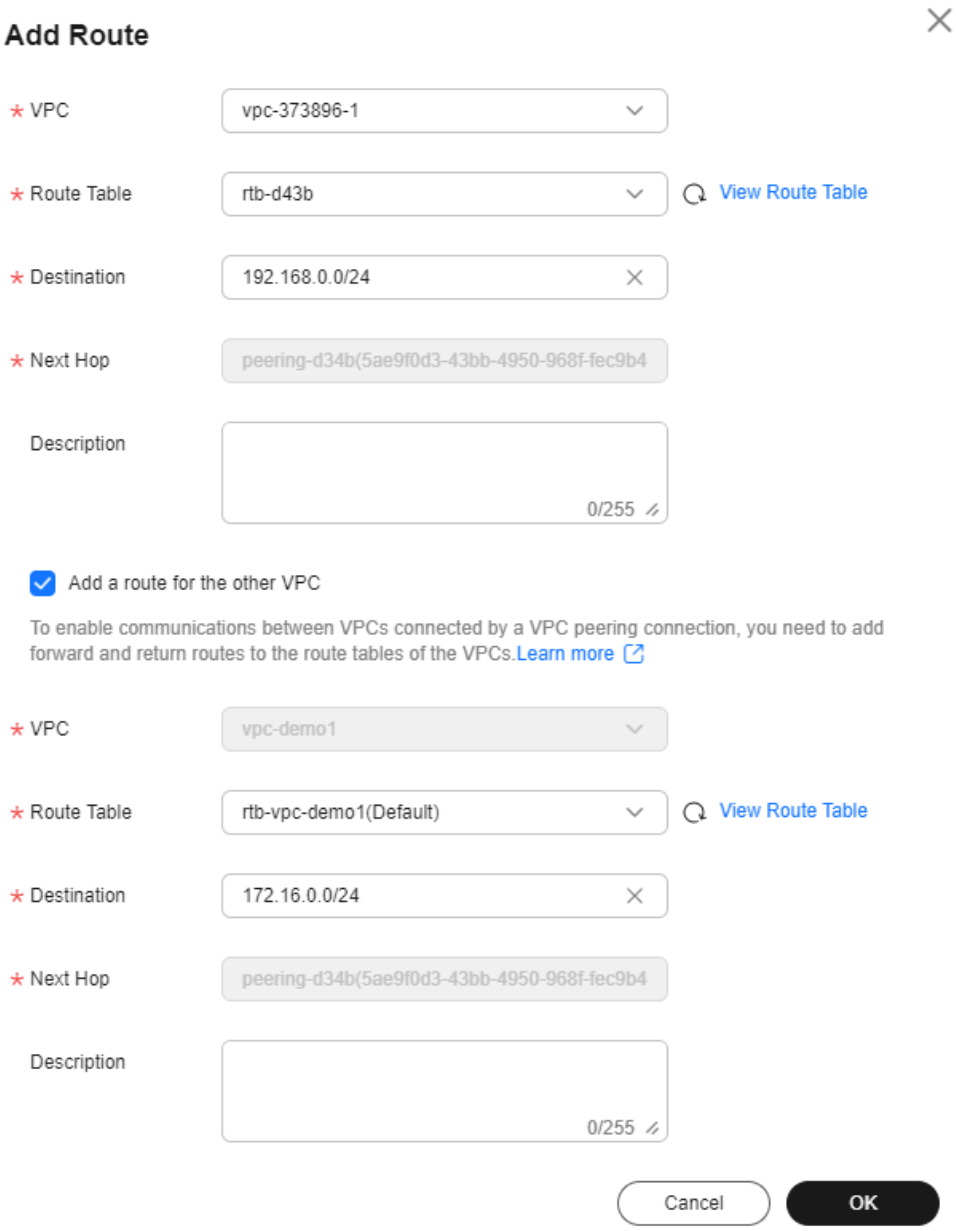


Table 10-22 Parameters for adding a route for the node subnet and destination subnet

Parameter	Description	Example
VPC	Select a VPC that is connected by the VPC peering connection.	vpc-373896-1

Parameter	Description	Example
Route Table	Select the route table of the VPC. The route will be added to this route table. Each VPC comes with a default route table that manages the flow of outgoing traffic from the subnets in the VPC. In addition to the default route table, you can create a custom route table and associate it with the subnets in the VPC. Then, the custom route table controls outbound traffic of the subnets. • If there is only the default route table in the drop-down list, select the default route table. • If there are both default and custom route tables in drop-down list, select the route table associated with the subnet connected by the VPC peering connection.	rtb-d43b (custom route table) **NOTICE** The custom route table must be associated with the subnet connected by the VPC peering connection.
Destination	IP address in the VPC at the other end of the VPC peering connection. The value can be a VPC CIDR block, subnet CIDR block, or ECS IP address.	192.168.0.0/24
Add a route for the other VPC	If you select this option, you can also add a route for the other VPC connected by the VPC peering connection. To allow VPCs connected through VPC peering to communicate, you must include forward and return routes in the VPCs' route tables.	Selected
VPC	By default, the system selects the other VPC connected by the VPC peering connection. You do not need to specify this parameter.	vpc-demo1

Parameter	Description	Example
Route Table	Select the route table of the VPC. The route will be added to this route table. Each VPC comes with a default route table that manages the flow of outgoing traffic from the subnets in the VPC. In addition to the default route table, you can create a custom route table and associate it with the subnets in the VPC. Then, the custom route table controls outbound traffic of the subnets. • If there is only the default route table in the drop-down list, select the default route table. • If there are both default and custom route tables in drop-down list, select the route table associated with the subnet connected by the VPC peering connection.	rtb-vpc-demo1 (default route table)
Destination	IP address in the VPC at the other end of the VPC peering connection. The value can be a VPC CIDR block, subnet CIDR block, or ECS IP address.	172.16.0.0/24

3. Log in to the pod and enter the following code on the CloudShell page of the pod again, where *172.16.0.167* indicates the IP address of the RDS for MySQL DB instance to be accessed: (For details about how to log in to a container, see **Logging In to a Container**.)

```
ping 172.16.0.167
```

NOTE

If the access fails, check whether the traffic from the cluster node subnet is allowed in the inbound rules of the DB instance security group. If it is not allowed, you need to add a security group rule and allow the corresponding traffic. For details, see **Adding a Security Group Rule**.

– If a ping command is available and information similar to the following is displayed, cross-VPC access from the pod is successful:

```
PING 172.16.0.167 (172.16.0.167) 56(84) bytes of data.
64 bytes from 172.16.0.167: icmp_seq=1 ttl=63 time=0.516 ms
64 bytes from 172.16.0.167: icmp_seq=2 ttl=63 time=0.418 ms
64 bytes from 172.16.0.167: icmp_seq=3 ttl=63 time=0.376 ms
--- 172.16.0.167 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 1001ms
```

– If no ping command is available, add it.

```
ping: command not found
```

The following uses the **Nginx:latest** container as an example to describe how to add a ping command. If the ping command is already available, skip this step.

i. Ensure that the pod can access the Internet. For details, see **Accessing the Internet from a Pod**.

ii. Update the local software package index and install the **iputils-ping** software package that provides the ping command.

```
apt-get update
apt-get install iputils-ping
```

iii. Access the RDS for MySQL DB instance again.

```
ping 172.16.0.167
```

If information similar to the following is displayed, the ping command has been added and the cross-VPC access from the pod is successful:

```
PING 172.16.0.167 (172.16.0.167) 56(84) bytes of data.
64 bytes from 172.16.0.167: icmp_seq=1 ttl=63 time=0.516 ms
64 bytes from 172.16.0.167: icmp_seq=2 ttl=63 time=0.418 ms
64 bytes from 172.16.0.167: icmp_seq=3 ttl=63 time=0.376 ms
--- 172.16.0.167 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 1001ms
```

Accessing an RDS for MySQL DB instance from a pod in a CCE standard cluster that uses the VPC network model

1. Create a VPC peering connection between the cluster VPC and the destination VPC.
   a. Switch to the console, click ☰ in the upper left corner, and choose **Networking** > **Virtual Private Cloud** in the expanded list.
   b. In the navigation pane, choose **VPC Peering Connections**. In the upper right corner of the displayed page, click **Create VPC Peering Connection**.
   c. Configure parameters following instructions. For details about some of the parameters, see **Table 10-23**.

Figure 10-57 Creating a VPC peering connection

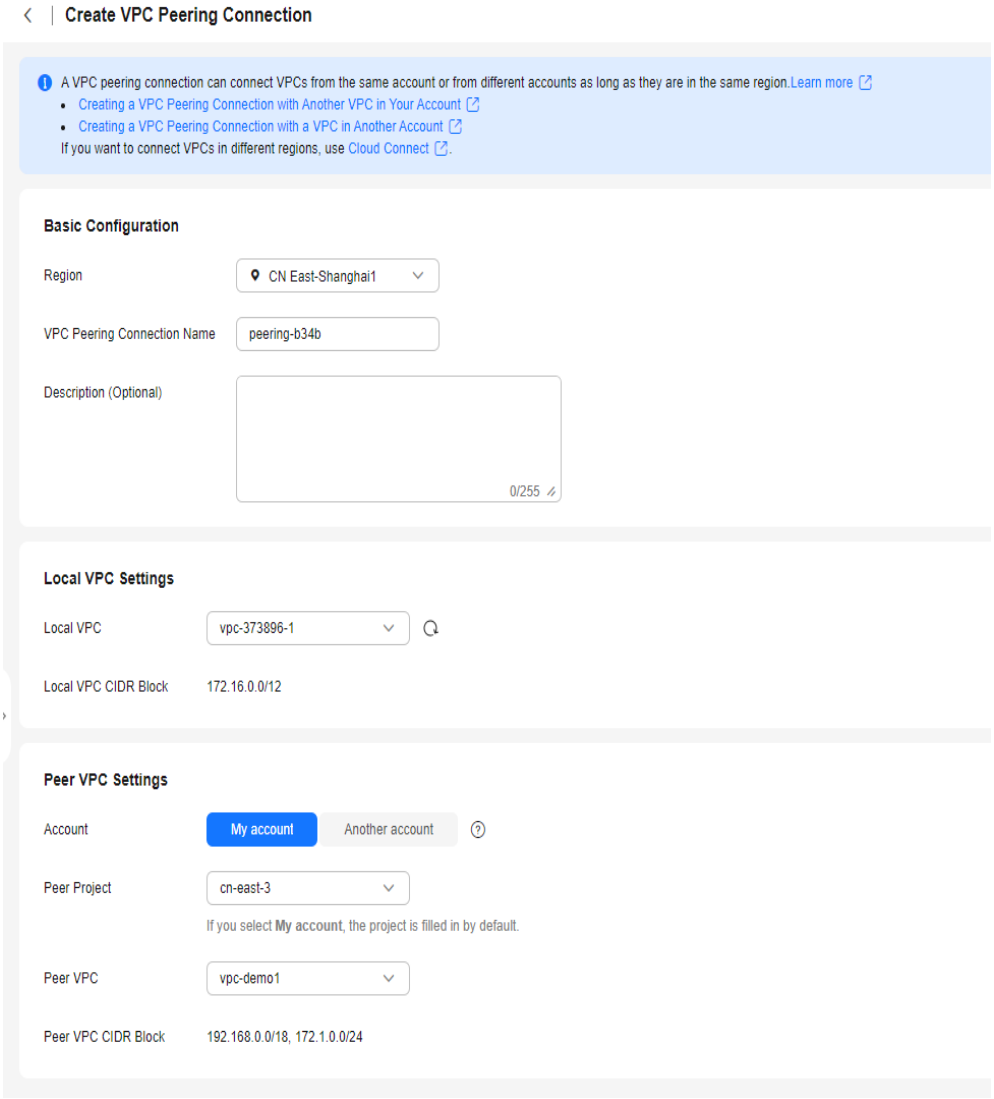


Table 10-23 Parameters for creating a VPC peering connection

Parameter	Description	Example
VPC Peering Connection Name	Mandatory. Enter a name for the VPC peering connection. The name can contain a maximum of 64 characters, including letters, digits, hyphens (-), and underscores (_).	peering-b34b
Local VPC	Mandatory. Local-end VPC of the peering connection. You can choose one from the drop-down list.	vpc-373896-1

Parameter	Description	Example
Local VPC CIDR Block	CIDR block of the selected local-end VPC.	172.16.0.0/12
Account	Mandatory. • **My account**: The local and peer VPCs are from the same account. • **Another account**: The local and peer VPCs are from different accounts.	My account
Peer Project	The system fills in the corresponding project by default because **Account** is set to **My account**. For example, vpc-demo1 and vpc-demo2 are both under account A in region A. Then, the system fills in the project of account A in region A by default.	None
Peer VPC	This parameter is mandatory if **Account** is set to **My account**. VPC at the other end of the peering connection. You can choose one from the drop-down list.	vpc-demo1
Peer VPC CIDR Block	CIDR block of the selected peer VPC. **NOTICE** If the local and peer VPCs have overlapping CIDR blocks, the VPC peering connection may not take effect.	192.168.0.0/18 and 172.1.0.0/24

d. After configuring the parameters, click **Create Now**.

2. In the displayed **VPC Peering Connection Created** dialog box, click **Add Now** and add a route for the node subnet and destination subnet. In the **Add Route** dialog box, configure the parameters following instructions. For details about the parameters, see **Table 10-24**.

Figure 10-58 Adding a route for the node subnet and destination subnet

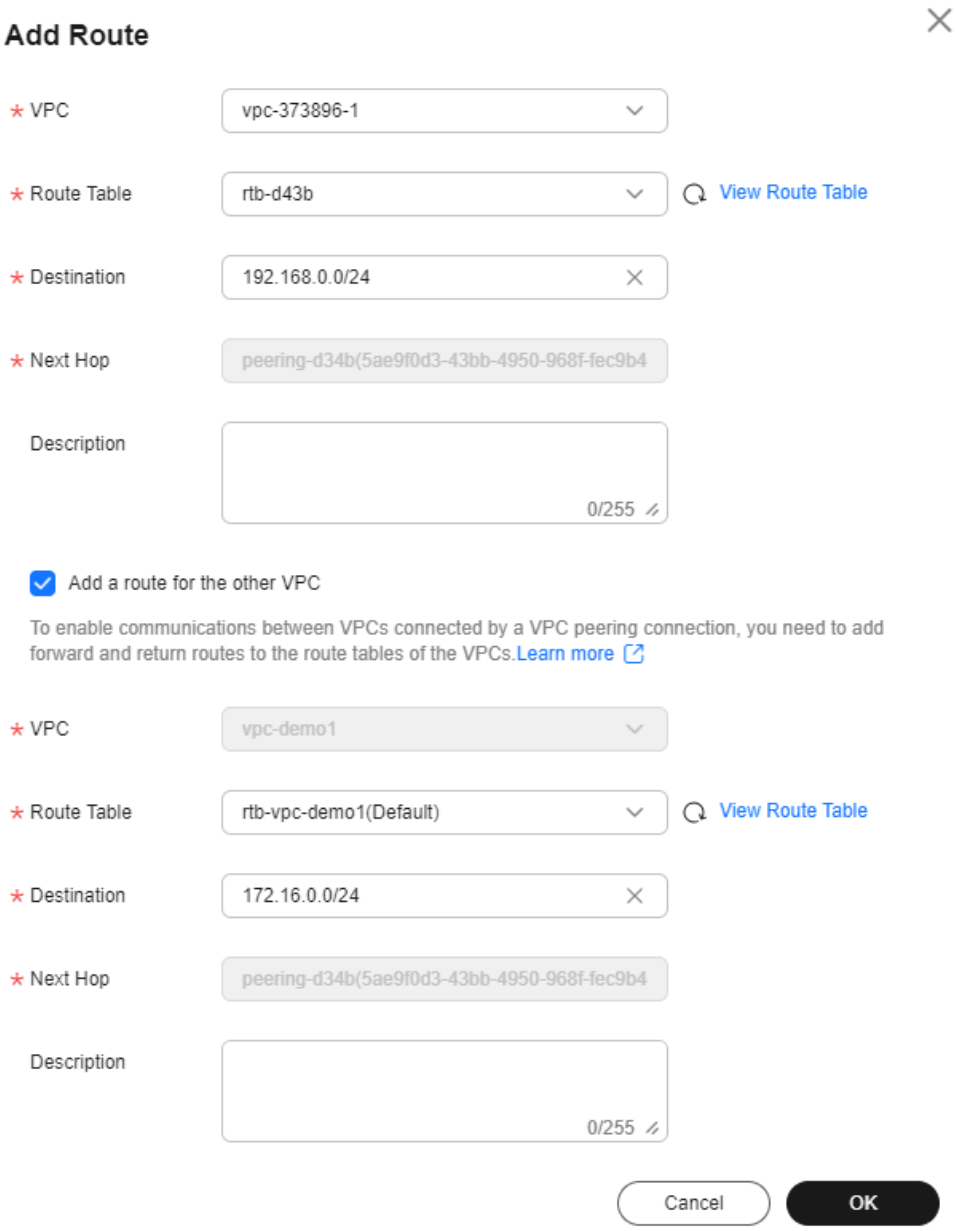


Table 10-24 Parameters for adding a route for the node subnet and destination subnet

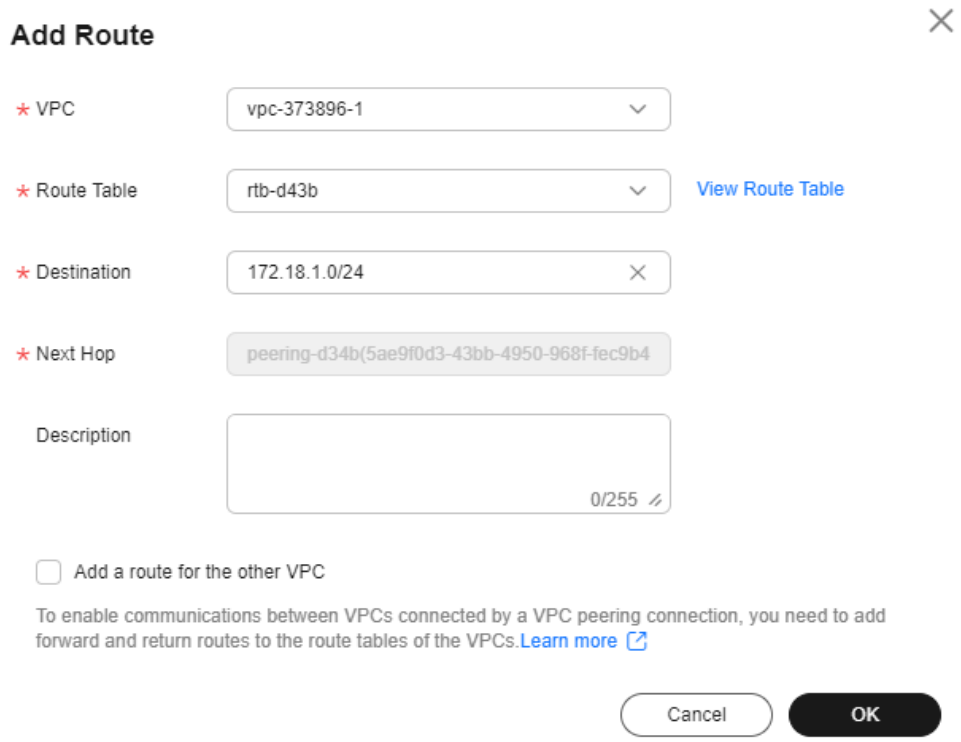
Parameter	Description	Example
VPC	Select a VPC that is connected by the VPC peering connection.	vpc-373896-1

Parameter	Description	Example
Route Table	Select the route table of the VPC. The route will be added to this route table. Each VPC comes with a default route table that manages the flow of outgoing traffic from the subnets in the VPC. In addition to the default route table, you can create a custom route table and associate it with the subnets in the VPC. Then, the custom route table controls outbound traffic of the subnets. • If there is only the default route table in the drop-down list, select the default route table. • If there are both default and custom route tables in drop-down list, select the route table associated with the subnet connected by the VPC peering connection.	rtb-d43b (custom route table) **NOTICE** The custom route table must be associated with the subnet connected by the VPC peering connection.
Destination	IP address in the VPC at the other end of the VPC peering connection. The value can be a VPC CIDR block, subnet CIDR block, or ECS IP address.	192.168.0.0/24
Add a route for the other VPC	If you select this option, you can also add a route for the other VPC connected by the VPC peering connection. To allow VPCs connected through VPC peering to communicate, you must include forward and return routes in the VPCs' route tables.	Selected
VPC	By default, the system selects the other VPC connected by the VPC peering connection. You do not need to specify this parameter.	vpc-demo1

Parameter	Description	Example
Route Table	Select the route table of the VPC. The route will be added to this route table. Each VPC comes with a default route table that manages the flow of outgoing traffic from the subnets in the VPC. In addition to the default route table, you can create a custom route table and associate it with the subnets in the VPC. Then, the custom route table controls outbound traffic of the subnets. • If there is only the default route table in the drop-down list, select the default route table. • If there are both default and custom route tables in drop-down list, select the route table associated with the subnet connected by the VPC peering connection.	rtb-vpc-demo1 (default route table)
Destination	IP address in the VPC at the other end of the VPC peering connection. The value can be a VPC CIDR block, subnet CIDR block, or ECS IP address.	172.16.0.0/24

3. On the current page, click **Add Route**. In the displayed dialog box, set **VPC** to **vpc-373896-1** and **Destination** to **172.18.1.0/24** and add a route for the destination VPC and the container CIDR block of the cluster. For details, see **Figure 10-59**.

Figure 10-59 Adding a route to the container CIDR block



4. Log in to the pod and enter the following code on the CloudShell page of the pod again, where *172.16.0.167* indicates the IP address of the RDS for MySQL DB instance to be accessed: (For details about how to log in to a container, see **Logging In to a Container**.)

```
ping 172.16.0.167
```

NOTE

If the access fails, check whether the traffic from the cluster node subnet and container CIDR block is allowed in the inbound rules of the DB instance security group. If it is not allowed, you need to add a security group rule and allow the corresponding traffic. For details, see **Adding a Security Group Rule**.

- If a ping command is available and information similar to the following is displayed, cross-VPC access from the pod is successful:

```
PING 172.16.0.167 (172.16.0.167) 56(84) bytes of data.
64 bytes from 172.16.0.167: icmp_seq=1 ttl=63 time=0.516 ms
64 bytes from 172.16.0.167: icmp_seq=2 ttl=63 time=0.418 ms
64 bytes from 172.16.0.167: icmp_seq=3 ttl=63 time=0.376 ms
--- 172.16.0.167 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 1001ms
```

- If no ping command is available, add it.

```
ping: command not found
```

  The following uses the **Nginx:latest** container as an example to describe how to add a ping command. If the ping command is already available, skip this step.

  i. Ensure that the pod can access the Internet. For details, see **Accessing the Internet from a Pod**.

  ii. Update the local software package index and install the **iputils-ping** software package that provides the ping command.


```
apt-get update
apt-get install iputils-ping
```

iii. Access the RDS for MySQL DB instance again.

```
ping 172.16.0.167
```

If information similar to the following is displayed, the ping command has been added and the cross-VPC access from the pod is successful:

```
PING 172.16.0.167 (172.16.0.167) 56(84) bytes of data.
64 bytes from 172.16.0.167: icmp_seq=1 ttl=63 time=0.516 ms
64 bytes from 172.16.0.167: icmp_seq=2 ttl=63 time=0.418 ms
64 bytes from 172.16.0.167: icmp_seq=3 ttl=63 time=0.376 ms
--- 172.16.0.167 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 1001ms
```

Accessing an RDS for MySQL DB instance from a pod in a CCE Turbo cluster that uses the Cloud Native 2.0 network model

1. Create a VPC peering connection between the cluster VPC and the destination VPC.

   a. Switch to the console, click ☰ in the upper left corner, and choose **Networking** > **Virtual Private Cloud** in the expanded list.

   b. In the navigation pane, choose **VPC Peering Connections**. In the upper right corner of the displayed page, click **Create VPC Peering Connection**.

   c. Configure parameters following instructions. For details about some of the parameters, see **Table 10-25**.

Figure 10-60 Creating a VPC peering connection

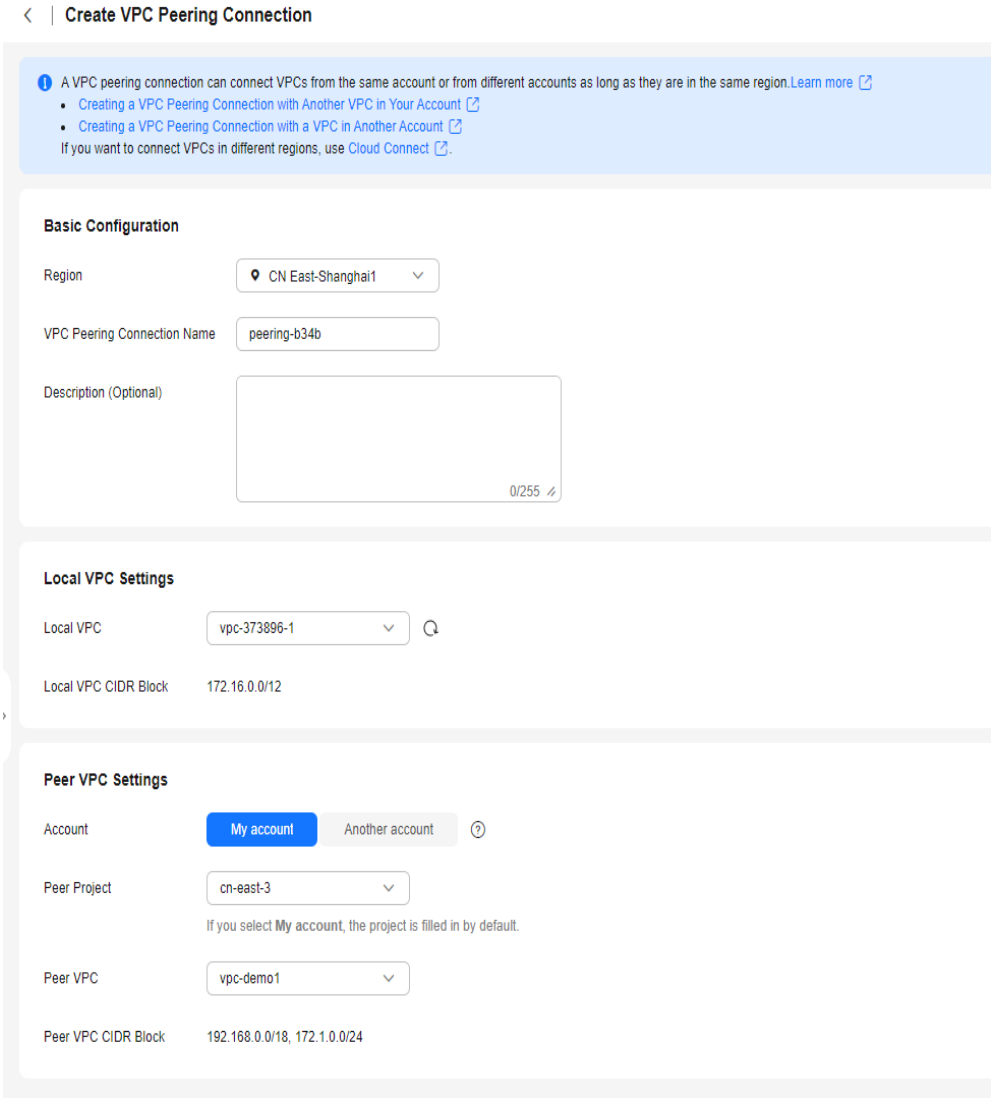


Table 10-25 Parameters for creating a VPC peering connection

Parameter	Description	Example
VPC Peering Connection Name	Mandatory. Enter a name for the VPC peering connection. The name can contain a maximum of 64 characters, including letters, digits, hyphens (-), and underscores (_).	peering-b34b
Local VPC	Mandatory. Local-end VPC of the peering connection. You can choose one from the drop-down list.	vpc-373896-1

Parameter	Description	Example
Local VPC CIDR Block	CIDR block of the selected local-end VPC.	172.16.0.0/12
Account	Mandatory. • **My account**: The local and peer VPCs are from the same account. • **Another account**: The local and peer VPCs are from different accounts.	My account
Peer Project	The system fills in the corresponding project by default because **Account** is set to **My account**. For example, vpc-demo1 and vpc-demo2 are both under account A in region A. Then, the system fills in the project of account A in region A by default.	None
Peer VPC	This parameter is mandatory if **Account** is set to **My account**. VPC at the other end of the peering connection. You can choose one from the drop-down list.	vpc-demo1
Peer VPC CIDR Block	CIDR block of the selected peer VPC. **NOTICE** If the local and peer VPCs have overlapping CIDR blocks, the VPC peering connection may not take effect.	192.168.0.0/18 and 172.1.0.0/24

d. After configuring the parameters, click **Create Now**.

2. In the displayed **VPC Peering Connection Created** dialog box, click **Add Now** and add a route for the container subnet and destination subnet. In the **Add Route** dialog box, configure the parameters following instructions. For details about the parameters, see **Table 10-26**.

Figure 10-61 Adding a route to the container CIDR block

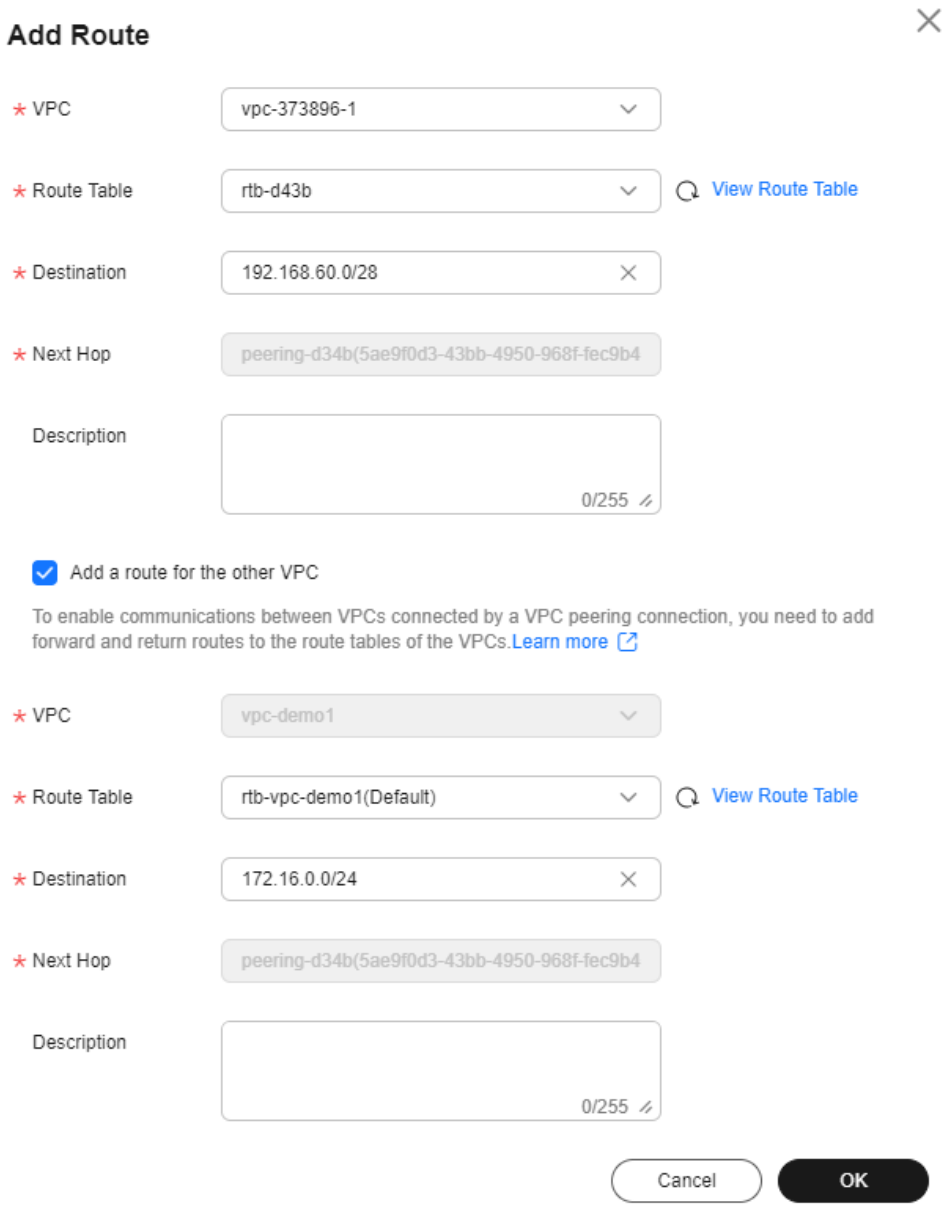


Table 10-26 Parameters for adding a route for the container subnet and destination subnet

Parameter	Description	Example
VPC	Select a VPC that is connected by the VPC peering connection.	vpc-373896-1

Parameter	Description	Example
Route Table	Select the route table of the VPC. The route will be added to this route table. Each VPC comes with a default route table that manages the flow of outgoing traffic from the subnets in the VPC. In addition to the default route table, you can create a custom route table and associate it with the subnets in the VPC. Then, the custom route table controls outbound traffic of the subnets. • If there is only the default route table in the drop-down list, select the default route table. • If there are both default and custom route tables in drop-down list, select the route table associated with the subnet connected by the VPC peering connection.	rtb-d43b (custom route table) **NOTICE** The custom route table must be associated with the subnet connected by the VPC peering connection.
Destination	IP address in the VPC at the other end of the VPC peering connection. The value can be a VPC CIDR block, subnet CIDR block, or ECS IP address.	192.168.60.0/28
Add a route for the other VPC	If you select this option, you can also add a route for the other VPC connected by the VPC peering connection. To allow VPCs connected through VPC peering to communicate, you must include forward and return routes in the VPCs' route tables.	Selected
VPC	By default, the system selects the other VPC connected by the VPC peering connection. You do not need to specify this parameter.	vpc-demo1

Parameter	Description	Example
Route Table	Select the route table of the VPC. The route will be added to this route table. Each VPC comes with a default route table that manages the flow of outgoing traffic from the subnets in the VPC. In addition to the default route table, you can create a custom route table and associate it with the subnets in the VPC. Then, the custom route table controls outbound traffic of the subnets. • If there is only the default route table in the drop-down list, select the default route table. • If there are both default and custom route tables in drop-down list, select the route table associated with the subnet connected by the VPC peering connection.	rtb-vpc-demo1 (default route table)
Destination	IP address in the VPC at the other end of the VPC peering connection. The value can be a VPC CIDR block, subnet CIDR block, or ECS IP address.	172.16.0.0/24

3. Log in to the pod and enter the following code on the CloudShell page of the pod again, where *172.16.0.167* indicates the IP address of the RDS for MySQL DB instance to be accessed: (For details about how to log in to a container, see **Logging In to a Container**.)

```
ping 172.16.0.167
```

NOTE

If the access fails, check whether the traffic from the cluster container subnet is allowed in the inbound rules of the DB instance security group. If it is not allowed, you need to add a security group rule and allow the corresponding traffic. For details, see **Adding a Security Group Rule**.

– If a ping command is available and information similar to the following is displayed, cross-VPC access from the pod is successful:

```
PING 172.16.0.167 (172.16.0.167) 56(84) bytes of data.
64 bytes from 172.16.0.167: icmp_seq=1 ttl=63 time=0.516 ms
64 bytes from 172.16.0.167: icmp_seq=2 ttl=63 time=0.418 ms
64 bytes from 172.16.0.167: icmp_seq=3 ttl=63 time=0.376 ms
--- 172.16.0.167 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 1001ms
```

– If no ping command is available, add it.

```
ping: command not found
```

The following uses the **Nginx:latest** container as an example to describe how to add a ping command. If the ping command is already available, skip this step.

i. Ensure that the pod can access the Internet. For details, see **Accessing the Internet from a Pod**.

ii. Update the local software package index and install the **iputils-ping** software package that provides the ping command.

```
apt-get update
apt-get install iputils-ping
```

iii. Access the RDS for MySQL DB instance again.

```
ping 172.16.0.167
```

If information similar to the following is displayed, the ping command has been added and the cross-VPC access from the pod is successful:

```
PING 172.16.0.167 (172.16.0.167) 56(84) bytes of data.
64 bytes from 172.16.0.167: icmp_seq=1 ttl=63 time=0.516 ms
64 bytes from 172.16.0.167: icmp_seq=2 ttl=63 time=0.418 ms
64 bytes from 172.16.0.167: icmp_seq=3 ttl=63 time=0.376 ms
--- 172.16.0.167 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 1001ms
```

Troubleshooting a Pod Access Failure

If a pod cannot access the network, rectify the fault by referring to **Table 10-27**. If the fault persists, **submit a service ticket** to contact Huawei Cloud customer service.

NOTE

The CIDR blocks used for pod access depend on the cluster network model. For details, see **Table 10-13**. The container CIDR blocks mentioned in the following section are specific to a cluster that uses the VPC network model.

Table 10-27 Troubleshooting methods

Check Item	Possible Fault	Solution
Security group rules of the accessed service	One of the following issues may be the cause of the failure: • The security group's inbound rules prevent access to the node CIDR block or container CIDR block. • The security group's inbound rules permit access to the node CIDR block and container CIDR block, but the protocol is incorrectly configured. **NOTICE** Run the **ping** command and use ICMP to test network connectivity. Before doing so, enable the ICMP port in the security group rule.	• For possible cause 1, add a security group rule. For details, see **Adding a Security Group Rule**. • For possible cause 2, change the protocol port in the security group rules. For details, see **Modifying a Security Group Rule**.

Check Item	Possible Fault	Solution
VPC peering connection	The CIDR blocks of the local and peer VPCs are overlapping.	There are two possible causes for this issue. For details, see **Overlapping CIDR Blocks of Local and Peer VPCs**. • If the subnet where the node CIDR block resides does not overlap with the subnet where the accessed service resides, you can create a VPC peering connection that points to the subnet. • If the subnet where the node CIDR block resides overlaps with the subnet where the accessed service resides, you need to replan the network.
Route	One of the following issues may be the cause of the failure: • The custom route table used to add routes for the two VPCs is not associated with the destination subnet. (The cluster VPC route table must be associated with the node subnet, and the route table of the accessed service must be associated with the subnet where the accessed service is located.) • There is no route between the accessed service subnet and the container CIDR block.	• For possible cause 1, locate the target route table, click **Associate Subnet**, and select the correct subnet. • For problem 2, add a route for the destination service subnet and the container CIDR block.
Trustlist	The trustlist for the accessed service does not have the node CIDR block and container CIDR block configured.	Add the container and node CIDR blocks to the trustlist. Find more information in the help document for the relevant service.

Check Item	Possible Fault	Solution
Domain name resolution	When accessing an external domain name, the pod uses its cluster's domain name resolution to resolve the destination address and accesses the address based on the pod's network policy. However, sometimes the domain name cannot be resolved, resulting in errors. The most common errors are listed below: • Name or service not known • Temporary failure in name resolution • Unable to resolve hostname • DNS resolution failed • Could not resolve MYHOST (nodename nor servname known), where *MYHOST* indicates the domain name that cannot be resolved	Locate the cause of the DNS exception. For details, see **DNS Overview** for troubleshooting.
Network policy (applicable only to tunnel networks)	If you have configured a network policy for both your tunnel network cluster and the namespace where the pod is located, the network policy may prevent the pod from accessing the destination address.	If so, modify the network policy. For details, see **Configuring Network Policies to Restrict Pod Access**.

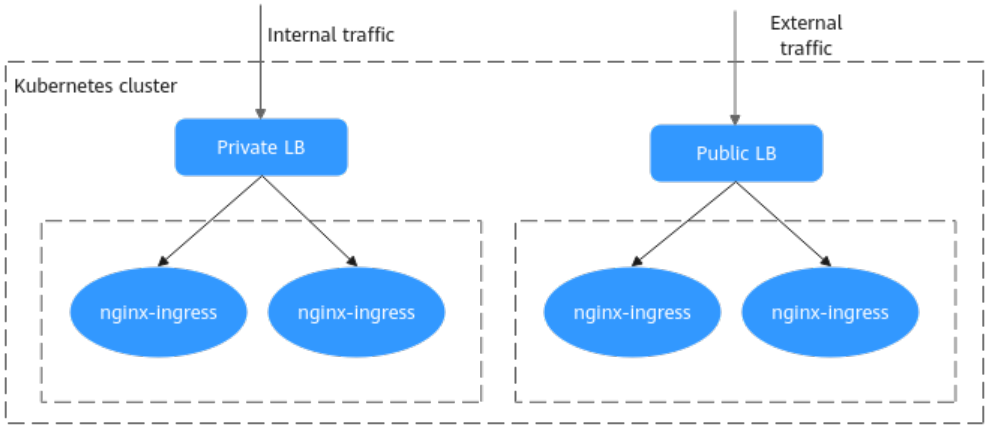
10.11 Deploying Nginx Ingress Controllers Using a Chart

10.11.1 Deploying NGINX Ingress Controller in Custom Mode

Background

Nginx Ingress Controller is a popular open source ingress controller in the industry and is widely used. Large-scale clusters require multiple ingress controllers to distinguish different traffic. For example, if some services in a cluster need to be accessed through a public network ingress, but some internal services cannot be accessed through a public network and can only be accessed by other services in the same VPC, you can deploy two independent Nginx Ingress Controllers and bind two different load balancers.

Figure 10-62 Application scenario of multiple Nginx ingresses



Solution

You can use either of the following solutions to deploy multiple NGINX ingress controllers in the same cluster.

- (Recommended) Install the NGINX Ingress Controller add-on and deploy multiple instances in the same cluster with just a few clicks. For details, see **Nginx Ingress Controller**.

  For clusters 1.23, the add-on of 2.2.52 or later must be installed. For clusters 1.23 or later, the add-on of 2.5.4 or later must be installed.
- Install the open source Helm package. The parameters to be configured in this solution are complex. You need to configure the **ingress-class** parameter (default value: **nginx**) to declare the listening ranges of different NGINX ingress controllers. In this way, when creating an ingress, you can select different NGINX ingress controllers to distinguish traffic.

Prerequisites

- Public images may need to be pulled during the installation. Therefore, bind an EIP to the node.

Constraints

- If multiple Nginx Ingress Controllers are deployed, each Controller needs to interconnect with a load balancer. Ensure that the load balancer has at least two listeners and ports 80 and 443 are not occupied by listeners. If dedicated load balancers are used, specify the network type.
- When the nginx-ingress template and image provided by the community are used, CCE does not provide additional maintenance for service loss caused by community software defects. **Exercise caution when serving commercial purposes.**

Deploying an Nginx Ingress Controller

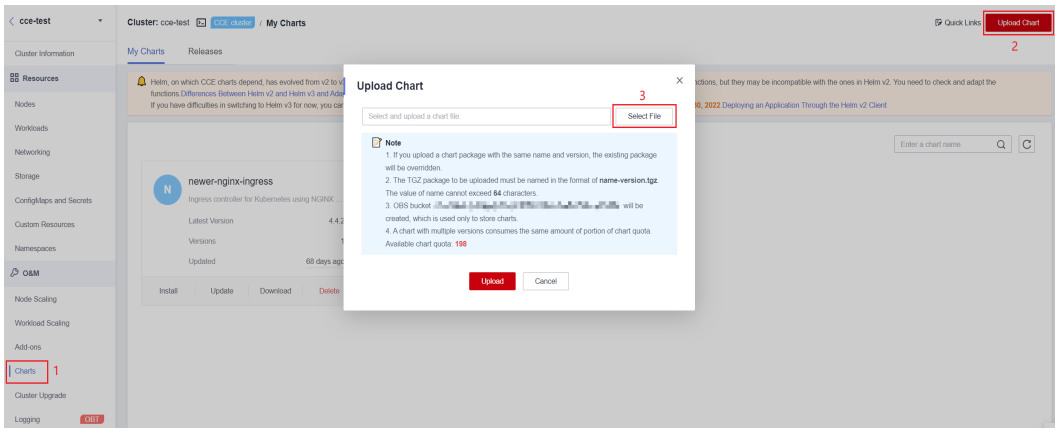
You can perform the following steps to deploy another NGINX Ingress Controller in the cluster.

Step 1 Obtain a chart.

Go to the **chart page**, select a proper version, and download the Helm chart in **.tgz** format. This section uses the chart of version **4.4.2** as an example. This chart applies to CCE clusters of v1.21 or later. The configuration items in the chart may vary according to the version. The configuration in this section takes effect only for the chart of **4.4.2** version.

Step 2 Upload the chart.

1. Log in to the CCE console and click the cluster name to access the cluster console. In the navigation pane, choose **App Templates** and click **Upload Chart** in the upper right corner.
2. Click **Select File**, select the chart to be uploaded, and click **Upload**.



Step 3 Customize the value.yaml file.

You can create a **value.yaml** configuration file on the local PC to configure workload installation parameters. During workload installation, you only need to import this configuration file for customized installation. Other unspecified parameters will use the default settings.

The configuration content is as follows:

```
controller:
  image:
    repository: registry.k8s.io/ingress-nginx/controller
    registry: ""
    image: ""
    tag: "v1.5.1"  # Controller version
    digest: ""
  ingressClassResource:
    name: ccedemo        # The name of each Ingress Controller in the same cluster must be unique and cannot be nginx or cce.
    controllerValue: "k8s.io/ingress-nginx-demo"  # The listening identifier of each Ingress Controller in the same cluster must be unique and cannot be set to k8s.io/ingress-nginx.
  ingressClass: ccedemo   # The name of each Ingress Controller in the same cluster must be unique and cannot be nginx or cce.
  service:
    annotations:
      kubernetes.io/elb.id: 5083f225-9bf8-48fa-9c8b-67bd9693c4c0     #ELB ID
      kubernetes.io/elb.class: performance  # This annotation is required only for dedicated load balancers.
  config:
    keep-alive-requests: 100
  extraVolumeMounts: # Mount the /etc/localtime file on the node to synchronize the time zone.
    - name: localtime
      mountPath: /etc/localtime
      readOnly: true
  extraVolumes:
```



```
  - name: localtime
    type: Hostpath
    hostPath:
      path: /etc/localtime
 admissionWebhooks: # Disable webhook authentication.
   enabled: false
   patch:
     enabled: false
 resources: # Set the controller's resource limit, which can be customized.
   requests:
     cpu: 200m
     memory: 200Mi
defaultBackend: # Set defaultBackend.
 enabled: true
 image:
   repository: registry.k8s.io/defaultbackend-amd64
   registry: ""
   image: ""
   tag: "1.5"
   digest: ""
```

For details about the preceding parameters, see **Table 10-28**.

Step 4 Create a release.

1. Log in to the CCE console and click the cluster name to access the cluster console. In the navigation pane, choose **App Templates**.
2. In the list of uploaded charts, click **Install**.
3. Set **Release Name**, **Namespace**, and **Version**.
4. Click **Select File** next to **Configuration File**, select the YAML file created locally, and click **Install**.
5. On the **Releases** tab page, you can view the installation status of the release.

----End

Performing Verification

Deploy a workload and configure the newly deployed Nginx Ingress Controller to provide network access for the workload.

Step 1 Create an Nginx workload.

1. Log in to the CCE console, click the created cluster, choose **Workloads** in the navigation pane, and click **Create Workload** in the upper right corner.
2. Enter the following information and click **OK**.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx
spec:
  replicas: 1
  selector:
    matchLabels:
      app: nginx
  strategy:
    type: RollingUpdate
  template:
    metadata:
```



```
      labels:
        app: nginx
    spec:
      containers:
      - image: nginx    # If an image from an open-source image registry is used, enter the image name. If you use an image in My Images, obtain the image path from SWR.
        imagePullPolicy: Always
        name: nginx
      imagePullSecrets:
      - name: default-secret
---
apiVersion: v1
kind: Service
metadata:
  labels:
    app: nginx
  name: nginx
spec:
  ports:
  - name: service0
    port: 80                # Port for accessing a Service.
    protocol: TCP           # Protocol used for accessing a Service. The value can be TCP or UDP.
    targetPort: 80          # Port used by the service to access the target container. In this example, the Nginx image uses port 80 by default.
  selector:                 # Label selector. A Service selects a pod based on the label and forwards the requests for accessing the Service to the pod.
    app: nginx
  type: ClusterIP           # Type of a Service. ClusterIP indicates that a Service is only reachable from within the cluster.
```

Step 2 Create an ingress and use the newly deployed Nginx Ingress Controller to provide network access.

1. In the navigation pane, choose **Services & Ingresses**. Click the **Ingresses** tab and click **Create from YAML** in the upper right corner.

   NOTE

   When interconnecting with Nginx Ingress Controller that is not deployed using an add-on, you can create an ingress only through YAML.

2. Enter the following information and click **OK**.

   For clusters of v1.23 or later:

```
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: ingress-test
  namespace: default
spec:
  ingressClassName: ccedemo  # Enter the ingressClass of the newly created Nginx Ingress Controller.
  rules:
  - host: foo.bar.com
    http:
      paths:
      - path: /
        pathType: ImplementationSpecific   # The matching depends on IngressClass.
        backend:
          service:
            name: nginx    # Replace it with the name of your target Service.
            port:
              number: 80   # Replace it with the port of your target Service.
        property:
          ingress.beta.kubernetes.io/url-match-mode: STARTS_WITH
```

   For clusters earlier than v1.23:

```
apiVersion: networking.k8s.io/v1beta1
kind: Ingress
metadata:
```



```
  name: tomcat-t1
  namespace: test
  annotations:
    kubernetes.io/ingress.class: ccedemo  # Enter the ingressClass of the newly created Nginx Ingress
Controller.
spec:
  rules:
    - host: foo.bar.com
      http:
        paths:
          - path: /
            pathType: ImplementationSpecific
            backend:
              serviceName: nginx  # Replace it with the name of your target Service.
              servicePort: 80     # Replace it with the port of your target Service.
            property:
              ingress.beta.kubernetes.io/url-match-mode: STARTS_WITH
```

Step 3 Log in to the cluster node and access the application through the Controller in the nginx-ingress add-on of the cluster and the newly deployed Nginx Ingress Controller service, respectively.

- Use the new Nginx Ingress Controller service to access the application (the Nginx page is expected to be displayed). **192.168.114.60** is the ELB address of the new Nginx Ingress Controller service.

  ```
  curl -H "Host: foo.bar.com" http://192.168.114.60
  ```

  ```
  [root@192-168-9-72 paas]# curl -H "Host: foo.bar.com" http://192.168.114.60
  <!DOCTYPE html>
  <html>
  <head>
  <title>Welcome to nginx!</title>
  <style>
      body {
          width: 35em;
          margin: 0 auto;
          font-family: Tahoma, Verdana, Arial, sans-serif;
      }
  </style>
  </head>
  <body>
  <h1>Welcome to nginx!</h1>
  <p>If you see this page, the nginx web server is successfully installed and
  working. Further configuration is required.</p>

  <p>For online documentation and support please refer to
  <a href="http://nginx.org/">nginx.org</a>.<br/>
  Commercial support is available at
  <a href="http://nginx.com/">nginx.com</a>.</p>

  <p><em>Thank you for using nginx.</em></p>
  </body>
  </html>
  ```

- Use the Controller service in the nginx-ingress add-on (404 is expected to be returned). **192.168.9.226** is the ELB address of the nginx-ingress add-on.

  ```
  curl -H "Host: foo.bar.com" http://192.168.9.226
  ```

  ```
  [root@192-168-9-72 paas]# curl -H "Host: foo.bar.com" http://192.168.9.226
  default backend - 404[root@192-168-9-72 paas]#
  ```

----End

Parameter Description

Table 10-28 nginx-ingress parameters

Parameter	Description
controller.image.repository	ingress-nginx image address. It is recommended that this parameter be set to the same as the nginx-ingress add-on image provided by CCE. You can also customize the parameter. • nginx-ingress add-on image: You can view its image path in the YAML file of the installed add-on. • Custom: The custom path must ensure that the image can be pulled.
controller.image.registry	Domain name of the image repository. This parameter must be set together with **controller.image.image**. If **controller.image.repository** has been set, you do not need to set this parameter. You are advised to leave **controller.image.registry** and **controller.image.image** empty.
controller.image.image	Image name. This parameter must be set together with **controller.image.registry**. If **controller.image.repository** has been set, you do not need to set this parameter. You are advised to leave **controller.image.registry** and **controller.image.image** empty.
controller.image.tag	ingress-nginx image version. It is recommended that this parameter be set to the same as the nginx-ingress add-on image provided by CCE. You can also customize the image. The image version of the nginx-ingress add-on can be viewed in the YAML file of the installed add-on and needs to be replaced based on the add-on version.
controller.ingressClass	Specifies the name of the IngressClass of the Ingress Controller. **NOTE** The name of each Ingress Controller in the same cluster must be unique and cannot be set to **nginx** or **cce**. **nginx** is the default listening identifier of Nginx Ingress Controller in the cluster, and **cce** is the configuration of ELB Ingress Controller. Example: **ccedemo**
controller.image.digest	You are advised to leave this parameter empty. If this parameter is specified, pulling the nginx- ingress add-on image provided by CCE may fail.

Parameter	Description
controller.ingressClassResource.name	The parameter value must be the same as that of ingressClass. Example: **ccedemo**
controller.ingressClassResource.controllerValue	The listening identifier of each Ingress Controller in the same cluster must be unique and cannot be set to **k8s.io/ingress-nginx**, which is the default listening identifier of Nginx Ingress Controller. Example: **k8s.io/ingress-nginx-demo**
controller.config	Nginx configuration parameter. For details, see **Community Documents**. Parameter settings out of the range do not take effect. You are advised to add the following configurations: "keep-alive-requests": "100"
controller.extraInitContainers	init container, which is executed before the main container is started and can be used to initialize pod parameters. For details about parameter configuration examples, see **Parameter Optimization in High-Concurrency Scenarios**.
controller.admissionWebhooks.enabled	Specifies whether to enable admissionWebhooks to verify the validity of ingress objects. This prevents ingress-controller from continuously reloading resources due to incorrect configurations, which may cause service interruption. Set this parameter to **false**, indicating that the function is disabled. To enable this function, see the example in **admissionWebhook Configuration**.
controller.admissionWebhooks.patch.enabled	Specifies whether to enable admissionWebhooks. Set this parameter to **false**.
controller.service.annotations	A key-value pair. The ELB ID needs to be added, as shown in the following: kubernetes.io/elb.id: 5083f225-9bf8-48fa-9c8b-67bd9693c4c0 For dedicated load balancers, add **elb.class** as follows: kubernetes.io/elb.class: performance
controller.resources.requests.cpu	Specifies the quantity of CPU resources requested by the Nginx controller. This parameter can be customized.
controller.resources.requests.memory	Specifies the quantity of memory resources requested by the Nginx controller. This parameter can be customized.

Parameter	Description
defaultBackend.image.repository	default-backend image path. It is recommended that this parameter be set to the same as the nginx-ingress add-on image provided by CCE. You can also customize the parameter. • nginx-ingress add-on image: You can view its image path in the YAML file of the installed add-on. • Custom: The custom path must ensure that the image can be pulled.
defaultBackend.image.tag	default-backend image version. It is recommended that this parameter be set to the same as the nginx-ingress add-on image provided by CCE. You can also customize the image.

For details about more parameters, see **ingress-nginx**.

10.11.2 Advanced Configuration of Nginx Ingress Controller

Parameter Optimization in High-Concurrency Scenarios

In high-concurrency scenarios, you can configure parameters for optimization in either of the following ways:

1. Use ConfigMap to optimize the overall parameters of Nginx Ingress Controller.
2. Use InitContainers to optimize the kernel parameters of Nginx Ingress Controller.

The optimized **value.yaml** configuration file is as follows:

```
controller:
  image:
    repository: registry.k8s.io/ingress-nginx/controller
    registry: ""
    image: ""
    tag: "v1.5.1"  # Controller version
    digest: ""
  ingressClassResource:
    name: ccedemo         # The name of each Ingress Controller in the same cluster must be unique and cannot be nginx or cce.
    controllerValue: "k8s.io/ingress-nginx-demo"  # The listening identifier of each Ingress Controller in the same cluster must be unique and cannot be set to k8s.io/ingress-nginx.
  ingressClass: ccedemo    # The name of each Ingress Controller in the same cluster must be unique and cannot be nginx or cce.
  service:
    annotations:
      kubernetes.io/elb.id: 5083f225-9bf8-48fa-9c8b-67bd9693c4c0     #ELB ID
    kubernetes.io/elb.class: performance  # This annotation is required only for dedicated load balancers.
# Nginx parameter optimization
  config:
    keep-alive-requests: 10000
    upstream-keepalive-connections: 200
    max-worker-connections: 65536
# Kernel parameter optimization
  extraInitContainers:
```



```
  - name: init-myservice
    image: busybox
    securityContext:
      privileged: true
    command: ['sh', '-c', 'sysctl -w net.core.somaxconn=65535;sysctl -w
net.ipv4.ip_local_port_range="1024 65535"']
  extraVolumeMounts: # Mount the /etc/localtime file on the node to synchronize the time zone.
    - name: localtime
      mountPath: /etc/localtime
      readOnly: true
  extraVolumes:
    - name: localtime
      type: Hostpath
      hostPath:
        path: /etc/localtime
  admissionWebhooks: # Disable webhook authentication.
    enabled: false
    patch:
      enabled: false
  resources: # Set the controller's resource limit, which can be customized.
    requests:
      cpu: 200m
      memory: 200Mi
defaultBackend: # Set defaultBackend.
  enabled: true
  image:
    repository: registry.k8s.io/defaultbackend-amd64
    registry: ""
    image: ""
    tag: "1.5"
    digest: ""
```

admissionWebhook Configuration

Nginx Ingress Controller supports admissionWebhook configuration. You can configure the **controller.admissionWebhook** parameter to verify the validity of ingress objects. This prevents ingress-controller from continuously reloading resources due to incorrect configuration, which may cause service interruption.

NOTE

- When the admissionWebhook feature is used, webhook-related configurations must be enabled on the API server, including MutatingAdmissionWebhook and ValidatingAdmissionWebhook.

  The feature switch is --admission-control=MutatingAdmissionWebhook,ValidatingAdmissionWebhook.

  If it is not enabled, submit a service ticket to enable it.
- After admissionWebhook is enabled, if you need to uninstall and reinstall Nginx Ingress Controller, residual secrets exist and need to be manually cleared.

The **value.yaml** configuration file for enabling admissionWebhook is as follows:

```
controller:
  image:
    repository: registry.k8s.io/ingress-nginx/controller
    registry: ""
    image: ""
    tag: "v1.5.1"  # Controller version
    digest: ""
  ingressClassResource:
    name: ccedemo         # The name of each Ingress Controller in the same cluster must be unique and
cannot be nginx or cce.
    controllerValue: "k8s.io/ingress-nginx-demo"  # The listening identifier of each Ingress Controller in the
same cluster must be unique and cannot be set to k8s.io/ingress-nginx.
  ingressClass: ccedemo   # The name of each Ingress Controller in the same cluster must be unique and
```



```
cannot be nginx or cce.
  service:
    annotations:
      kubernetes.io/elb.id: 5083f225-9bf8-48fa-9c8b-67bd9693c4c0     #ELB ID
    kubernetes.io/elb.class: performance  # This annotation is required only for dedicated load balancers.
  config:
    keep-alive-requests: 100
  extraVolumeMounts: # Mount the /etc/localtime file on the node to synchronize the time zone.
    - name: localtime
      mountPath: /etc/localtime
      readOnly: true
  extraVolumes:
    - name: localtime
      type: Hostpath
      hostPath:
        path: /etc/localtime
  admissionWebhooks:
    annotations: {}
    enabled: true
    extraEnvs: []
    failurePolicy: Fail
    port: 8443
    certificate: "/usr/local/certificates/cert"
    key: "/usr/local/certificates/key"
    namespaceSelector: {}
    objectSelector: {}
    labels: {}
    existingPsp: ""
    networkPolicyEnabled: false
    service:
      annotations: {}
      externalIPs: []
      loadBalancerSourceRanges: []
      servicePort: 443
      type: ClusterIP
    createSecretJob:
      resources:          #Annotation{}
        limits:
          cpu: 20m
          memory: 40Mi
        requests:
          cpu: 10m
          memory: 20Mi
    patchWebhookJob:
      resources: {}
    patch:
      enabled: true
      image:
        registry: registry.k8s.io      #registry.k8s.io is the image repository of the webhook official website.
Replace it with the address of the repository where the image is located.
        image: ingress-nginx/kube-webhook-certgen          # webhook image
        tag: v1.1.1
        digest: ""
        pullPolicy: IfNotPresent
      priorityClassName: ""
      podAnnotations: {}
      nodeSelector:
        kubernetes.io/os: linux
      tolerations: []
      labels: {}
      securityContext:
        runAsNonRoot: true
        runAsUser: 2000
        fsGroup: 2000
  resources: # Set the controller's resource limit, which can be customized.
    requests:
      cpu: 200m
      memory: 200Mi
defaultBackend: # Set defaultBackend.
```



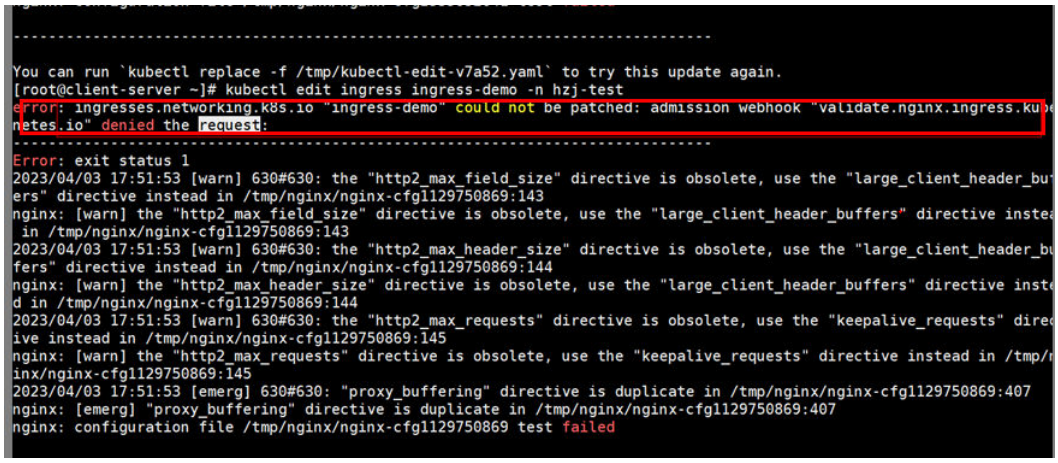
```
enabled: true
image:
  repository: registry.k8s.io/defaultbackend-amd64
  registry: ""
  image: ""
  tag: "1.5"
  digest: ""
```

Check whether admissionWebhook is verified when incorrect annotations are configured for the ingress.

For example, configure the following incorrect annotations for the ingress:

```
...
 annotations:
   nginx.ingress.kubernetes.io/auth-tls-pass-certificate-to-upstream: "false"
   nginx.ingress.kubernetes.io/auth-tls-verify-client: optional
   nginx.ingress.kubernetes.io/auth-tls-verify-depth: "1"
...
```

When the ingress service is created, the following interception information is displayed:



10.12 CoreDNS Configuration Optimization

10.12.1 CoreDNS Optimization Overview

Application Scenarios

DNS is one of the important basic services in Kubernetes. When the container DNS policy is not properly configured and the cluster scale is large, DNS resolution may time out or fail. In extreme cases, a large number of services in the cluster may fail to be resolved. This section describes the best practices of CoreDNS configuration optimization in Kubernetes clusters to help you avoid such problems.

Solution

CoreDNS configuration optimization includes clients and servers.

On the client, you can optimize domain name resolution requests to reduce resolution latency, and use proper container images and NodeLocal DNSCache to reduce resolution exceptions.

- **Optimizing Domain Name Resolution Requests**
- **Selecting a Proper Image**
- **Avoiding Occasional DNS Resolution Timeout Caused by IPVS Defects**
- **Using NodeLocal DNSCache**
- **Upgrading the CoreDNS in the Cluster Timely**
- **Adjusting the DNS Configuration of the VPC and VM**

On the server, you can adjust the CoreDNS deployment status or CoreDNS configuration to improve the availability and throughput of CoreDNS in the cluster.

- **Monitoring the coredns Add-on**
- **Adjusting the CoreDNS Deployment Status**
- **Configuring CoreDNS**

For more information about CoreDNS configurations, see **https://coredns.io/**.

CoreDNS open source community: **https://github.com/coredns/coredns**

Prerequisites

- You have created a CCE cluster. For details about how to create a cluster, see **Buying a CCE Standard/Turbo Cluster**.
- You can access the cluster using kubectl. For details, see **Connecting to a Cluster Using kubectl**.
- The CoreDNS add-on is installed in the cluster. The latest version of CoreDNS is recommended. For details, see **CoreDNS**.

10.12.2 Client

10.12.2.1 Optimizing Domain Name Resolution Requests

DNS resolution is frequently used in Kubernetes clusters. Based on the characteristics of DNS resolution in Kubernetes, you can optimize domain name resolution requests in the following ways.

Using a Connection Pool

When a containerized application needs to frequently request another service, you are advised to use a connection pool. The connection pool can cache the link information of the upstream service to avoid the overhead of DNS resolution and TCP link reestablishment for each access.

Optimizing the resolve.conf File in the Container

The **ndots** and **search** parameters in the **resolve.conf** file determine the domain name resolution efficiency. For details about the two parameters, see **DNS Configuration**.

Optimizing the Domain Name Configuration

When a container needs to access a domain name, configure the domain name based on the following rules to improve the domain name resolution efficiency.

1. When a pod accesses a Service in the same namespace, use ***<service-name>***, which indicates the Service name.
2. When a pod accesses a Service across namespaces, use ***<service-name>.<namespace-name>***. ***namespace-name*** indicates the namespace where the Service is located.
3. When a pod accesses an external domain name of a cluster, it uses the FQDN domain name. This type of domain name is specified by adding a period (.) at the end of a common domain name to avoid multiple invalid search attempts caused by search domain combination. For example, to access **www.huaweicoud.com**, use the FQDN domain name **www.huaweicoud.com.**.

Using Local Cache

If the cluster specifications are large and the number of DNS resolution requests is large, you can cache the DNS resolution result on the node. You are advised to use NodeLocal DNSCache. For details, see **Using NodeLocal DNSCache to Improve DNS Performance**.

10.12.2.2 Selecting a Proper Image

The musl libc library of the Alpine container image differs from the standard glibc library in the following aspects:

- Alpine 3.3 and earlier versions do not support the **search** parameter. As a result, search domains cannot be specified for discovering Services.
- Multiple DNS servers configured in **/etc/resolve.conf** are concurrently requested. As a result, NodeLocal DNSCache cannot improve the DNS performance.
- When the same Socket is used to request A and AAAA records concurrently, the Conntrack source port conflict is triggered in the kernel of an earlier version. As a result, packet loss occurs.
- If the domain name cannot be resolved when Alpine is used as the base container image, update the base container image for testing.

For details about the functional differences from glibc, see **Functional differences from glibc**.

10.12.2.3 Avoiding Occasional DNS Resolution Timeout Caused by IPVS Defects

Description

When kube-proxy uses IPVS load balancing, you may encounter DNS resolution timeout occasionally during CoreDNS scale-in or restart.

This problem is caused by a Linux kernel defect. For details, see **https://github.com/torvalds/linux/commit/35dfb013149f74c2be1ff9c78f14e6a3cd1539d1**.

Solution

You can use NodeLocal DNSCache to minimize the impact of IPVS defects. For details, see **Using NodeLocal DNSCache to Improve DNS Performance**.

10.12.2.4 Using NodeLocal DNSCache

Challenges

When the number of DNS requests in a cluster increases, the load of CoreDNS increases and the following issues may occur:

- Increased delay: CoreDNS needs to process more requests, which may slow down the DNS query and affect service performance.
- Increased resource usage: To ensure DNS performance, CoreDNS requires higher specifications.

Solution

NodeLocal DNSCache can improve the stability and performance of service discovery.

For details about NodeLocal DNSCache and how to deploy it in a cluster, see **Using NodeLocal DNSCache to Improve DNS Performance**.

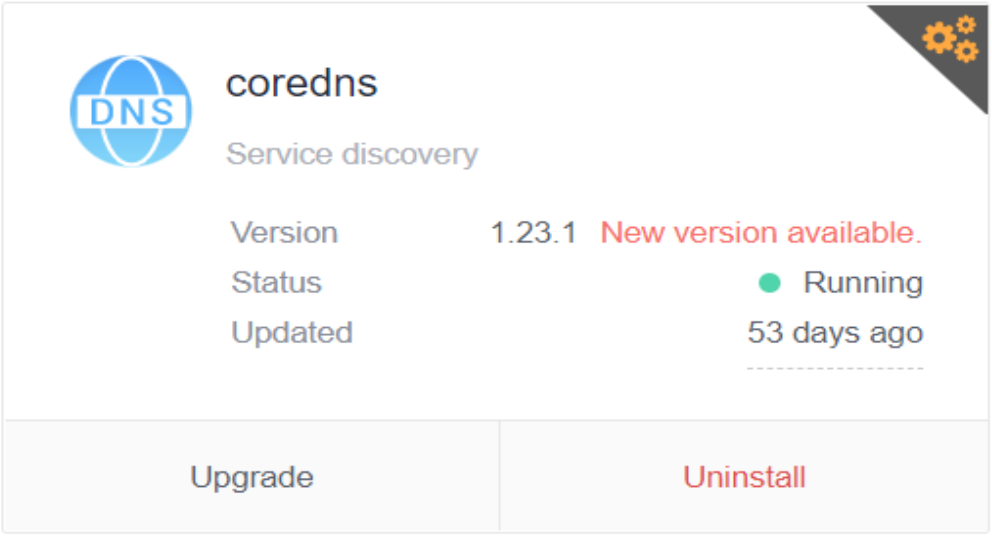
10.12.2.5 Upgrading the CoreDNS in the Cluster Timely

CoreDNS provides simple functions and is compatible with different Kubernetes versions. CCE periodically synchronizes bugs from the community and upgrades the coredns add-on. You are advised to periodically upgrade the CoreDNS. The CCE add-on management center supports the CoreDNS installation and upgrade. You can define the CoreDNS version in the cluster. If the version can be upgraded, upgrade the CoreDNS component in the cluster as soon as possible.

You can upgrade CoreDNS in a cluster by performing the following procedure:

Step 1 Log in to the CCE console and click the name of the target cluster to access the cluster console. In the navigation pane, choose **Add-ons**.

Step 2 Locate the CoreDNS add-on and click **Upgrade**.



Step 3 Set parameters as prompted. For details, see **coredns (System Resource Add-on, Mandatory)**.

----End

10.12.2.6 Adjusting the DNS Configuration of the VPC and VM

When the coredns add-on is started, it obtains the DNS configuration in the **resolve.conf** file from the deployed instance by default and uses the configuration as the upstream resolution server address. Before the coredns add-on is restarted, the **resolve.conf** configuration on the node is not reloaded. Suggestions:

- Ensure that the **resolve.conf** configuration of each node in the cluster is the same. In this way, the coredns add-on can schedule requests to any node in the cluster.
- When modifying the **resolve.conf** file, if the node has a coredns add-on, restart the coredns add-on timely to ensure status consistency.

10.12.3 Server

10.12.3.1 Monitoring the coredns Add-on

- CoreDNS exposes health metrics such as resolution results through the standard Prometheus API to detect exceptions on the CoreDNS server or even upstream DNS server.
- Port for obtaining coredns metrics. The default zone listening IP address is **{$*POD_IP*}:9153**. Retain the default value. Otherwise, Prometheus cannot collect the metrics.
- If you use on-premises Prometheus to monitor Kubernetes clusters, you can observe related metrics on Prometheus and configure alarms for the key metrics. For details, see **prometheus**.

10.12.3.2 Adjusting the CoreDNS Deployment Status

In CCE clusters, the CoreDNS add-on is installed by default, and it can run on the same cluster nodes as your service containers. You need to pay attention to the following points when deploying CoreDNS:

- **Properly Changing the Number of CoreDNS Replicas**
- **Properly Deploying the CoreDNS Pods**
- **Deploying CoreDNS Separately Using Custom Parameters**
- **Automatically Expanding the CoreDNS Capacity Based on the HPA**

Properly Changing the Number of CoreDNS Replicas

You are advised to set the number of CoreDNS replicas to at least 2 in any case and keep the number of replicas within a proper range to support the resolution of the entire cluster. The default number of pods for installing the add-on in a CCE cluster is **2**.

- Modifying the number of CoreDNS replicas, CPUs, and memory size will change CoreDNS' parsing capability. Therefore, evaluate the impact before the operation.
- By default, podAntiAffinity (pod anti-affinity) is configured for the add-on. If a node already has a CoreDNS pod, no new pod can be added. That is, only one CoreDNS pod can run on a node. If there are more configured CoreDNS replicas than cluster nodes, the excess pods cannot be scheduled. Therefore, keep the number of replicas less than or equal to the number of nodes.

Properly Deploying the CoreDNS Pods

- By default, podAntiAffinity (pod anti-affinity) is configured for CoreDNS, so CoreDNS pods are forcibly deployed on different nodes in a cluster. It is recommended that you deploy CoreDNS pods on nodes in different AZs to prevent the add-on from being interrupted by faults in a single AZ.
- The CPU and memory of the cluster node where the coredns add-on runs must not be used up. Otherwise, the QPS and response of domain name resolution will be affected. It is recommended that you use the custom parameters to **deploy CoreDNS separately**.

Deploying CoreDNS Separately Using Custom Parameters

It is recommended that CoreDNS be deployed separately from resource-intensive workloads to prevent CoreDNS performance deterioration or unavailability due to service fluctuation. You can customize parameters to deploy CoreDNS on a dedicated node.

NOTE

There should be more nodes than CoreDNS pods. You need to avoid deploying multiple CoreDNS pods on a single node.

Step 1 Log in to the CCE console and click the cluster name to access the cluster console. In the navigation pane, choose **Nodes**.

Step 2 Click the **Nodes** tab, select the node dedicated for CoreDNS, and click **Labels and Taints** above the node list.

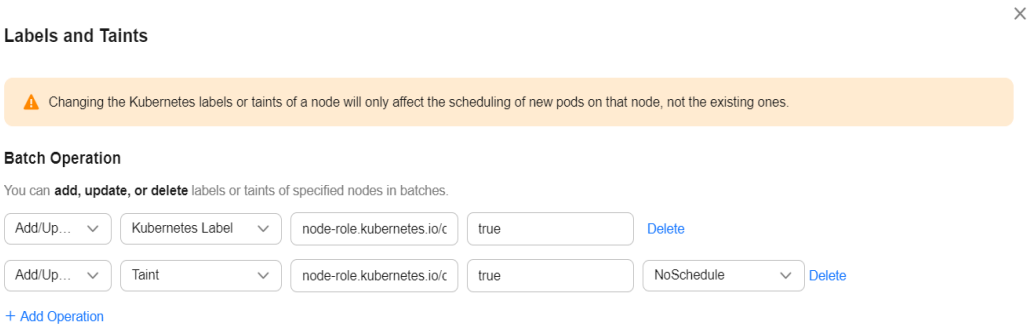
Add the following labels:

- Key: **node-role.kubernetes.io/coredns**
- Value: **true**

Add the following taints:

- Key: **node-role.kubernetes.io/coredns**
- Value: **true**
- Effect: **NoSchedule**

Figure 10-63 Adding a label and a taint

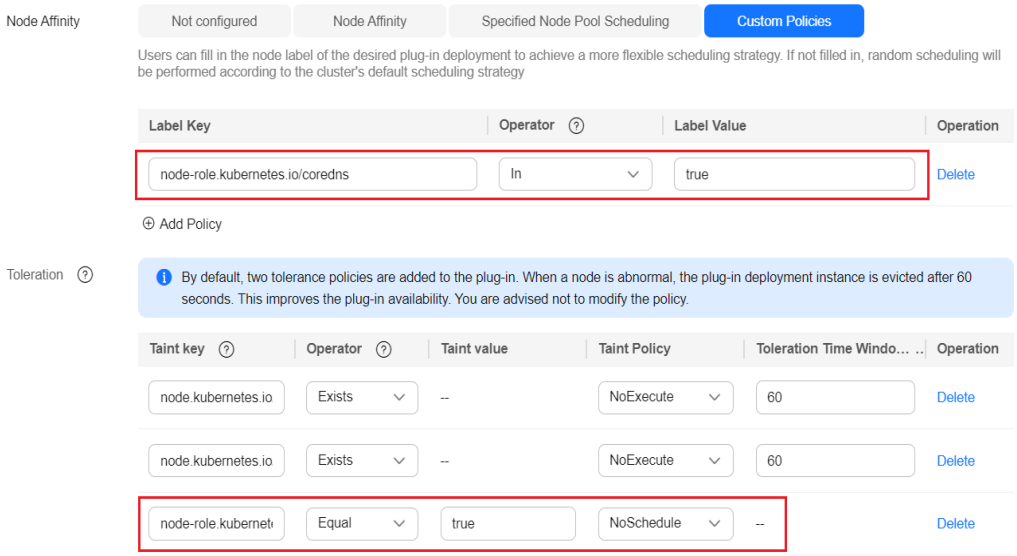


Step 3 In the navigation pane, choose **Add-ons**, locate **CoreDNS**, and click **Edit**.

Step 4 Select Custom Policies for **Node Affinity** and add the preceding node label.

Add tolerations for the preceding taint.

Figure 10-64 Adding a toleration



Step 5 Click **OK**.

----End

Automatically Expanding the CoreDNS Capacity Based on the HPA

HPA frequently scales down the number of the coredns add-on replicas. Therefore, you are advised not to use HPA. If HPA is required, you can configure HPA auto scaling policies using the CCE Advanced HPA add-on. The process is as follows:

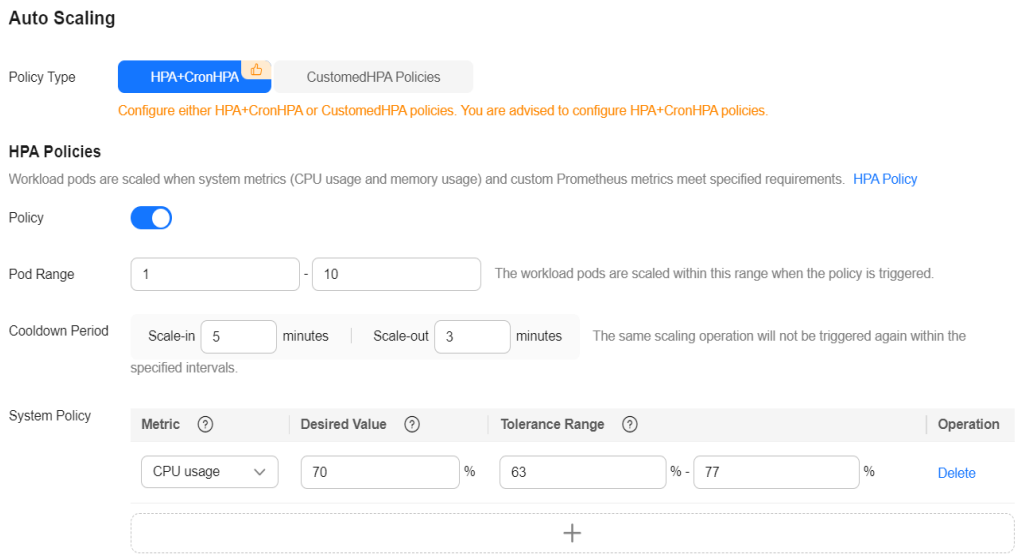
Step 1 Log in to the CCE console and click the name of the target cluster to access the cluster console. In the navigation pane, choose **Add-ons**, locate the **CCE Advanced HPA** add-on on the right, and click **Install**.

Step 2 Configure the add-on parameters and click **Install**. For details about the add-on, see **CCE Advanced HPA**.

Step 3 In the navigation pane, choose **Workloads**, select the **kube-system** namespace, locate the row containing the CoreDNS pod, and click **Auto Scaling** in the **Operation** column.

In the **HPA Policies** area, you can customize HPA policies based on metrics such as CPU usage and memory usage to automatically scale out the CoreDNS pods.

Figure 10-65 Creating an auto scaling policy



Step 4 Click **Create**. If the latest status is **Started**, the policy has taken effect.

----End

10.12.3.3 Configuring CoreDNS

On the console, the CoreDNS add-on can only be configured with the preset specifications, which can satisfy most of the service requirements. In some scenarios where there are requirements on the CoreDNS resource usage, you may need to customize the add-on specifications.

CoreDNS official document: **https://coredns.io/plugins/**

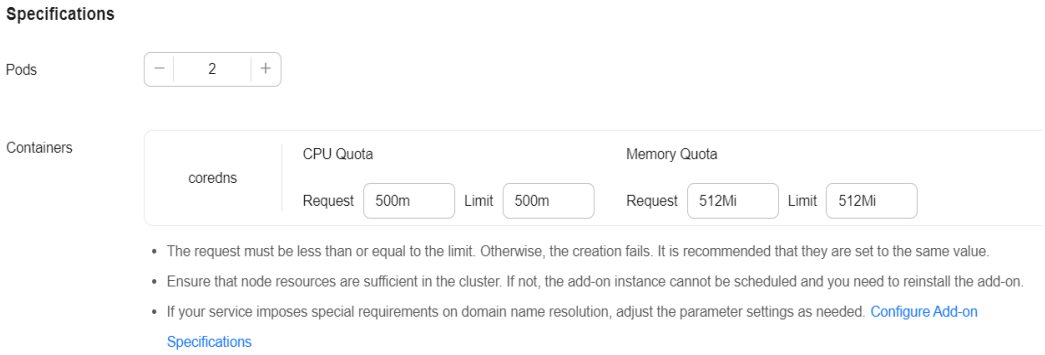
Configuring CoreDNS Specifications

Step 1 Log in to the CCE console and click the cluster name to access the cluster console.

Step 2 In the navigation pane, choose **Add-ons**. Then, click **Edit** under **CoreDNS**.

Step 3 In the **Specifications** area, configure coredns specifications.

Step 4 Change the number of replicas, CPU quotas, and memory quotas as needed to adjust the domain name resolution QPS provided by CoreDNS.



Step 5 Click **OK**.

----End

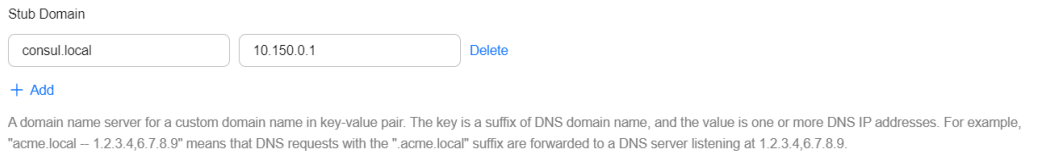
Properly Configuring the Stub Domain for DNS

Step 1 Log in to the CCE console and click the cluster name to access the cluster console.

Step 2 In the navigation pane, choose **Add-ons**. Then, click **Edit** under **CoreDNS**.

Step 3 Add a stub domain in the **Parameters** area. The format is a key-value pair. The key is a DNS suffix domain name, and the value is a DNS IP address or a group of DNS IP addresses, for example, **consul.local -- 10.150.0.1**.

Figure 10-66 Adding a stub domain



Corefile:

```
.:5353 {
    bind {$POD_IP}
    cache 30 {
        servfail 5s
    }
    errors
    health {$POD_IP}:8080
    kubernetes cluster.local in-addr.arpa ip6.arpa {
        pods insecure
        fallthrough in-addr.arpa ip6.arpa
    }
    loadbalance round_robin
    prometheus {$POD_IP}:9153
```



```
    forward . /etc/resolv.conf {
        policy random
    }
    reload
    ready {$POD_IP}:8081
}
consul.local:5353 {
    bind {$POD_IP}
    errors
    cache 30
    forward . 10.150.0.1
}
```

Step 4 Click **OK**.

Step 5 Choose **ConfigMaps and Secrets** in the navigation pane, select the **kube-system** namespace, and view the ConfigMap data of **coredns** to check whether the update is successful.

----End

Properly Configuring the Host

To specify hosts for a specific domain name, you can use the hosts add-on. An example is as follows:

Step 1 Log in to the CCE console and click the cluster name to access the cluster console.

Step 2 In the navigation pane, choose **Add-ons**. Then, click **Edit** under **CoreDNS**.

Step 3 Edit extended parameters in **Parameters** and add the following content to the **plugins** field:

```
{
  "configBlock": "192.168.1.1 www.example.com\nfallthrough",
  "name": "hosts"
}
```

NOTICE

The **fallthrough** field must be configured. **fallthrough** indicates that when the domain name to be resolved cannot be found in the hosts file, the resolution task is transferred to the next add-on of CoreDNS. If **fallthrough** is not specified, the task ends and the domain name resolution stops. As a result, the domain name resolution in the cluster fails.

For details about how to configure the hosts file, visit **https://coredns.io/plugins/hosts/**.

Figure 10-67 Modifying the CoreDNS hosts configuration

Corefile:

```
.:5353 {
    bind {$POD_IP}
    hosts {
      192.168.1.1 www.example.com
      fallthrough
    }
    cache 30
    errors
    health {$POD_IP}:8080
    kubernetes cluster.local in-addr.arpa ip6.arpa {
        pods insecure
        fallthrough in-addr.arpa ip6.arpa
    }
    loadbalance round_robin
    prometheus {$POD_IP}:9153
    forward . /etc/resolv.conf {
        policy random
    }
    reload
    ready {$POD_IP}:8081
}
```

Step 4 Click **OK**.

Step 5 Choose **ConfigMaps and Secrets** in the navigation pane, select the **kube-system** namespace, and view the ConfigMap data of **coredns** to check whether the update is successful.

----End

Configuring the Default Protocol Between the forward Plug-in and the Upstream DNS Service

Step 1 The NodeLocal DNSCache uses TCP to communicate with the CoreDNS. The CoreDNS communicates with the upstream DNS server based on the protocol used by the request source. By default, external domain name resolution requests from service containers pass through NodeLocal DNSCache and CoreDNS in sequence, and finally request the DNS server in the VPC using TCP.

Step 2 However, the cloud server does not support TCP. To use NodeLocal DNSCache, modify the CoreDNS configuration so that UDP is preferentially used to communicate with the upstream DNS server, preventing resolution exceptions. You are advised to use the following method to modify the CoreDNS configuration file:

The forward plug-in is used to set the upstream Nameservers DNS server. The following parameters are included:

prefer_udp: Even if a request is received through TCP, UDP must be used first.

If you want CoreDNS to preferentially use UDP to communicate with upstream systems, set the protocol in the forward plug-in to **prefer_udp**. For details about the forward plug-in, see **https://coredns.io/plugins/forward/**.

1. Log in to the CCE console and click the cluster name to access the cluster console.
2. In the navigation pane, choose **Add-ons**. Then, click **Edit** under **CoreDNS**.
3. Edit the advanced configuration under **Parameters** and modify the following content in the **plugins** field:

```
{
    "configBlock": "prefer_udp",
    "name": "forward",
    "parameters": ". /etc/resolv.conf"
}
```

Corefile:

```
Corefile: |-
  .:5353 {
      bind {$POD_IP}
      cache 30 {
          servfail 5s
      }
      errors
      health {$POD_IP}:8080
      kubernetes cluster.local in-addr.arpa ip6.arpa {
          pods insecure
          fallthrough in-addr.arpa ip6.arpa
      }
      loadbalance round_robin
      prometheus {$POD_IP}:9153
      forward . /etc/resolv.conf {
          prefer_udp
      }
      reload
      ready {$POD_IP}:8081
  }
```

----End

Configuring IPv6 Resolution Properly

If the IPv6 kernel module is not disabled on the Kubernetes cluster host machine, the container initiates IPv4 and IPv6 resolution at the same time by default when requesting the coredns add-on. Generally, only IPv4 addresses are used. Therefore, if you only configure **DOMAIN in IPv4 address**, the coredns add-on forwards the request to the upstream DNS server for resolution because the local configuration cannot be found. As a result, the DNS resolution request of the container slows down.

CoreDNS provides the template plug-in. After being configured, CoreDNS can immediately return an empty response to all IPv6 requests to prevent the requests from being forwarded to the upstream DNS.

Step 1 Log in to the CCE console and click the cluster name to access the cluster console.

Step 2 In the navigation pane, choose **Add-ons**. Then, click **Edit** under **CoreDNS**.

Step 3 Edit extended parameters in **Parameters** and add the following content to the **plugins** field.

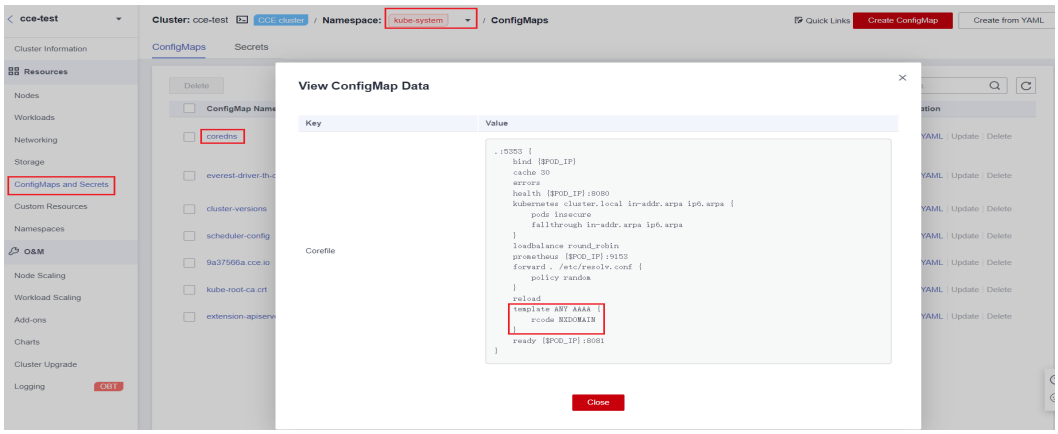
- AAAA indicates an IPv6 resolution request. If **NXDOMAIN** is returned in the **rcode** control response, meaning that no resolution result is returned.

For details about the template plug-in, visit **https://github.com/coredns/coredns/tree/master/plugin/template**.

```
{
  "configBlock": "rcode NXDOMAIN",
  "name": "template",
  "parameters": "ANY AAAA"
}
```

Step 4 Click **OK**.

Step 5 In the navigation pane, choose **ConfigMaps and Secrets**. In the **kube-system** namespace, view the coredns configuration data to check whether the update is successful.



Corresponding Corefile content:

```
.:5353 {
    bind {$POD_IP}
    cache 30
    errors
    health {$POD_IP}:8080
    kubernetes cluster.local in-addr.arpa ip6.arpa {
        pods insecure
        fallthrough in-addr.arpa ip6.arpa
    }
    loadbalance round_robin
    prometheus {$POD_IP}:9153
    forward . /etc/resolv.conf {
        policy random
    }
    reload
    template ANY AAAA {
        rcode NXDOMAIN
    }
    ready {$POD_IP}:8081
}
```

----End

Properly Configuring Cache Policies

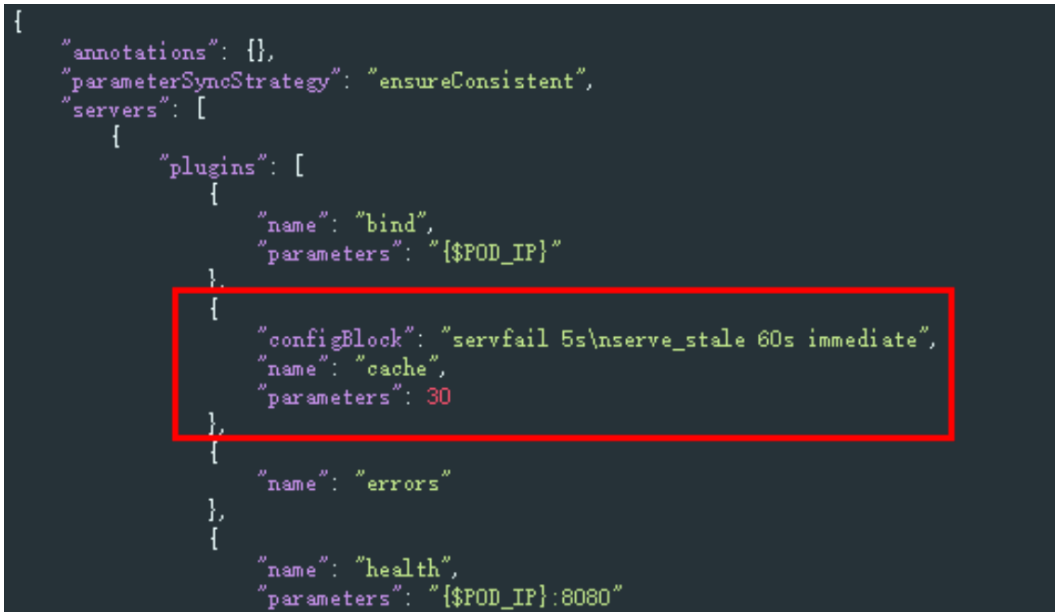
If you configure CoreDNS with an upstream DNS server, you can implement a cache policy that enables CoreDNS to use the expired local cache when it is unable to access the upstream DNS server.

Step 1 Log in to the CCE console and click the cluster name to access the cluster console.

Step 2 In the navigation pane, choose **Add-ons**. Then, click **Edit** under **CoreDNS**.

Step 3 Edit extended parameters in **Parameters** and modify the cache content in the **plugins** field. For details about how to configure the cache, see **https://coredns.io/plugins/cache/**.

```
{
    "configBlock": "servfail 5s\nserve_stale 60s immediate",
    "name": "cache",
    "parameters": 30
}
```



Step 4 Click **OK**.

Step 5 In the navigation pane, choose **ConfigMaps and Secrets**. Select the **kube-system** namespace, view the data of the ConfigMap named **coredns** to check whether the update is successful.

Corresponding Corefile content:

```
.:5353 {
    bind {$POD_IP}
    cache 30 {
        servfail 5s
        serve_stale 60s immediate
    }
    errors
    health {$POD_IP}:8080
    kubernetes cluster.local in-addr.arpa ip6.arpa {
        pods insecure
        fallthrough in-addr.arpa ip6.arpa
    }
    loadbalance round_robin
    prometheus {$POD_IP}:9153
```



```
    forward . /etc/resolv.conf {
        policy random
    }
    reload
    ready {$POD_IP}:8081
}
```

----End

10.13 Pre-Binding Container ENI for CCE Turbo Clusters

In the Cloud Native 2.0 network model, each pod is allocated an ENI or a sub-ENI (called container ENI). The speed of ENI creation and binding is slower than that of pod scaling, severely affecting the container startup speed in large-scale batch creation. Therefore, the Cloud Native Network 2.0 model provides the dynamic pre-binding of container ENIs to accelerate pod startup while improving IP resource utilization.

Constraints

- CCE Turbo clusters of 1.19.16-r4, 1.21.7-r0, 1.23.5-r0, 1.25.1-r0, or later support ENI pre-binding, global configuration at the cluster level, and custom settings at the node pool level. Custom settings of nodes out of a node pool is not supported.
- CCE Turbo clusters of 1.19.16-r2, 1.21.5-r0, 1.23.3-r0 to 1.19.16-r4, 1.21.7-r0, 1.23.5-r0 only support two parameters, **nic-minimum-target** and **nic-warm-target**, and do not support custom settings at the node pool level.
- Modify the dynamic pre-binding parameters using the console or API instead of the node annotations in the background. Otherwise, the modified annotations will be overwritten by the original values after the cluster is upgraded.
- CCE Turbo clusters of 1.19.16-r4, 1.21.7-r0, 1.23.5-r0, 1.25.1-r0, or earlier support high and low threshold for ENI buffers. If users have enabled this feature, the original high and low threshold for ENI pre-binding parameters is automatically converted to the dynamic pre-binding parameters of the container ENIs. If you want to modify the dynamic pre-binding parameters of the container ENIs on the console, change the original high and low threshold to **0:0** on the cluster configuration management console.
- If the node type of a CCE Turbo node pool is BMS and the cluster version is 1.19.16-r4, 1.21.7-r0, 1.23.5-r0, or any version earlier than 1.25.1-r0, the high and low thresholds for ENI pre-binding (0.3:0.6 by default) are used by default. After the cluster is upgraded, the original high and low thresholds still take effect. You are advised to convert the high and low threshold parameters to the dynamic pre-binding parameters of container ENIs on the configuration management console of the node pool and delete the high and low threshold configuration to enable the latest dynamic pre-binding parameters.
- If the node type of a CCE Turbo node pool is not BMS and the cluster version is 1.19.16-r4, 1.21.7-r0, 1.23.5-r0, or any version earlier than 1.25.1-r0, the high and low thresholds for ENI pre-binding (0.3:0.6 by default) are used by default. After the cluster is upgraded, the original high and low threshold still takes effect. If you want to enable the cluster-level global configuration, delete the annotation (**node.yangtse.io/eni-warm-policy**) of the node in the background.

How It Works

CCE Turbo provides four dynamic pre-binding parameters for container ENIs. You can properly configure the parameters based on your service requirements. (The node pool-level dynamic ENI pre-binding parameters take priority over the cluster-level dynamic ENI pre-binding parameters.)

Table 10-29 Parameters of the dynamic ENI pre-binding policy

Parameter	Default Value	Description	Suggestion
Minimum Number of Container ENIs Bound to a Node	10	Minimum number of container ENIs bound to a node. The parameter value must be a positive integer. The value **10** indicates that there are at least 10 container ENIs bound to a node. If the number you entered exceeds the container ENI quota of the node, the ENI quota will be used.	Configure these parameters based on the number of pods.
Upper Limit of Pre-bound Container ENIs	0	If the number of ENIs bound to a node exceeds the value of **nic-maximum-target**, the system does not proactively pre-bind ENIs. If the value of this parameter is greater than or equal to the value of **nic-minimum-target**, the check on the maximum number of the pre-bound ENIs is enabled. Otherwise, the check is disabled. The parameter value must be a positive integer. The value **0** indicates that the check on the upper limit of pre-bound container ENIs is disabled. If the number you entered exceeds the container ENI quota of the node, the ENI quota will be used.	Configure these parameters based on the number of pods.
Container ENIs Dynamically Pre-bound to a Node	2	Minimum number of pre-bound ENIs on a node. The value must be a number. When the value of **nic-warm-target** + the number of bound ENIs is greater than the value of **nic-maximum-target**, the system will pre-bind ENIs based on the difference between the value of **nic-maximum-target** and the number of bound ENIs.	Set this parameter to the number of pods that can be scaled out instantaneously within 10 seconds.

Parameter	Default Value	Description	Suggestion
Threshold for Unbinding Pre-bound Container ENIs	2	Only when the number of idle ENIs on a node minus the value of **nic-warm-target** is greater than the threshold, the pre-bound ENIs will be unbound and reclaimed. The value can only be a number. • Setting a larger value of this parameter slows down the recycling of idle ENIs and accelerates pod startup. However, the IP address usage decreases, especially when IP addresses are insufficient. Therefore, **exercise caution when increasing the value of this parameter**. • Setting a smaller value of this parameter accelerates the recycling of idle ENIs and improves the IP address usage. However, when a large number of pods increase instantaneously, the startup of some pods slows down.	Set this parameter based on the difference between the number of pods that are frequently scaled on most nodes within minutes and the number of pods that are instantly scaled out on most nodes within 10 seconds.

Configuration Example

Level	Service Scenario	Configuration Example
Cluster	All nodes use the c7.4xlarge.2 model (sub-ENI quota: 128). Most nodes run about 20 pods. Most nodes can run a maximum of 60 pods. Most nodes can scale out 10 pods within 10 seconds. Most nodes frequently scale in or out 15 pods within minutes.	Cluster-level global configuration: • nic-minimum-target: 20 • nic-maximum-target: 60 • nic-warm-target: 10 • nic-max-above-warm-target: 5

Level	Service Scenario	Configuration Example
Node pool	A node pool that uses the c7.8xlarge.2 high-specification model is created in the cluster. (sub-ENI quota: 256) Most nodes run about 100 pods. Most nodes can run a maximum of 128 pods. Most nodes can scale out 10 pods within 10 seconds. Most nodes frequently scale in or out 12 pods within minutes.	Custom settings at the node pool level: • nic-minimum-target: 100 • nic-maximum-target: 120 • nic-warm-target: 10 • nic-max-above-warm-target: 2

NOTE

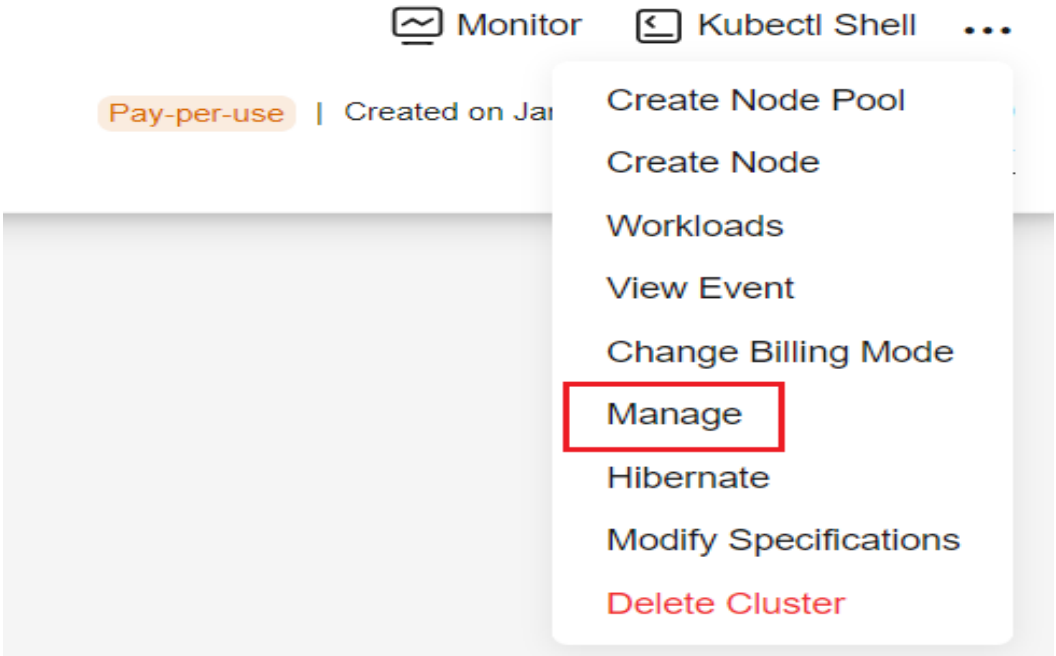
Pods using HostNetwork are excluded.

Cluster-level Global Configuration

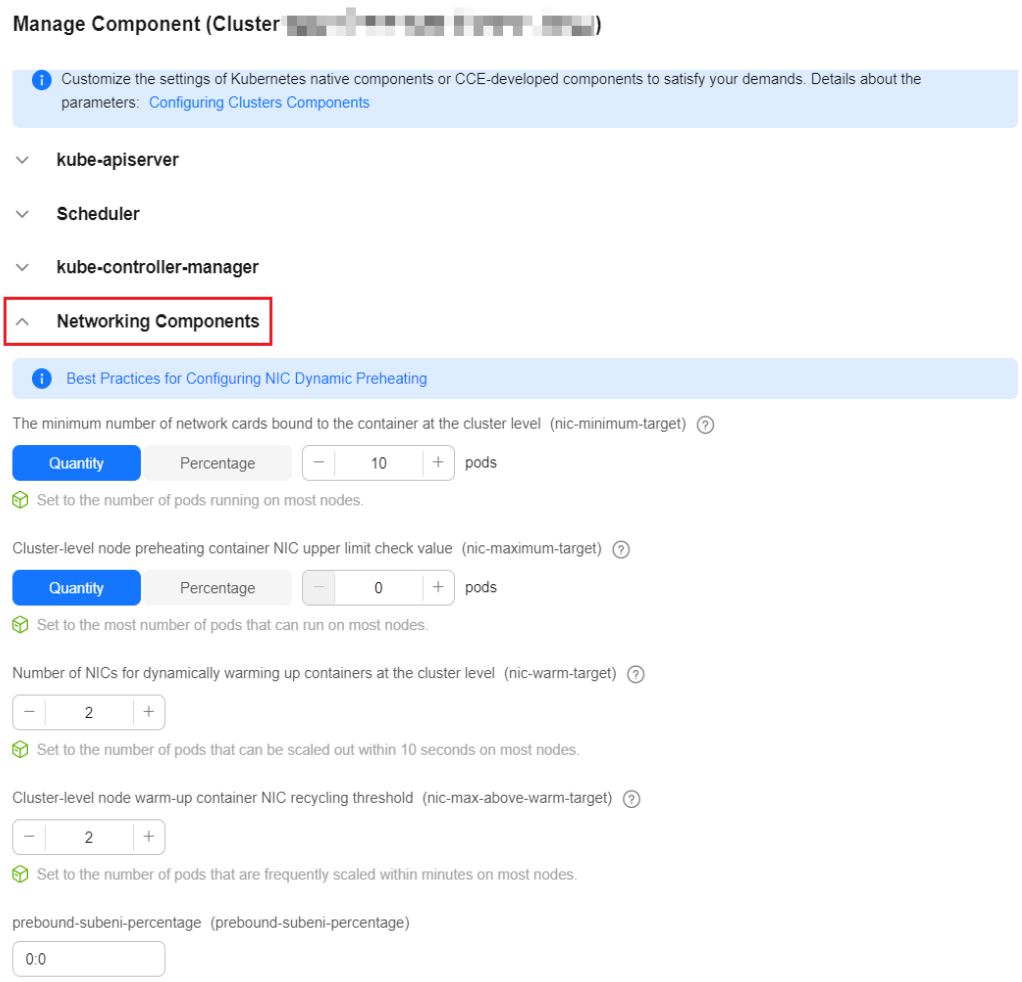
Step 1 Log in to the CCE console. In the navigation pane, choose **Clusters**.

Step 2 Click ··· next to the target cluster and choose **Manage**.

Figure 10-68 Managing a cluster



Step 3 In the window that slides out from the right, click **Networking Components**. For details about the parameter configurations, see **Configuration Example**.



Step 4 After the configuration is complete, click **OK**. Wait for about 10 seconds for the configuration to take effect.

----End

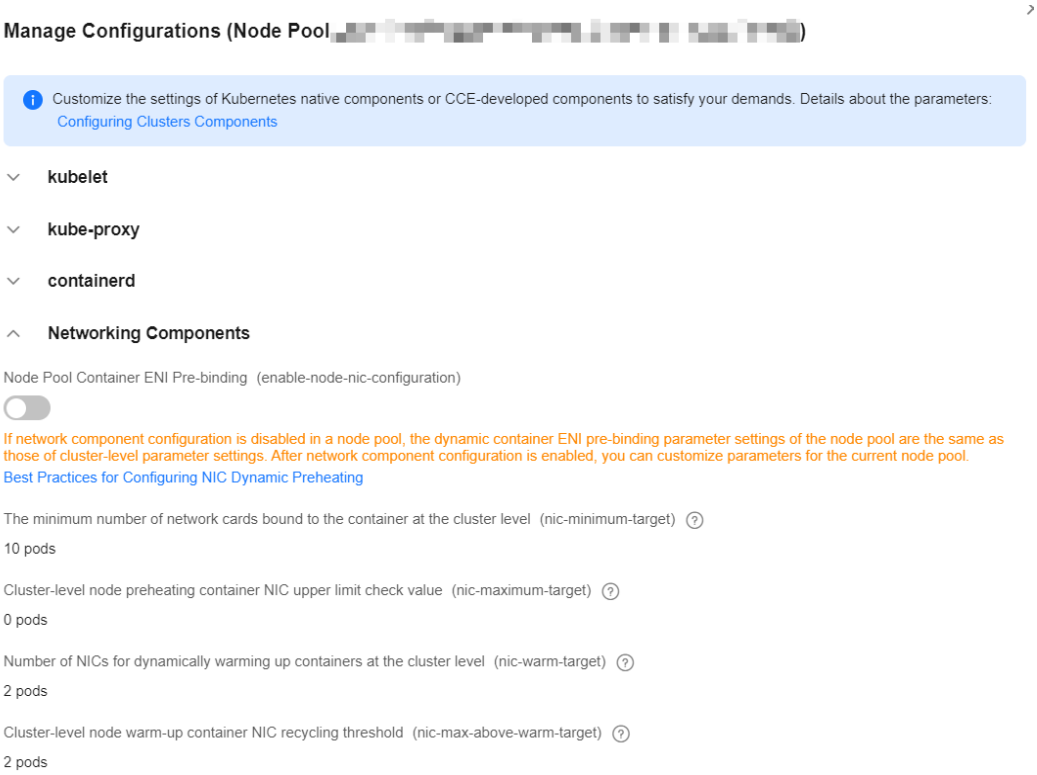
Custom Settings at the Node Pool Level

Step 1 Log in to the CCE console.

Step 2 Click the cluster name to access the cluster console, choose **Nodes** in the navigation pane, and click the **Node Pools** tab.

Step 3 Locate the row containing the target node pool and click **Manage**.

Step 4 In the window that slides out from the right, click **Networking Components** and enable node pool container ENI pre-binding. For details about the parameter configurations, see **Configuration Example**.



Step 5 After the configuration is complete, click **OK**. Wait for about 10 seconds for the configuration to take effect.

----End

10.14 Connecting a Cluster to the Peer VPC Through an Enterprise Router

Application Scenarios

An enterprise router connects virtual private clouds (VPCs) and on-premises networks to build a central hub network and implement communication between VPCs in the same region. It has high specifications, provides high bandwidth, and delivers high performance. With the enterprise routers, CCE clusters in different VPCs can access each other.

Clusters in different VPCs cannot communicate with VMs in the peer VPCs within a short period of time after containers are created in the clusters. To solve this problem, attach the peer VPCs to the enterprise routers. In a CCE Turbo cluster, configure parameters to delay the pod startup to solve this problem. For details, see **Configuring Parameters to Delay the Pod Startup in a CCE Turbo Cluster**.

Network Planning

Before attaching VPCs to the enterprise routers, determine the VPC CIDR blocks and the enterprise routers' route table. Ensure that the following requirements are met.

Resource	Description
VPC	• The VPC CIDR blocks cannot overlap. • The CIDR blocks of the VPCs are propagated to the enterprise routers' route tables. These CIDR blocks cannot be modified. Overlapping CIDR blocks may cause route conflicts. Additionally, the container CIDR blocks cannot conflict with the node CIDR blocks in the peer VPCs. Otherwise, the network is unavailable. • If your existing VPCs have overlapping CIDR blocks, manually add static routes to the route tables of the enterprise routers. The destination can be the VPC subnet CIDR blocks or smaller ones.
Enterprise router	After **Default Route Table Association** and **Default Route Table Propagation** are enabled and a VPC attachment is created, the system automatically: • Associates the VPC attachment with the default route table of the enterprise router. • Propagates the VPC attachment to the default route table of the enterprise router. The route table automatically learns the VPC CIDR blocks.

For details, see **Step 1: Plan Networks and Resources**.

Creating an Enterprise Router

Step 1 Log in to the management console.

Step 2 Click  in the upper left corner and select the desired region and project.

Step 3 Choose **Service List** > **Networking** > **Enterprise Router**.

Step 4 Enter the **Enterprise Router** page.

Step 5 Click **Create Enterprise Router** in the upper right corner.

Step 6 Enter the **Create Enterprise Router** page.

Step 7 Configure basic information following instructions. For details about the parameter settings, see **Table 10-30**.

Figure 10-69 Creating an enterprise router

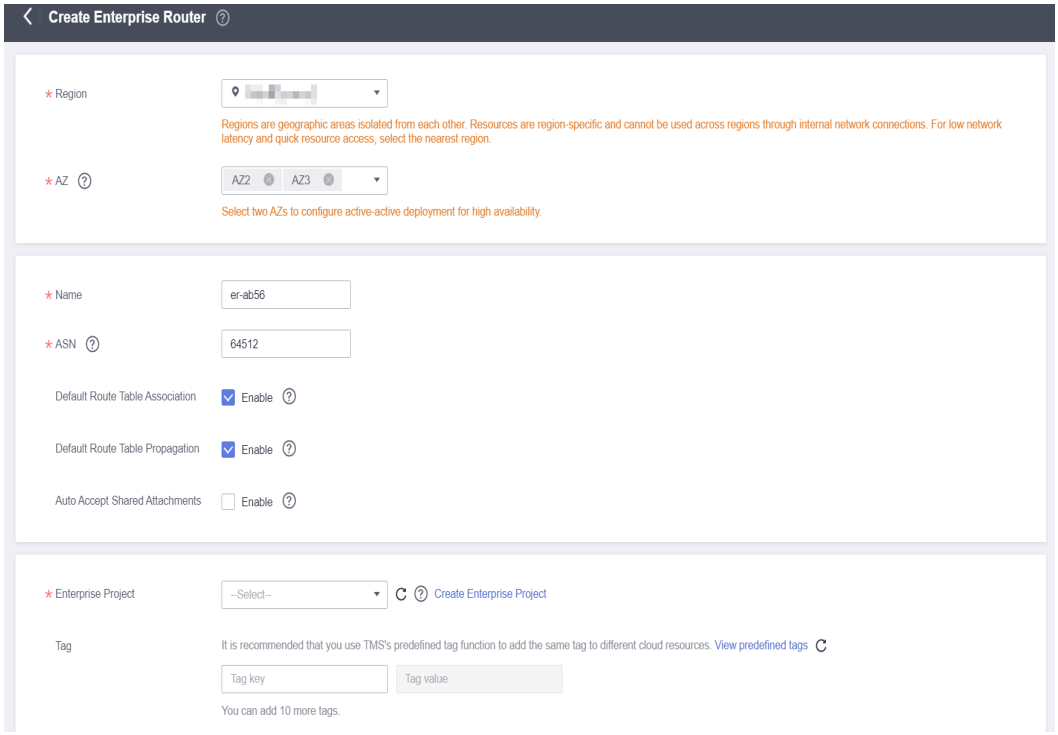


Table 10-30 Parameters for creating an enterprise router

Parameter	Setting	Example Value
Region	Select the region nearest to your target users. Once the enterprise router is created, the region cannot be changed.	CN-Hong Kong
AZ	Select two AZs to deploy your enterprise router. You can change them after the enterprise router is created.	AZ1 AZ2
Name	Specify the enterprise router name. You can change it after the enterprise router is created.	er-test-01
ASN	Enter an ASN based on your network plan. It cannot be changed after the enterprise router is created.	64800
Default Route Table Association	If you select this option, you do not need to create route tables or associations. You can change your option after the enterprise router is created.	Enable
Default Route Table Propagation	If you select this option, you do not need to create route tables, propagations, or routes. You can change your option after the enterprise router is created.	Enable

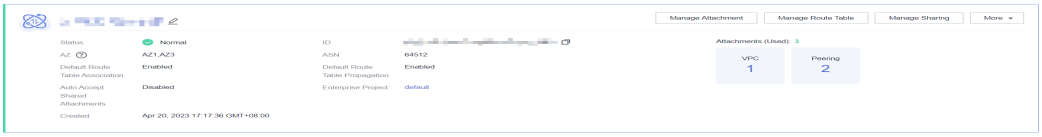
Parameter	Setting	Example Value
Auto Accept Shared Attachments	If you do not select this option, you must accept the requests for creating attachments to this enterprise router from other users with whom this enterprise router is shared.	Disable
Enterprise Project	Select an enterprise project for the enterprise router. You can change it after the enterprise router is created.	default
Tag	Add tags to help you identify your enterprise router. You can change them after the enterprise router is created.	**Tag key**: test **Tag value**: 01
Description	Provide supplementary information about the enterprise router. You can change it after the enterprise router is created.	-

Step 8 Click **Create Now**.

Step 9 Check the information on the page displayed and click **Submit**. Back to the enterprise router list.

Step 10 View the enterprise router's status. If its status changes from **Creating** to **Normal**, the enterprise router is created.

Figure 10-70 Enterprise router created



----End

Creating a VPC Attachment to an Enterprise Router

Step 1 Log in to the management console.

Step 2 Click in the upper left corner and select the desired region and project.

Step 3 Choose **Service List** > **Networking** > **Enterprise Router**.

Step 4 Search for the target enterprise router by name.

Step 5 Perform either of the following operations to go to the **Attachments** tab:

- Locate the pane containing the target enterprise router and click **Manage Attachment**.
- Click the name of the enterprise router and click the **Attachments** tab. For details, see **Adding VPC Attachments to an Enterprise Router**.

Step 6 Click **Create Attachment** to go to the corresponding page.

Step 7 Configure the parameters following instructions. For details, see **Table 10-31**.

Figure 10-71 Creating an attachment

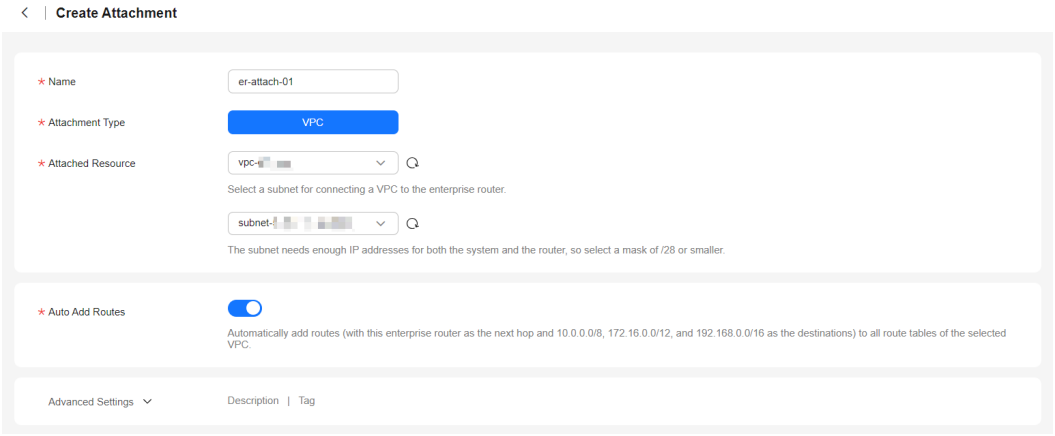


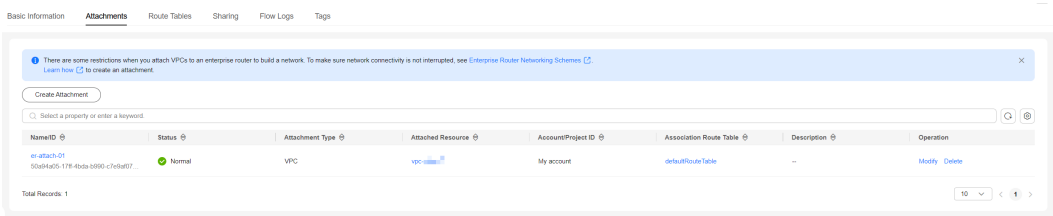
Table 10-31 Parameter description

Parameter	Setting	Example Value
Name	Specify the name of the VPC attachment. You can change it after the attachment is created.	er-attach-01
Attachment Type	Select **VPC**. The type cannot be changed after the attachment is created.	VPC
Attached Resource	1. Select the VPC to be attached to the enterprise router from the drop-down list. The VPC cannot be changed after the attachment is created. 2. Select the subnet to be attached to the enterprise router from the drop-down list. The subnet cannot be changed after the attachment is created.	• VPC: vpc-demo-01 • Subnet: subnet-demo-01

Parameter	Setting	Example Value
Auto Add Routes	• If you enable **Auto Add Routes** when creating a VPC attachment, you do not need to manually add static routes to the VPC route table. Instead, the system automatically adds routes (with this enterprise router as the next hop and 10.0.0.0/8, 172.16.0.0/12, and 192.168.0.0/16 as the destinations) to all route tables of the VPC. • If an existing route in the VPC route tables has a destination to 10.0.0.0/8, 172.16.0.0/12, or 192.168.0.0/16, the routes will fail to be added. In this case, do not enable **Auto Add Routes**. After the attachment is created, manually add routes. • Do not set the destination of a route (with an enterprise router as the next hop) to 0.0.0.0/0 in the VPC route table. If an ECS in the VPC has an EIP bound, the VPC route table will have a policy-based route with 0.0.0.0/0 as the destination, which has a higher priority than the route with the enterprise router as the next hop. In this case, traffic is forwarded to the EIP and cannot reach the enterprise router.	Enable
Description	Provide supplementary description about the attachment. You can change it after the attachment is created.	-
Tag	Add tags to help you identify your attachment. You can change them after the attachment is created.	**Tag key**: test **Tag value**: 01

Step 8 Click **Create Now**. If the status changes from **Creating** to **Normal**, the attachment is created. Repeat steps **Step 6** to **Step 7** to attach other VPCs.

Figure 10-72 Attaching a VPC to the enterprise router



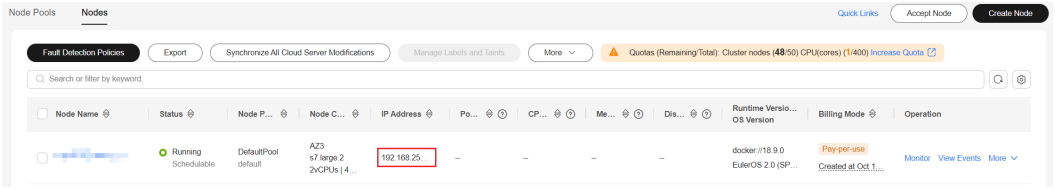
----End

Verifying the Network

Step 1 Log in to the CCE console and search for the CCE cluster that has been attached to the VPC.

Step 2 Click the name of the target cluster. In the navigation pane, choose **Nodes** to view the IP address of the node.

Figure 10-73 Viewing the IP address of the node on the CCE console



Step 3 Log in to the node. For details, see **Logging In to a Node**. In this example, use VNC provided on the management console to log in to the ECS.

Step 4 Run the following command on the ECS console:

```
ping {ECS address}
```

Take the cluster in **vpc-ER-demo2** as an example. Log in to the **er-demo2-04260** node and access the **er-demo1-61379** node in the cluster in **vpc-ER-demo1**. The IP address of the node is **192.168.0.131**.

```
ping 192.168.0.131
```

If the following information is displayed, the network is accessible.

Figure 10-74 Viewing the command output

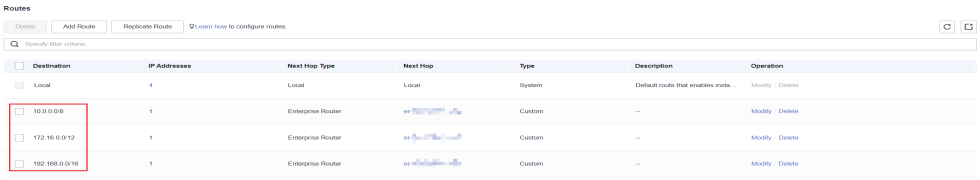
```
[root@er-demo-91067 ~]# ping 192.168.0.131
PING 192.168.0.131 (192.168.0.131) 56(84) bytes of data.
64 bytes from 192.168.0.131: icmp_seq=1 ttl=63 time=0.417 ms
64 bytes from 192.168.0.131: icmp_seq=2 ttl=63 time=0.399 ms
64 bytes from 192.168.0.131: icmp_seq=3 ttl=63 time=0.356 ms
64 bytes from 192.168.0.131: icmp_seq=4 ttl=63 time=0.340 ms
64 bytes from 192.168.0.131: icmp_seq=5 ttl=63 time=0.323 ms
64 bytes from 192.168.0.131: icmp_seq=6 ttl=63 time=0.354 ms
```

Step 5 Repeat the preceding steps to verify the communication between nodes.

If a node using the peer VPC cannot be pinged, check:

1. Whether the security group rules of the node allow the ICMP protocol.
2. Whether a CIDR block conflict occurs in the VPC route table. Note that the container CIDR blocks cannot conflict with the default CIDR blocks of the enterprise routers. For details, see **Network Planning**.

Figure 10-75 Viewing the VPC route table



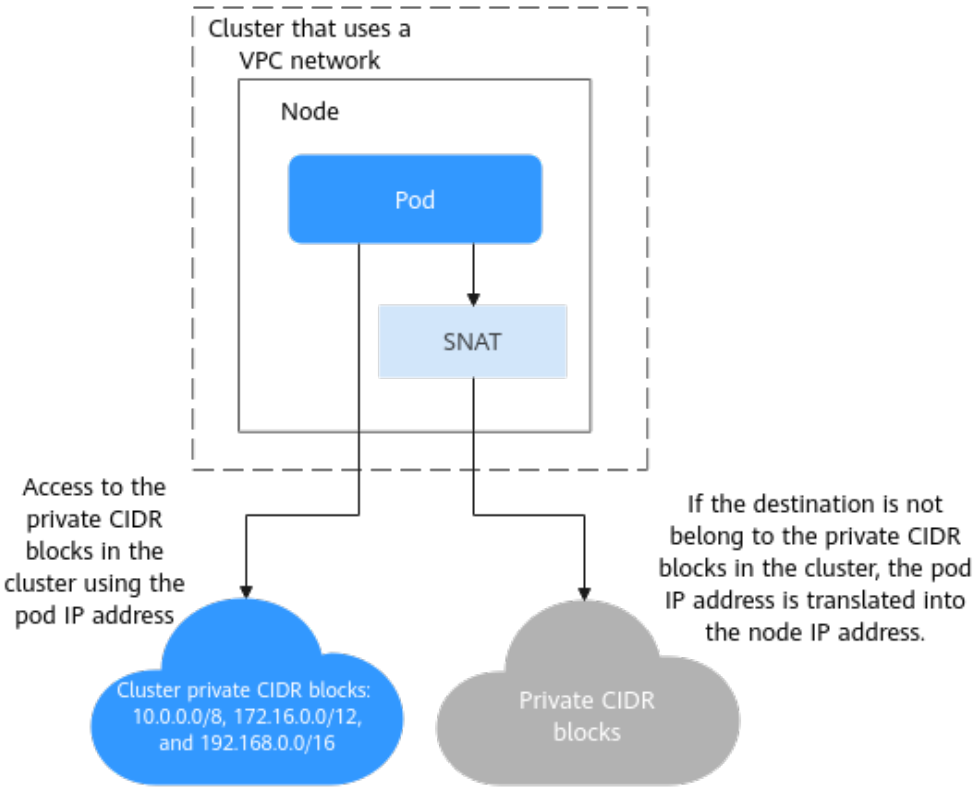
----End

10.15 Accessing an IP Address Outside a Cluster That Uses a VPC Network Using Source Pod IP Addresses in the Cluster

In a CCE cluster that uses a VPC network, when pods try to communicate with external systems, CCE automatically translates the source IP addresses of the pods into the IP addresses of the nodes that are running them. This allows pods to communicate with external systems using the node IP addresses. This process is known as pod IP address masquerading or Source Network Address Translation (SNAT).

You are allowed to configure private CIDR blocks for your clusters using the **nonMasqueradeCIDRs** parameter. If a pod tries to access a private CIDR block, the source node will not perform NAT on the pod IP address. Instead, the VPC route table can directly send the pod data packet to the destination, which means, the pod IP address is directly used to communicate with the private CIDR block in the cluster.

Figure 10-76 Pod IP address translation



Prerequisites

You have a cluster that uses the VPC network and whose version is v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later.

Default Non-Masqueraded CIDR Block Settings in a CCE Cluster

By default, CCE uses the following well-known private CIDR blocks as non-masqueraded CIDR blocks in each cluster:

- 10.0.0.0/8
- 172.16.0.0/12
- 192.168.0.0/16

Additionally, in a CCE cluster that uses a secondary VPC CIDR block, adding or resetting a node will automatically include the secondary CIDR block in the non-masqueraded CIDR blocks.

This means that when a pod communicates with external resources and accesses these CIDR blocks, the source IP address of the data packet remains unchanged and is not translated into the node IP address.

Scenarios Where the Default Non-Masqueraded CIDR Blocks Do Not Fit

The default non-masqueraded CIDR block settings in CCE clusters apply to typical scenarios, but in certain specific scenarios, these default settings may not be sufficient to meet user requirements. The following shows typical examples:

- Cross-node access to pods in a cluster

  When a node in a Kubernetes cluster needs to access a pod on another node, the response data packet sent from the pod is automatically subject to SNAT. This changes the source IP address from the pod IP address to the IP address of the node that runs the pod. However, this automatic IP address translation can sometimes lead to communication issues, making cross-node access impossible.

  To enable a node to access pods on other nodes, you can add the CIDR block of the subnet where the node is located to the **nonMasqueradeCIDRs** parameter. This will skip SNAT and allow the original IP addresses of pods on these nodes to be retained.

- Access from other resources in the same VPC as a cluster to pods in the cluster

  In certain scenarios, it may be necessary to access the original IP addresses of pods on different nodes in a CCE cluster directly from other resources (such as ECSs) in the same VPC as the cluster. However, with SNAT enabled by default, the source IP addresses of the data packets are replaced with the IP addresses of the nodes that run these pods when the data packets pass through the nodes. This makes it difficult for these resources to access pods directly.

  To enable direct access from resources in the same VPC as the cluster to pods, you can add the CIDR blocks of the subnets where these resources are located to the **nonMasqueradeCIDRs** parameter. This will skip SNAT and ensure that the source IP addresses of the data packets remain the same as the original IP addresses of pods.

Precautions

If a security group or ACL is configured for a cloud service and only the IP address of the node where the pod runs is allowed to access the service, SNAT is required to translate the pod IP address into the node IP address for successful access. As a result, the CIDR block of the subnet where the server is located cannot be added to the **nonMasqueradeCIDRs** configuration.

The default setting of pod IP address masquerading (SNAT) is usually sufficient. However, if you need to retain the original IP addresses of pods in specific scenarios, you can configure the **nonMasqueradeCIDRs** parameter.

Before doing so, make sure you have evaluated your application scenario and understood the potential risks of improper configuration, because it may block access within clusters. If you are unsure whether to configure this parameter, it is recommended that you keep the default settings and adjust the configuration later once the requirement is clarified.

Procedure

To reserve the source IP address of a pod when the pod accesses a CIDR block, you can configure **nonMasqueradeCIDRs** to specify the CIDR block that does not need to be masqueraded.

Step 1 Log in to the CCE console and click the name of the target cluster to access the cluster console.

Step 2 In the navigation pane, choose **Settings** and click the **Network** tab.

Step 3 Modify the range of the CIDR block for non-masquerading access to preserve the source pod IP address when accessing a specified CIDR block. Make sure the parameter configuration complies with the following rules:

- Each CIDR block must comply with the CIDR format and must be a valid IPv4 CIDR block.

  Example of a correct CIDR block: **192.168.1.0/24**

  Example of an incorrect CIDR block: **192.168.1.1/24** (incompliant with the CIDR format)

- The CIDR blocks you configured do not overlap with each other.

  Example of correct CIDR blocks: **192.168.1.0/24** and **192.168.2.0/24**

  Example of incorrect CIDR blocks: **192.168.1.0/24** and **192.168.1.128/25** (The two CIDR blocks overlap.)

- The **nonMasqueradeCIDRs** parameter must contain all destination CIDR blocks that you want them to use the original pod IP addresses for communications.

Step 4 After the modification, click **Confirm configuration**. The setting takes effect within 1 minute.

----End

11 Storage

11.1 Expanding the Storage Space

The storage classes that can be expanded for CCE nodes are as follows:

Table 11-1 Capacity expansion methods

Type	Name	Purpose	Capacity Expansion Method
Node disk	System disk	A disk attached to a node for installing the operating system	**Expanding System Disk Capacity**
	Data disk	The first data disk attached to a node for container engine and kubelet	• **Expanding the Container Engine Capacity** • **Expanding the kubelet Capacity** • **Expanding Capacity of the Disk Shared by Container Engine and kubelet**
Container storage	Pod container space	The base size of a container, which is, the upper limit of the disk space occupied by each pod (including the storage space occupied by container images)	**Expanding the Capacity of a Data Disk Used by Pod (basesize)**
	PVC	Storage resources mounted to the containers	**Expanding a PVC**

Expanding System Disk Capacity

EulerOS 2.9 is used as the sample OS. There is only one partition (**/dev/vda1**) with a capacity of 50 GiB in the system disk **/dev/vda**, and then 50 GiB is added to the system disk. In this example, the additional 50 GiB is allocated to the existing **/dev/vda1** partition.

Step 1 Expand the system disk capacity on the EVS console. For details, see **Expanding EVS Disk Capacity**.

Only the storage capacity of the EVS disk is expanded. You also need to perform the following steps to expand the partition and file system.

Step 2 Log in to the node and run the **growpart** command to check whether growpart has been installed.

If the tool operation guide is displayed, the growpart has been installed. Otherwise, run the following command to install growpart:

```
yum install cloud-utils-growpart
```

Step 3 Run the following command to view the total capacity of the system disk **/dev/vda**:

```
fdisk -l
```

If the following information is displayed, the total capacity of **/dev/vda** is 100 GiB.

```
[root@test-48162 ~]# fdisk -l
Disk /dev/vda: 100 GiB, 107374182400 bytes, 209715200 sectors
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
Disklabel type: dos
Disk identifier: 0x78d88f0b

Device     Boot Start       End   Sectors Size Id Type
/dev/vda1  *     2048 104857566 104855519  50G 83 Linux

Disk /dev/vdb: 100 GiB, 107374182400 bytes, 209715200 sectors
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes

Disk /dev/mapper/vgpaas-dockersys: 90 GiB, 96632569856 bytes, 188735488 sectors
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes

Disk /dev/mapper/vgpaas-kubernetes: 10 GiB, 10733223936 bytes, 20963328 sectors
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
```

Step 4 Run the following command to check the capacity of the system disk partition **/dev/vda1**:

```
df -TH
```

Information similar to the following is displayed:

```
[root@test-48162 ~]# df -TH
Filesystem              Type      Size  Used Avail Use% Mounted on
devtmpfs                devtmpfs  1.8G     0  1.8G   0% /dev
tmpfs                   tmpfs     1.8G     0  1.8G   0% /dev/shm
tmpfs                   tmpfs     1.8G   13M  1.8G   1% /run
tmpfs                   tmpfs     1.8G     0  1.8G   0% /sys/fs/cgroup
```



```
/dev/vda1                  ext4      53G  3.3G   47G   7% /
tmpfs                      tmpfs     1.8G   75M  1.8G   5% /tmp
/dev/mapper/vgpaas-dockersys  ext4       95G  1.3G   89G   2% /var/lib/docker
/dev/mapper/vgpaas-kubernetes ext4       11G   39M   10G   1% /mnt/paas/kubernetes/kubelet
...
```

Step 5 Run the following command to extend the partition using growpart:

```
growpart System disk Partition number
```

The partition number is **1** because there is only one **/dev/vda1** partition in the system disk, as shown in the following command:

```
growpart /dev/vda 1
```

Information similar to the following is displayed:

```
CHANGED: partition=1 start=2048 old: size=104855519 end=104857567 new: size=209713119
end=209715167
```

Step 6 Run the following command to extend the file system:

```
resize2fs Disk partition
```

An example command is as follows:

```
resize2fs /dev/vda1
```

Information similar to the following is displayed:

```
resize2fs 1.45.6 (20-Mar-2020)
Filesystem at /dev/vda1 is mounted on /; on-line resizing required
old_desc_blocks = 7, new_desc_blocks = 13
The filesystem on /dev/vda1 is now 26214139 (4k) blocks long.
```

Step 7 Run the following command to view the new capacity of the **/dev/vda1** partition:

```
df -TH
```

Information similar to the following is displayed:

```
[root@test-48162 ~]# df -TH
Filesystem                 Type      Size  Used Avail Use% Mounted on
devtmpfs                   devtmpfs  1.8G     0  1.8G   0% /dev
tmpfs                      tmpfs     1.8G     0  1.8G   0% /dev/shm
tmpfs                      tmpfs     1.8G   13M  1.8G   1% /run
tmpfs                      tmpfs     1.8G     0  1.8G   0% /sys/fs/cgroup
/dev/vda1                  ext4      106G  3.3G   98G   4% /
tmpfs                      tmpfs     1.8G   75M  1.8G   5% /tmp
/dev/mapper/vgpaas-dockersys  ext4       95G  1.3G   89G   2% /var/lib/docker
/dev/mapper/vgpaas-kubernetes ext4       11G   39M   10G   1% /mnt/paas/kubernetes/kubelet
...
```

Step 8 Log in to the CCE console and click the cluster. In the navigation pane, choose **Nodes**. Click **More** > **Sync Server Data** in the row containing the target node.

----End

Expanding Data Disk Capacity

The first data disk of a CCE node is composed of container engine and kubelet space by default. If either of them reaches full capacity, you can expand the disk space as needed.

In clusters of v1.21.10-r0, v1.23.8-r0, v1.25.3-r0, and later, CCE enables container engine (Docker/containerd) and kubelet to share the space of the first data disk. If the shared disk space is insufficient, you can expand it.

Expanding the Container Engine Capacity

The available container engine space affects image pulls and container startup and running. This section uses containerd as an example to describe how to expand the container engine capacity.

Step 1 Expand the capacity of a data disk on the EVS console. For details, see **Expanding EVS Disk Capacity**.

Only the storage capacity of the EVS disk is expanded. You also need to perform the following steps to expand the capacity of the logical volume and file system.

Step 2 Log in to the CCE console and click the cluster. In the navigation pane, choose **Nodes**. Click **More** > **Sync Server Data** in the row containing the target node.

Step 3 Log in to the target node.

Step 4 Run the **lsblk** command to check the block device information of the node.

A data disk is divided depending on the container storage **Rootfs**:

Overlayfs: No independent thin pool is allocated. Image data is stored in **dockersys**.

1. Check the disk and partition sizes of the device.

```
# lsblk
NAME              MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
sda                 8:0    0   50G  0 disk
└─sda1              8:1    0   50G  0 part /
sdb                 8:16   0  150G  0 disk      # The data disk has been expanded to 150 GiB, but 50 GiB space is not allocated.
├─vgpaas-dockersys 253:0    0   90G  0 lvm  /var/lib/containerd
└─vgpaas-kubernetes 253:1   0   10G  0 lvm  /mnt/paas/kubernetes/kubelet
```

2. Expand the disk capacity.

   Add the new disk capacity to the **dockersys** logical volume used by the container engine.

   a. Expand the PV capacity so that LVM can identify the new EVS capacity. */dev/sdb* specifies the physical volume where dockersys is located.

   ```
   pvresize /dev/sdb
   ```

   Information similar to the following is displayed:

   ```
   Physical volume "/dev/sdb" changed
   1 physical volume(s) resized or updated / 0 physical volume(s) not resized
   ```

   b. Expand 100% of the free capacity to the logical volume. *vgpaas/dockersys* specifies the logical volume used by the container engine.

   ```
   lvextend -l+100%FREE -n vgpaas/dockersys
   ```

   Information similar to the following is displayed:

   ```
   Size of logical volume vgpaas/dockersys changed from <90.00 GiB (23039 extents) to 140.00 GiB (35840 extents).
   Logical volume vgpaas/dockersys successfully resized.
   ```

   c. Adjust the size of the file system. */dev/vgpaas/dockersys* specifies the file system path of the container engine.

   ```
   resize2fs /dev/vgpaas/dockersys
   ```

   Information similar to the following is displayed:

   ```
   Filesystem at /dev/vgpaas/dockersys is mounted on /var/lib/containerd; on-line resizing required
   old_desc_blocks = 12, new_desc_blocks = 18
   The filesystem on /dev/vgpaas/dockersys is now 36700160 blocks long.
   ```


3. Check whether the capacity is expanded.

```
# lsblk
NAME              MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
sda               8:0    0   50G  0 disk
└─sda1              8:1    0   50G  0 part /
sdb               8:16   0  150G  0 disk
├─vgpaas-dockersys 253:0    0   140G  0 lvm  /var/lib/containerd
└─vgpaas-kubernetes 253:1    0   10G  0 lvm  /mnt/paas/kubernetes/kubelet
```

Devicemapper: A thin pool is allocated to store image data.

1. Check the disk and partition sizes of the device.

```
# lsblk
NAME                        MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
vda                         8:0    0   50G  0 disk
└─vda1                        8:1    0   50G  0 part /
vdb                         8:16   0  200G  0 disk
├─vgpaas-dockersys            253:0    0   18G  0 lvm  /var/lib/docker
├─vgpaas-thinpool_tmeta         253:1    0    3G  0 lvm
│ └─vgpaas-thinpool           253:3    0   67G  0 lvm              # Space used by thinpool
│   ...
├─vgpaas-thinpool_tdata         253:2    0   67G  0 lvm
│ └─vgpaas-thinpool           253:3    0   67G  0 lvm
│   ...
└─vgpaas-kubernetes             253:4    0   10G  0 lvm  /mnt/paas/kubernetes/kubelet
```

2. Expand the disk capacity.

   Option 1: Add the new disk capacity to the thin pool disk.

   a. Expand the PV capacity so that LVM can identify the new EVS capacity. */dev/vdb* specifies the physical volume where thinpool is located.

```
pvresize /dev/vdb
```

      Information similar to the following is displayed:

```
Physical volume "/dev/vdb" changed
1 physical volume(s) resized or updated / 0 physical volume(s) not resized
```

   b. Expand 100% of the free capacity to the logical volume. *vgpaas/thinpool* specifies the logical volume used by the container engine.

```
lvextend -l+100%FREE -n vgpaas/thinpool
```

      Information similar to the following is displayed:

```
Size of logical volume vgpaas/thinpool changed from <67.00 GiB (23039 extents) to <167.00
GiB (48639 extents).
Logical volume vgpaas/thinpool successfully resized.
```

   c. Do not need to adjust the size of the file system, because the thin pool is not mounted to any devices.

   d. Check whether the capacity is expanded. Run the **lsblk** command to check the disk and partition sizes of the device. If the new disk capacity has been added to the thin pool, the capacity is expanded.

```
# lsblk
NAME                        MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
vda                         8:0    0   50G  0 disk
└─vda1                        8:1    0   50G  0 part /
vdb                         8:16   0  200G  0 disk
├─vgpaas-dockersys            253:0    0   18G  0 lvm  /var/lib/docker
├─vgpaas-thinpool_tmeta         253:1    0    3G  0 lvm
│ └─vgpaas-thinpool           253:3    0   167G  0 lvm            # Thin pool space after
capacity expansion
│   ...
├─vgpaas-thinpool_tdata         253:2    0   67G  0 lvm
│ └─vgpaas-thinpool           253:3    0   67G  0 lvm
│   ...
└─vgpaas-kubernetes             253:4    0   10G  0 lvm  /mnt/paas/kubernetes/kubelet
```

   Option 2: Add the new disk capacity to the **dockersys** disk.

a. Expand the PV capacity so that LVM can identify the new EVS capacity. */dev/vdb* specifies the physical volume where dockersys is located.

```
pvresize /dev/vdb
```

Information similar to the following is displayed:

```
Physical volume "/dev/vdb" changed
1 physical volume(s) resized or updated / 0 physical volume(s) not resized
```

b. Expand 100% of the free capacity to the logical volume. *vgpaas/dockersys* specifies the logical volume used by the container engine.

```
lvextend -l+100%FREE -n vgpaas/dockersys
```

Information similar to the following is displayed:

```
Size of logical volume vgpaas/dockersys changed from <18.00 GiB (4607 extents) to <118.00 GiB (30208 extents).
Logical volume vgpaas/dockersys successfully resized.
```

c. Adjust the size of the file system. */dev/vgpaas/dockersys* specifies the file system path of the container engine.

```
resize2fs /dev/vgpaas/dockersys
```

Information similar to the following is displayed:

```
Filesystem at /dev/vgpaas/dockersys is mounted on /var/lib/docker; on-line resizing required
old_desc_blocks = 3, new_desc_blocks = 15
The filesystem on /dev/vgpaas/dockersys is now 30932992 blocks long.
```

d. Check whether the capacity is expanded. Run the **lsblk** command to check the disk and partition sizes of the device. If the new disk capacity has been added to the dockersys, the capacity is expanded.

```
# lsblk
NAME                      MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
vda                       8:0    0   50G  0 disk
└─vda1                      8:1    0   50G  0 part /
vdb                       8:16   0  200G  0 disk
├─vgpaas-dockersys          253:0    0   118G  0 lvm  /var/lib/docker     # dockersys after capacity expansion
├─vgpaas-thinpool_tmeta       253:1    0    3G  0 lvm
│ └─vgpaas-thinpool           253:3    0   67G  0 lvm
│   ...
├─vgpaas-thinpool_tdata       253:2    0   67G  0 lvm
│ └─vgpaas-thinpool           253:3    0   67G  0 lvm
│   ...
└─vgpaas-kubernetes           253:4    0   10G  0 lvm  /mnt/paas/kubernetes/kubelet
```

----End

Expanding the kubelet Capacity

The kubelet space serves as a temporary storage location for kubelet components and EmptyDir. You can follow the following steps to increase the kubelet capacity:

Step 1 Expand the capacity of a data disk on the EVS console. For details, see **Expanding EVS Disk Capacity**.

Only the storage capacity of the EVS disk is expanded. You also need to perform the following steps to expand the capacity of the logical volume and file system.

Step 2 Log in to the CCE console and click the cluster. In the navigation pane, choose **Nodes**. Click **More** > **Sync Server Data** in the row containing the target node.

Step 3 Log in to the target node.

Step 4 Run **lsblk** to view the block device information of the node.


```
# lsblk
NAME              MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
sda               8:0    0   50G  0 disk
└─sda1            8:1    0   50G  0 part /
sdb               8:16   0  200G  0 disk      #The data disk has been expanded to 200 GiB, but 50 GiB space is not allocated.
├─vgpaas-dockersys  253:0    0  140G  0 lvm  /var/lib/containerd
└─vgpaas-kubernetes 253:1    0   10G  0 lvm  /mnt/paas/kubernetes/kubelet
```

Step 5 Perform the following operations on the node to add the new disk capacity to the kubelet space:

1. Expand the PV capacity so that LVM can identify the new EVS capacity. */dev/sdb* specifies the physical volume where kubelet is located.
   ```
   pvresize /dev/sdb
   ```
   Information similar to the following is displayed:
   ```
   Physical volume "/dev/sdb" changed
   1 physical volume(s) resized or updated / 0 physical volume(s) not resized
   ```
2. Expand 100% of the free capacity to the logical volume. *vgpaas/kubernetes* specifies the logical volume used by kubelet.
   ```
   lvextend -l+100%FREE -n vgpaas/kubernetes
   ```
   Information similar to the following is displayed:
   ```
   Size of logical volume vgpaas/kubernetes changed from <10.00 GiB (2559 extents) to <60.00 GiB (15359 extents).
   Logical volume vgpaas/kubernetes successfully resized.
   ```
3. Adjust the size of the file system. */dev/vgpaas/kubernetes* specifies the file system path of the container engine.
   ```
   resize2fs /dev/vgpaas/kubernetes
   ```
   Information similar to the following is displayed:
   ```
   Filesystem at /dev/vgpaas/kubernetes is mounted on /mnt/paas/kubernetes/kubelet; on-line resizing required
   old_desc_blocks = 2, new_desc_blocks = 8
   The filesystem on /dev/vgpaas/kubernetes is now 15727616 blocks long.
   ```

Step 6 Run **lsblk** to view the block device information of the node.

```
# lsblk
NAME              MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
sda               8:0    0   50G  0 disk
└─sda1            8:1    0   50G  0 part /
sdb               8:16   0  200G  0 disk
├─vgpaas-dockersys  253:0    0  140G  0 lvm  /var/lib/containerd
└─vgpaas-kubernetes 253:1    0   60G  0 lvm  /mnt/paas/kubernetes/kubelet  # Allocate the new disk to the kubelet space.
```

----End

Expanding Capacity of the Disk Shared by Container Engine and kubelet

To expand the capacity of the disk shared by container engine and kubelet, perform the following steps:

Step 1 Expand the capacity of a data disk on the EVS console. For details, see **Expanding EVS Disk Capacity**.

Only the storage capacity of the EVS disk is expanded. You also need to perform the following steps to expand the capacity of the logical volume and file system.

Step 2 Log in to the CCE console and click the cluster. In the navigation pane, choose **Nodes**. Click **More** > **Sync Server Data** in the row containing the target node.

Step 3 Log in to the target node.

Step 4 Run **lsblk** to view the block device information of the node.

```
# lsblk
NAME          MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
sda             8:0    0   50G  0 disk
└─sda1          8:1    0   50G  0 part /
sdb             8:16   0  120G  0 disk   # The data disk has been expanded to 120 GiB, but 20 GiB space is not allocated.
└─vgpaas-share 253:0    0  100G  0 lvm  /mnt/paas # Space used by the container engine and the kubelet component
```

Step 5 Run the following commands on the node to add the new disk capacity to the shared disk:

1. Expand the PV capacity so that LVM can identify the new EVS capacity. */dev/sdb* specifies the physical volume where the shared disk is located.

   ```
   pvresize /dev/sdb
   ```

   Information similar to the following is displayed:

   ```
   Physical volume "/dev/sdb" changed
   1 physical volume(s) resized or updated / 0 physical volume(s) not resized
   ```

2. Expand 100% of the free capacity to the logical volume. *vgpaas/share* specifies the logical volume shared by the container engine and the kubelet component.

   ```
   lvextend -l+100%FREE -n vgpaas/share
   ```

   Information similar to the following is displayed:

   ```
   Size of logical volume vgpaas/share changed from <100.00 GiB (25599 extents) to <120.00 GiB (30719 extents).
   Logical volume vgpaas/share successfully resized.
   ```

3. Adjust the size of the file system. */dev/vgpaas/share* specifies the file system path of the shared disk.

   ```
   resize2fs /dev/vgpaas/share
   ```

   Information similar to the following is displayed:

   ```
   Filesystem at /dev/vgpaas/share is mounted on /mnt/paas; on-line resizing required
   old_desc_blocks = 13, new_desc_blocks = 15
   The filesystem on /dev/vgpaas/share is now 31456256 blocks long.
   ```

Step 6 Run **lsblk** to view the block device information of the node.

```
# lsblk
NAME          MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
sda             8:0    0   50G  0 disk
└─sda1          8:1    0   50G  0 part /
sdb             8:16   0  120G  0 disk
└─vgpaas-share 253:0    0  120G  0 lvm  /mnt/paas # Space of the new disk used by the container engine and the kubelet component
```

----End

Expanding the Capacity of a Data Disk Used by Pod (basesize)

Step 1 Log in to the CCE console and click the cluster name to access the cluster console.

Step 2 Choose **Nodes** from the navigation pane.

Step 3 Click the **Nodes** tab, locate the row containing the target node, and choose **More** > **Reset Node** in the **Operation** column.

NOTICE

Resetting a node may make the node-specific resources (such as local storage and workloads scheduled to this node) unavailable. Exercise caution when performing this operation to avoid impact on running services.

Step 4 Reconfigure node parameters.

If you need to adjust the container storage space, pay attention to the following configurations:

Storage Settings: Click **Expand** next to the data disk to set the following parameter:

Space Allocation for Pods: indicates the base size of a pod. It is the maximum size that a workload's pods (including the container images) can grow to in the disk space. Proper settings can prevent pods from taking all the disk space available and avoid service exceptions. It is recommended that the value is less than or equal to 80% of the container engine space. This parameter is related to the node OS and container storage rootfs and is not supported in some scenarios.

For more information about container storage space allocation, see **Data Disk Space Allocation**.

Step 5 After the node is reset, log in to the node and check whether the container capacity has been expanded. The command output varies with the container storage rootfs.

- Overlayfs: No independent thin pool is allocated. Image data is stored in **dockersys**. Run the following command to check whether the container capacity has been expanded:

  docker exec -it *container_id* **/bin/sh** or **kubectl exec -it** *container_id* **/bin/sh**

  df -h

  If the information similar to the following is displayed, the overlay capacity has been expanded from 10 GiB to 15 GiB.

  ```
  Filesystem                Size  Used  Avail  Use%  Mounted on
  overlay                   15G   104K  15G    1%    /
  tmpfs                     64M   0     64M    0%    /dev
  tmpfs                     3.6G  0     3.6G   0%    /sys/fs/cgroup
  /dev/mapper/vgpaas-share  98G   4.0G  89G    5%    /etc/hosts
  ...
  ```

- Devicemapper: A thin pool is allocated to store image data. Run the following command to check whether the container capacity has been expanded:

  docker exec -it *container_id* **/bin/sh** or **kubectl exec -it** *container_id* **/bin/sh**

  df -h

  If the information similar to the following is displayed, the thin pool capacity has been expanded from 10 GiB to 15 GiB.

  ```
  Filesystem                      Size  Used  Avail  Use%  Mounted on
  /dev/mapper/vgpaas-thinpool-snap-84  15G  232M  15G  2%  /
  tmpfs                           64M   0     64M    0%    /dev
  tmpfs                           3.6G  0     3.6G   0%    /sys/fs/cgroup
  /dev/mapper/vgpaas-kubernetes   11G   41M   11G    1%    /etc/hosts
  /dev/mapper/vgpaas-dockersys    20G   1.1G  18G    6%    /etc/hostname
  ...
  ```

----End

Expanding a PVC

Cloud storage:

- OBS and SFS: There is no storage restriction and capacity expansion is not required.
- EVS:
  - You can expand the capacity of automatically created pay-per-use volumes on the console. The procedure is as follows:
    i. Choose **Storage** in the navigation pane. In the right pane, click the **PVCs** tab. Click **More** in the **Operation** column of the target PVC and select **Scale-out**.
    ii. Enter the capacity to be added and click **OK**.
  - For yearly/monthly-billed instances, expand the capacity on the EVS console and then change the capacity in the PVC.
- SFS Turbo: You can expand the capacity on the SFS console and then change the capacity in the PVC.

11.2 Mounting Object Storage Across Accounts

Application Scenarios

- Cross-account data sharing. For example, multiple teams within a company need to share data, but each team uses a different account.
- Cross-account data migration and backup. When account A is about to be disabled, all data stored in the account needs to be transferred to a new account (account B).
- Data processing and analysis. For example, account B is an external data processor and needs to access raw data from account A to perform tasks such as big data analysis and machine learning.

By linking object storage across accounts, you can share data, lower storage and transmission expenses, and guarantee data security and consistency. This enables various teams or organizations to securely and conveniently access each other's data resources, eliminating the need for repeated storage and redundant transmission. Additionally, data is kept current and compliant, enhancing overall service efficiency and security.

Procedure

Assume that account B needs to access and use an OBS bucket of account A. For details, see **Figure 11-1** and **Table 11-2**.

Figure 11-1 Mounting an OBS bucket across accounts

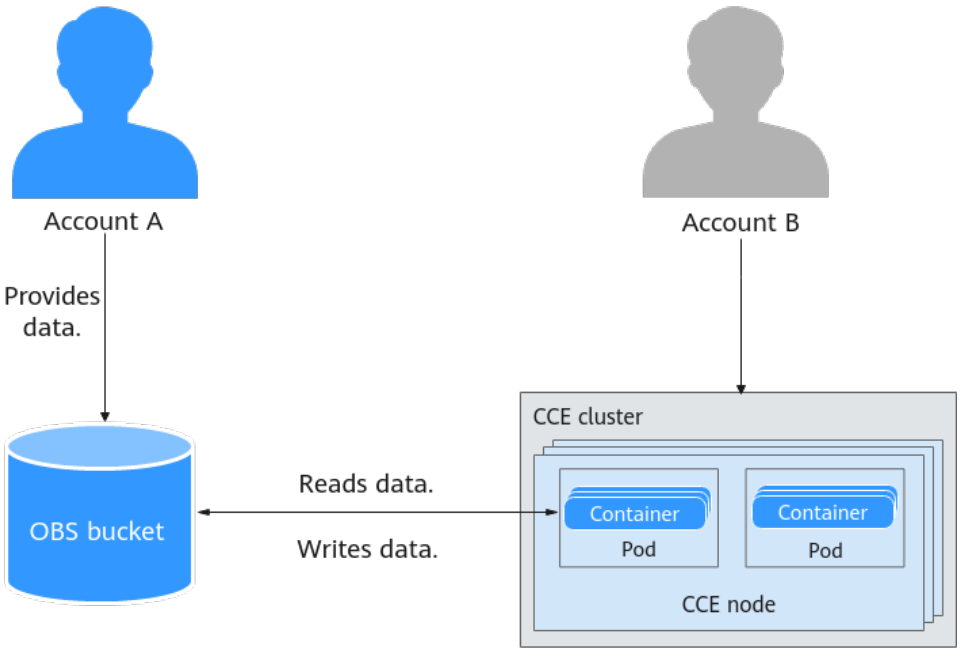


Table 11-2 Process description

Procedure	Description
Step 1: Create an OBS Bucket Policy and ACL	Configure an OBS bucket policy and ACL using account A and grant account B required permissions like the read and write permissions.
Step 2: Create a Workload with an OBS Volume Mounted	Create a PV and a PVC based on the OBS bucket of account A using account B and mount the PVC to the required workload.
Step 3: Check the Pod Actions on the OBS Bucket	Check whether the pod created by account B has the required permissions based on the bucket policy.
Step 4: Clear Resources	Once you have studied this example, delete any associated resources to prevent incurring settlement fees.

Prerequisites

- The involved accounts are in the same region.
- You have created a cluster where the CCE Container Storage (Everest) add-on is installed. The add version must be 1.1.11 or later, and the cluster version must be 1.15 or later. If no cluster is available, create one by referring to **Buying a CCE Standard/Turbo Cluster**.
- An ECS with an EIP bound has been created in the same VPC as the cluster, and the ECS has been connected to the cluster through kubectl. For details

about how to connect an ECS to a cluster, see **Connecting to a Cluster Using kubectl**.

Step 1: Create an OBS Bucket Policy and ACL

Configure an OBS bucket policy and ACL using account A and grant account B required permissions like the read and write permissions.

Step 1 Log in to the OBS console. In the navigation pane, choose **Object Storage**.

Step 2 Click the name of the target bucket to go to the **Objects** page.

Step 3 In the navigation pane, choose **Permissions** > **Bucket Policies**. On the page displayed, click **Create**.

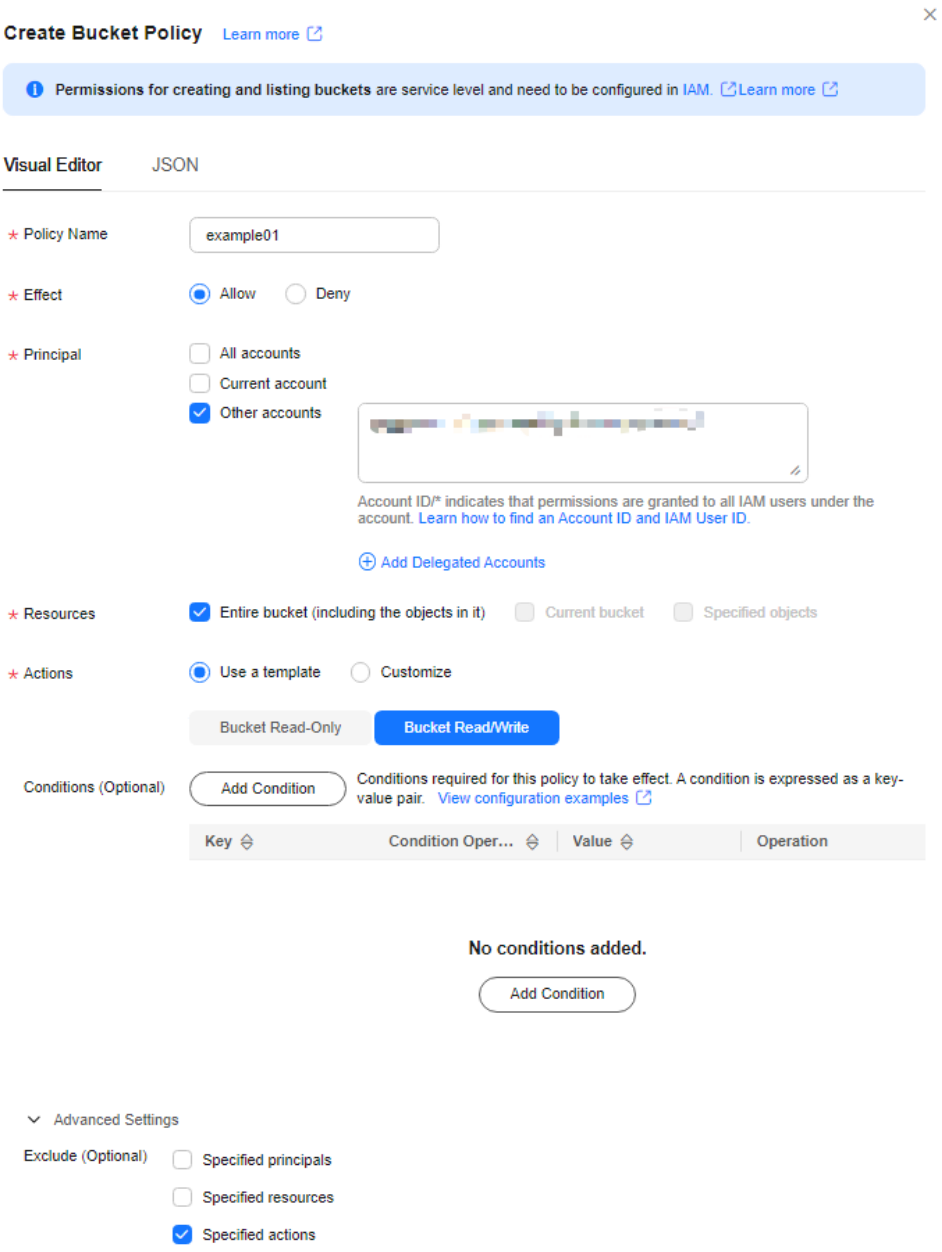
Step 4 Configure the parameters. In this example, only some mandatory parameters are described. You can keep the default values for other parameters. For details about the parameters, see **Bucket Policies**.

Table 11-3 Bucket policy parameters

Parameter	Description	Example
Policy Name	Enter a name.	example01
Effect	Specify the behavior of a policy. • **Allow**: The actions defined in the policy are allowed. • **Deny**: The actions defined in the policy are denied.	Allow
Principal	Specify authorized accounts. (Multiple accounts can be selected.) For different types of authorized accounts, the OBS console provides different templates for authorizations. For details, see **Creating a Bucket Policy with a Template**. • **All accounts**: Any account can execute the current bucket policy without identity authentication, which may pose data security risks. • **Current account**: Grant permissions to a specific IAM account under the current account. • **Other accounts**: Grant permissions to a specific IAM account under another account.	Other accounts XXX(account ID)/XXX (IAM ID)

Parameter	Description	Example
Resources	Specify the authorized resources. • **Entire bucket (including the objects in it)**: Allow authorized accounts to perform certain actions on a bucket and the objects in it. • **Current bucket**: Allow authorized accounts to perform certain actions on the current bucket. • **Specific objects**: Allow authorized accounts to perform certain actions on the specified objects in a bucket.	Entire bucket (including the objects in it)
Actions	Specify actions. • **Use a template**: Use a permission template preset on the OBS console. If you selected **Bucket Read/Write**, the **Specified actions** option will be selected by default in the **Advanced Settings** area. • **Customize**: Customize the actions.	Use a template > Bucket Read/ Write

Figure 11-2 Creating a bucket policy



Step 5 In the navigation pane, choose **Permissions** > **Bucket ACL**. In the right pane, click **Add** under **User Access**. Enter the account ID of the authorized user, select **Read** and **Write** for **Access to Bucket**, select **Read** for **Access to Objects**, select **Read** and **Write** for **Access to ACL**, and click **OK**.

----End

Step 2: Create a Workload with an OBS Volume Mounted

Create a PV and a PVC based on the OBS bucket of account A using account B and mount the PVC to the required workload.

Step 1 Create a ConfigMap named **paas-obs-endpoint** and configure the region and endpoint of OBS.


```
vim config.yaml
```

The content is as follows: (For details about the parameters, see **Table 11-4**.)

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: paas-obs-endpoint   # The value must be paas-obs-endpoint.
  namespace: kube-system    # The value must be kube-system.
data:
  obs-endpoint: |
    {"<region_name>": "<endpoint_address>"}
```

Create the ConfigMap using **config.yaml**.

```
kubectl create -f config.yaml
```

Table 11-4 ConfigMap parameters

ConfigMap	Description	Example
metadata.name	ConfigMap name, which is fixed at **paas-obs-endpoint** and cannot be changed	paas-obs-endpoint
metadata.namespace	Namespace, which is fixed at **kube-system** and cannot be changed	kube-system
data.obs-endpoint	Region names and endpoints are in key-value pairs. Replace *<region_name>* and *<endpoint_address>* with specific values. If multiple values are needed, use commas (,) to separate them. For details about its value, see **Regions and Endpoints**.	{"ap-southeast-1": "https://obs.ap-southeast-1.myhuaweicloud.com:443", "ap-southeast-3": "https://obs.ap-southeast-3.myhuaweicloud.com:443"}

Step 2 Create a secret named **test-user**. (This secret is used to provide access credentials when volumes are mounted to CSI, and its name can be customized.)

1. Obtain the AK. Go back to the management console, hover the cursor over the username in the upper right corner and choose **My Credentials** from the drop-down list.

   In the navigation pane, choose **Access Keys**. On the page displayed, click **Create Access Key**.

   Click **OK** and download the AK.

2. Encode the AK using Base64 and save the encoded AK and SK. If the AK obtained is **xxx** and the SK is **yyy**, run the following commands:

   ```
   echo -n xxx|base64
   echo -n yyy|base64
   ```

3. Create a secret YAML file, for example, **test_user.yaml**.

   ```
   vim test_user.yaml
   ```

   The content is as follows: (For details about the parameters, see **Table 11-5**.)

   ```
   apiVersion: v1
   data:
     access.key: QUxPQUlJU******
     secret.key: aVMwZkduQ******
   kind: Secret
   metadata:
   ```



```
  name: test-user
  namespace: default
type: cfe/secure-opaque
```

Create a secret using **test_user.yaml**.

```
kubectl create -f test_user.yaml
```

Table 11-5 Secret parameters

Parameter	Description	Example
access.key	A Base64-encoded AK	QUxPQUlJU******
secret.key	A Base64-encoded SK	aVMwZkduQ******
type	Key type, which is fixed at **cfe/secure-opaque** and cannot be changed When this type is used, the data entered by users will be automatically encrypted.	cfe/secure-opaque

Step 3 Create a PV named **testing_abc** and mount the secret named **test_user** to the PV.

```
vim testing_abc.yaml
```

The content is as follows: (For details about the parameters, see **Table 11-6**.)

```
kind: PersistentVolume
apiVersion: v1
metadata:
  name: testing-abc
  annotations:
    pv.kubernetes.io/bound-by-controller: 'yes'
    pv.kubernetes.io/provisioned-by: everest-csi-provisioner
spec:
  capacity:
    storage: 1Gi
  mountOptions:
  - default_acl=bucket-owner-full-control      #New OBS mounting parameters
  csi:
    driver: obs.csi.everest.io
    volumeHandle: obs-cce-test                # Name of the OBS bucket to be mounted
    fsType: s3fs                              # obsfs indicates a parallel file system, and s3fs indicates an OBS bucket.
    volumeAttributes:
      everest.io/obs-volume-type: STANDARD     # Bucket type, which can be STANDARD or WARM when an OBS bucket is used
      everest.io/region: <region_name>         # Region where the OBS bucket is located (Replace it with the actual value.)
      storage.kubernetes.io/csiProvisionerIdentity: everest-csi-provisioner
    nodePublishSecretRef:                     # AK/SK used for mounting the OBS bucket
      name: test-user
      namespace: default
  accessModes:
    - ReadWriteMany
  persistentVolumeReclaimPolicy: Retain       # PV reclaim policy
  storageClassName: csi-obs                   # csi-obs specifies an OBS storage class that is automatically created. You can customize it as required.
  volumeMode: Filesystem
```

Create the PV using **testing_abc.yaml**.

```
kubectl create -f testing_abc.yaml
```


Table 11-6 PV parameters

Parameter	Description	Example
mountOptions.default_acl	Specify access control policies for a bucket and objects in the bucket. In this example, account A owns the bucket, and both account A and account B have the ability to upload data. • **private**: The bucket or objects can only be fully accessed by the owner of the bucket. • **public-read**: The owner of the bucket has complete control over both the bucket and its objects. While other users can read data from the bucket, they are unable to modify, delete, or upload any data within it. • **public-read-write**: The owner of the bucket has complete control over the bucket and its objects. Other users can read and write data from and to the bucket. • **bucket-owner-read**: Users who have uploaded objects to the bucket has complete control over the objects, while the bucket owner is only granted read permissions for said objects. **This mode is usually used in cross-account sharing scenarios**. • **bucket-owner-full-control**: Users who have uploaded objects to the bucket are granted write permissions for those specific objects, but not read permissions by default. The bucket owner has complete control over all objects within the bucket. **This mode is usually used in cross-account sharing scenarios.**	bucket-owner-full-control **NOTE** Due to the bucket policy that was configured using account A, account B has been granted read and write permissions for the entire bucket, including objects uploaded by both account A and B.
csi.nodePublishSecretRef	Specify the secret to be mounted. • name: name of a secret • namespace: namespace where the secret is in	test-user default
csi.volumeHandle	Specify the name of the OBS bucket to be mounted.	obs-cce-test (OBS bucket name authorized by account A)

Parameter	Description	Example
csi.fsType	Specify the file type. • **obsfs**: Create an OBS parallel file system. • **s3fs**: Create an OBS bucket.	s3fs **NOTICE** The file type specified by the PV and the PVC must match in order for the PV to be bound to the corresponding PVC. If they do not match, the binding cannot occur.
accessModes	Specify the access mode of the storage volume. OBS supports only **ReadWriteMany**. • **ReadWriteOnce**: A storage volume can be mounted to a single node in read-write mode. • **ReadWriteMany**: A storage volume can be mounted to multiple nodes in read-write mode.	ReadWriteMany
persistentVolumeReclaimPolicy	Specify the reclaim policy for the PV. • **Delete**: When a PVC is deleted, both the PV and underlying storage resources will be deleted. If the **everest.io/reclaim-policy: retain-volume-only** annotation is added to the YAML file, the underlying storage resources will be retained. • **Retain**: When a PVC is deleted, both the PV and underlying storage resources will be retained. You need to manually delete them. After the PVC is deleted, the PV is in the **Released** state and cannot be bound to a PVC again.	Retain **NOTE** If multiple PVs use the same OBS volume, use **Retain** to prevent the underlying volume from being deleted with one of the PV.

Step 4 Create a PVC named **pvc-test-abc** and bind the new PV **testing_abc** to it.

```
vim pvc_test_abc.yaml
```

The file content is as follows:

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: pvc-test-abc
  namespace: default
  annotations:
    csi.storage.k8s.io/node-publish-secret-name: test-user      # Mount a secret.
    csi.storage.k8s.io/node-publish-secret-namespace: default   # Namespace of the secret
      everest.io/obs-volume-type: STANDARD      # Bucket type, which can be STANDARD or WARM when an OBS bucket is used
    csi.storage.k8s.io/fstype: s3fs             # File type. obsfs indicates a parallel file system, and s3fs indicates an OBS bucket.
    volume.beta.kubernetes.io/storage-provisioner: everest-csi-provisioner
spec:
```



```
  accessModes:
  - ReadWriteMany            # The value must be ReadWriteMany for object storage.
  resources:
    requests:
      storage: 1Gi           # Storage capacity of a PVC. This parameter is valid only for verification (fixed to 1, cannot be empty or 0). The value setting does not take effect for OBS buckets.
  storageClassName: csi-obs   # csi-obs specifies an OBS storage class that is automatically created. You can customize it as required.
  volumeName: testing-abc     # PV name
```

Create the PVC using **pvc_test_abc.yaml**.

```
kubectl create -f pvc_test_abc.yaml
```

Step 5 Create a workload and mount the PVC to it. The following uses an Nginx Deployment as an example.

```
vim obs_deployment_example.yaml
```

The file content is as follows:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: obs-deployment-example                # Workload name, which can be customized
  namespace: default
spec:
  replicas: 1
  selector:
    matchLabels:
      app: obs-deployment-example             # Label, which can be customized
  template:
    metadata:
      labels:
        app: obs-deployment-example
    spec:
      containers:
      - image: nginx
        name: container-0
        volumeMounts:
        - mountPath: /tmp                     # PVC mount path, which can be customized as required
          name: pvc-obs-example
      restartPolicy: Always
      imagePullSecrets:
        - name: default-secret
      volumes:
      - name: pvc-obs-example
        persistentVolumeClaim:
          claimName: pvc-test-abc             # PVC name
```

Create the workload named **obs-deployment-example** using **obs_deployment_example.yaml**.

```
kubectl create -f obs_deployment_example.yaml
```

Check whether the workload has been created.

```
kubectl get pod
```

If information similar to the following is displayed and the workload is in the **Running** state, the workload has been created.

```
NAME                                  READY   STATUS             RESTARTS       AGE
obs-deployment-example-6b4dfd7b57-frfxv   1/1     Running            0              22h
```

----End

Step 3: Check the Pod Actions on the OBS Bucket

Check whether the pod created by account B has the required permissions based on the bucket policy.

Step 1 Check whether the pod can read and write objects in the OBS bucket created by account A and assume that a **test.txt** file is present in the OBS bucket.

Run the following command to access the created workload. (You can press **Ctrl**+**D** to exit the current workload.)

```
kubectl -n default exec -it obs-deployment-example-6b4dfd7b57-frfxv -c container-0 /bin/bash
```

Run the following command to check the pod actions on **test.txt**. **/tmp** specifies the PVC mount path.

```
ls -l /tmp/test.txt
```

If information similar to the following is displayed, the pod has the read and write permissions on the **test.txt** file, which is related to the bucket policy set by account A.

```
-rwxrwxrwx 1 root root 4 Sep  5 09:09 /tmp/test.txt
```

Step 2 Check whether the pod can read and write data from and to the objects uploaded by itself in the OBS bucket.

Create a **test01.txt** file in **/tmp** and write **test\n** into the file.

```
echo -e "test|n" > /tmp/test01.txt
```

Run the following command to check the **test01.txt** content and check whether the pod can read and write new objects uploaded by itself: (Account A can check the new objects in the OBS bucket.)

```
cat /tmp/test01.txt
```

If information similar the following is displayed, the pod has the read and write permissions on the objects uploaded by itself.

```
test
```

----End

Step 4: Clear Resources

Once you have studied this example, delete any associated resources to prevent incurring settlement fees. If you plan to learn other examples, wait until they are finished before doing any clean-up.

Step 1 Run the following command to delete the workload:

```
kubectl delete -f obs_deployment_example.yaml
```

Information similar to the following is displayed:

```
deployment.apps "obs-deployment-example" deleted
```

Step 2 Run the following command to delete the PVC:

```
kubectl delete -f pvc_test_abc.yaml
```

Information similar to the following is displayed:

```
persistentvolumeclaim "pvc-test-abc" deleted
```


Step 3 Run the following command to delete the PV:

```
kubectl delete -f testing_abc.yaml
```

Information similar to the following is displayed:

```
persistentvolume "testing-abc" deleted
```

Step 4 Run the following command to delete the secret:

```
kubectl delete -f test_user.yaml
```

Information similar to the following is displayed:

```
secret "test-user" deleted
```

Step 5 Run the following command to delete the ConfigMap:

```
kubectl delete -f config.yaml
```

Information similar to the following is displayed:

```
configmap "paas-obs-endpoint" deleted
```

----End

Common Issues

If a workload fails to be created, locate the fault based on the error information in the pod events. For details, see **Table 11-7**. If the problem persists, **create a service ticket** to contact customer service for help.

Table 11-7 Locating the fault

Error	Possible Cause	Fault Locating

0/4 nodes are available: pod has unbound immediate PersistentVolumeClaims. preemption: 0/4 nodes are available: 4 Preemption is not helpful for scheduling.	The PVC is not bound to any PV.	1. Run the following command to check the PVC status:
		`kubectl get pv`
		If the PVC is in the **Pending** state, it is not bound to any PV.
		2. Check the PVC details and locate the cause of the binding failure.
		`kubectl describe pv <pv_name>`
		3. Modify the YAML file to rectify the fault if the fault is caused by any of the following reasons:
		• The PVC is not bound to the proper PV.
		• The PVC and PV parameters do not match. This includes **fsType**, **StorageClass**, **accessModes**, and **storage**. The **StorageClass** must be object storage, and **accessModes** must be set to **ReadWriteMany** because OBS buckets only support this mode. Additionally, the **storage** value requested by the PVC must be equal to or less than the **storage** value provided by the PV.

Error	Possible Cause	Fault Locating
MountVolume.SetUp failed for volume *"obs-cce-example"*: rpc error: code = Unknown desc = failed to get secret(paas.longaksk), err: get secret(paas.longaksk) failed: get secret paas.longaksk from namespace kube-system failed: secrets "paas.longaksk" not found	The required secret cannot be found when the storage volume is mounted to the workload.	1. Check whether the mounted secret is present. `kubectl get secret` If it is present, the secret may be incorrectly configured. If it is not present, you can create one by referring to **Step 2**. 2. Check the secret parameter configurations. The following shows the common issues: • The **access.key** and **secret.key** parameters are not set to the AK and SK encoded using Base64. • The **type** parameter is not set to **cfe/secure-opaque**.
MountVolume.SetUp failed for volume *"pv-obs-example"*: rpc error: code = Internal desc = [8032c354-4e1b-41b0-81ce-9d4b3f8c49c9] get obsUrl failed before mount bucket obs-cce-example, get configMap paas-obs-endpoint from namespace kube-system failed: configmaps "paas-obs-endpoint" not found	The ConfigMap that stores the OBS endpoint is not present or is incorrectly configured.	1. Check whether the ConfigMap is present. `kubectl get configmap` If it is present, the ConfigMap may be incorrectly configured. If it is not present, you can create one by referring to **Step 1**. 2. Check the ConfigMap parameter configurations. The following shows the common issues: • The **name** parameter is not set to **paas-obs-endpoint**. • The **namespace** parameter is not set to **kube-system**. • The region name is not set to the region where the OBS bucket is located.

11.3 Dynamically Creating an SFS Turbo Subdirectory Using StorageClass

Background

The minimum capacity of an SFS Turbo file system is 500 GiB, and the SFS Turbo file system cannot be billed by usage. By default, the root directory of an SFS Turbo file system is mounted to a container which, in most case, does not require such a large capacity.

The everest add-on allows you to dynamically create subdirectories in an SFS Turbo file system and mount these subdirectories to containers. In this way, an SFS Turbo file system can be shared by multiple containers to increase storage efficiency.

Notes and Constraints

- Only clusters of v1.15 or later are supported.
- The cluster must use the everest add-on of version 1.1.13 or later.
- Kata containers are not supported.
- When the everest add-on earlier than 1.2.69 or 2.1.11 is used, a maximum of 10 PVCs can be created concurrently at a time by using the subdirectory function. everest of 1.2.69 or later or of 2.1.11 or later is recommended.
- A subPath volume is a subdirectory of an SFS Turbo file system. Increasing the capacity of a PVC of this type only changes the resource range specified by the PVC, but does not change the total capacity of the SFS Turbo file system. If the SFS Turbo file system's total resource capacity is not enough, the available capacity of the subPath volume will be restricted. To fix this, you must increase the resource capacity of the SFS Turbo file system on the SFS Turbo console.

  Deleting the subPath volume does not result in the deletion of the resources of the SFS Turbo file system.

Creating an SFS Turbo Volume of the subPath Type

Step 1 Create an SFS Turbo file system in the same VPC and subnet as the cluster.

Step 2 Create a YAML file of StorageClass, for example, **sfsturbo-subpath-sc.yaml**.

The following is an example:

```
apiVersion: storage.k8s.io/v1
allowVolumeExpansion: true
kind: StorageClass
metadata:
  name: sfsturbo-subpath-sc # Storage class name
mountOptions:  #Mount options
- lock
parameters:
  csi.storage.k8s.io/csi-driver-name: sfsturbo.csi.everest.io
  csi.storage.k8s.io/fstype: nfs
  everest.io/archive-on-delete: "true"
  everest.io/share-access-to: 7ca2dba2-1234-1234-1234-626371a8fb3a
```



```
  everest.io/share-expand-type: bandwidth
  everest.io/share-export-location: 192.168.1.1:/sfsturbo/  # Mount directory configuration
  everest.io/share-source: sfs-turbo
  everest.io/share-volume-type: STANDARD
  everest.io/volume-as: subpath
  everest.io/volume-id: 0d773f2e-1234-1234-1234-de6a35074696  # ID of an SFS Turbo volume
provisioner: everest-csi-provisioner
reclaimPolicy: Delete
volumeBindingMode: Immediate
```

In this example:

- **name**: indicates the name of the StorageClass.
- **mountOptions**: indicates the mount options. This field is optional.
  - In versions later than everest 1.1.13 and earlier than everest 1.2.8, only the **nolock** parameter can be configured. By default, the **nolock** parameter is used for the mount operation and does not need to be configured. If **nolock** is set to **false**, the **lock** field is used.
  - Starting from everest 1.2.8, more mount options are supported. For details, see **Configuring SFS Turbo Mount Options**. **Do not set nolock to true. Otherwise, the mount operation will fail.**

    ```
    mountOptions:
    - vers=3
    - timeo=600
    - nolock
    - hard
    ```
- **everest.io/volume-as**: This parameter is set to **subpath** to use the subPath volume.
- **everest.io/share-access-to**: This parameter is optional. In a subPath volume, set this parameter to the ID of the VPC where the SFS Turbo file system is located.
- **everest.io/share-expand-type**: This parameter is optional. If the type of the SFS Turbo file system is SFS Turbo Standard – Enhanced or SFS Turbo Performance – Enhanced, set this parameter to **bandwidth**.
- **everest.io/share-export-location**: This parameter indicates the mount directory. It consists of the SFS Turbo shared path and sub-directory. The shared path can be obtained on the SFS Turbo console. The sub-directory is user-defined. The PVCs created using the StorageClass are located in this sub-directory.
- **everest.io/share-volume-type**: This parameter is optional. It specifies the SFS Turbo file system type. The value can be **STANDARD** or **PERFORMANCE**. For enhanced types, this parameter must be used together with **everest.io/share-expand-type** (whose value should be **bandwidth**).
- **everest.io/zone**: This parameter is optional. Set it to the AZ where the SFS Turbo file system is located.
- **everest.io/volume-id**: This parameter indicates the ID of the SFS Turbo volume. You can obtain the volume ID on the SFS Turbo page.
- **everest.io/archive-on-delete**: If this parameter is set to **true** and **Delete** is selected for **Reclaim Policy**, the original documents of the PV will be archived to the directory named **archived-***{$PV name.timestamp}* before the PVC is deleted. If this parameter is set to **false**, the SFS Turbo subdirectory of the corresponding PV will be deleted. The default value is **true**, indicating that the original documents of the PV will be archived to the directory named **archived-***{$PV name.timestamp}* before the PVC is deleted.

Step 3 Run **kubectl create -f sfsturbo-subpath-sc.yaml**.

Step 4 Create a PVC YAML file named **sfs-turbo-test.yaml**.

The following is an example:

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: sfs-turbo-test  # PVC name
  namespace: default
spec:
  accessModes:
  - ReadWriteMany
  resources:
    requests:
      storage: 50Gi
  storageClassName: sfsturbo-subpath-sc  # Storage class name
  volumeMode: Filesystem
```

In this example:

- **name**: indicates the name of the PVC.
- **storageClassName**: specifies the name of the StorageClass.
- **storage**: In a subPath volume, modifying the value of this parameter does not impact the resource capacity of the SFS Turbo file system. A subPath volume is essentially a file path within an SFS Turbo file system. As a result, increasing the capacity of the subPath volume in a PVC does not lead to an increase in the resources of the SFS Turbo file system.

  NOTE

  The capacity of a subPath volume is restricted by the overall resource capacity of the corresponding SFS Turbo file system. If the resources of the SFS Turbo file system are inadequate, you can adjust the resource capacity via the SFS Turbo console.

Step 5 Run **kubectl create -f sfs-turbo-test.yaml**.

----End

Creating a Deployment and Mounting an Existing Volume

Step 1 Create a YAML file for the Deployment, for example, **deployment-test.yaml**.

The following is an example:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: test-turbo-subpath-example   # Name of the created workload
  namespace: default
  generation: 1
  labels:
    appgroup: ''
spec:
  replicas: 1
  selector:
    matchLabels:
      app: test-turbo-subpath-example
  template:
    metadata:
      labels:
        app: test-turbo-subpath-example
    spec:
      containers:
```



```
    - image: nginx:latest  # Image of the workload
      name: container-0
      volumeMounts:
      - mountPath: /tmp   #Mount path in a container
        name: pvc-sfs-turbo-example
    restartPolicy: Always
    imagePullSecrets:
    - name: default-secret
    volumes:
    - name: pvc-sfs-turbo-example
      persistentVolumeClaim:
        claimName: sfs-turbo-test   # Name of an existing PVC
```

In this example:

- **name**: indicates the name of the created workload.
- **image**: specifies the image used by the workload.
- **mountPath**: indicates the mount path of the container. In this example, the volume is mounted to the **/tmp** directory.
- **claimName**: indicates the name of an existing PVC.

Step 2 Create the Deployment.

kubectl create -f deployment-test.yaml

----End

Dynamically Creating a subPath Volume for a StatefulSet

Step 1 Create a YAML file for a StatefulSet, for example, **statefulset-test.yaml**.

The following is an example:

```
apiVersion: apps/v1
kind: StatefulSet
metadata:
  name: test-turbo-subpath # Name of the created workload
  namespace: default
  generation: 1
  labels:
    appgroup: ''
spec:
  replicas: 2
  selector:
    matchLabels:
      app: test-turbo-subpath
  template:
    metadata:
      labels:
        app: test-turbo-subpath
      annotations:
        metrics.alpha.kubernetes.io/custom-endpoints: '[{"api":"","path":"","port":"","names":""}]'
        pod.alpha.kubernetes.io/initialized: 'true'
    spec:
      containers:
        - name: container-0
          image: 'nginx:latest'  # Image of the workload
          resources: {}
          volumeMounts:
            - name: sfs-turbo-160024548582479676
              mountPath: /tmp  # Mount path in a container
          terminationMessagePath: /dev/termination-log
          terminationMessagePolicy: File
          imagePullPolicy: IfNotPresent
      restartPolicy: Always
```



```
    terminationGracePeriodSeconds: 30
    dnsPolicy: ClusterFirst
    securityContext: {}
    imagePullSecrets:
      - name: default-secret
    affinity: {}
    schedulerName: default-scheduler
volumeClaimTemplates:
  - metadata:
      name: sfs-turbo-160024548582479676
      namespace: default
      annotations: {}
    spec:
      accessModes:
        - ReadWriteMany
      resources:
        requests:
          storage: 10Gi
      storageClassName: sfsturbo-subpath-sc # Enter the name of a self-managed storage class.
serviceName: wwww
podManagementPolicy: OrderedReady
updateStrategy:
  type: RollingUpdate
revisionHistoryLimit: 10
```

In this example:

- **name**: indicates the name of the created workload.
- **image**: specifies the image used by the workload.
- **mountPath**: indicates the mount path of the container. In this example, the volume is mounted to the **/tmp** directory.
- **spec.template.spec.containers.volumeMounts.name** and **spec.volumeClaimTemplates.metadata.name**: must be consistent because they have a mapping relationship.
- **storageClassName**: specifies the name of an on-premises StorageClass.

Step 2 Create the StatefulSet.

kubectl create -f statefulset-test.yaml

----End

11.4 Changing the Storage Class Used by a Cluster of v1.15 from FlexVolume to CSI Everest

In clusters later than v1.15.11-r1, CSI (the everest add-on) has taken over all functions of fuxi FlexVolume (the storage-driver add-on) for managing container storage. You are advised to use CSI Everest.

To migrate your storage volumes, create a static PV to associate with the original underlying storage, and then create a PVC to associate with this static PV. When you upgrade your application, mount the new PVC to the original mounting path to migrate the storage volumes.

WARNING

Services will be interrupted during the migration. Therefore, properly plan the migration and back up data.

Procedure

Step 1 (Optional) Back up data to prevent data loss in case of exceptions.

Step 2 Configure a YAML file of the PV in the CSI format according to the PV in the FlexVolume format and associate the PV with the existing storage.

To be specific, run the following commands to configure the pv-example.yaml file, which is used to create a PV.

touch pv-example.yaml

vi pv-example.yaml

Configuration example of **a PV for an EVS volume**:

```
apiVersion: v1
kind: PersistentVolume
metadata:
  labels:
    failure-domain.beta.kubernetes.io/region: ap-southeast-1
    failure-domain.beta.kubernetes.io/zone: <zone name>
  annotations:
    pv.kubernetes.io/provisioned-by: everest-csi-provisioner
  name: pv-evs-example
spec:
  accessModes:
  - ReadWriteOnce
  capacity:
    storage: 10Gi
  csi:
    driver: disk.csi.everest.io
    fsType: ext4
    volumeAttributes:
      everest.io/disk-mode: SCSI
      everest.io/disk-volume-type: SAS
      storage.kubernetes.io/csiProvisionerIdentity: everest-csi-provisioner
    volumeHandle: 0992dbda-6340-470e-a74e-4f0db288ed82
  persistentVolumeReclaimPolicy: Delete
  storageClassName: csi-disk
```

Pay attention to the fields in bold and red. The parameters are described as follows:

Table 11-8 EVS volume configuration parameters

Parameter	Description
failure-domain.beta.kubernetes.io/region	Region where the EVS disk is located. Use the same value as that of the FlexVolume PV.
failure-domain.beta.kubernetes.io/zone	AZ where the EVS disk is located. Use the same value as that of the FlexVolume PV.
name	Name of the PV, which must be unique in the cluster.
storage	EVS volume capacity in the unit of Gi. Use the value of **spec.capacity.storage** of the FlexVolume PV.

Parameter	Description
driver	Storage driver used to attach the volume. Set the driver to **disk.csi.everest.io** for the EVS volume.
volumeHandle	Volume ID of the EVS disk. Use the value of **spec.flexVolume.options.volumeID** of the FlexVolume PV.
everest.io/disk-mode	EVS disk mode. Use the value of **spec.flexVolume.options.disk-mode** of the FlexVolume PV.
everest.io/disk-volume-type	EVS disk type. Currently, high I/O (SAS) and ultra-high I/O (SSD) are supported. Use the value of **kubernetes.io/volumetype** in the storage class corresponding to **spec.storageClassName** of the FlexVolume PV.
storageClassName	Name of the Kubernetes storage class associated with the storage volume. Set this field to **csi-disk** for EVS disks.

Configuration example of **a PV for an SFS volume**:

```
apiVersion: v1
kind: PersistentVolume
metadata:
  name: pv-sfs-example
  annotations:
    pv.kubernetes.io/provisioned-by: everest-csi-provisioner
spec:
  accessModes:
  - ReadWriteMany
  capacity:
    storage: 10Gi
  csi:
    driver: nas.csi.everest.io
    fsType: nfs
    volumeAttributes:
      everest.io/share-export-location: sfs-nas01.ap-southeast-1.myhuaweicloud.com:/share-436304e8
      storage.kubernetes.io/csiProvisionerIdentity: everest-csi-provisioner
    volumeHandle: 682f00bb-ace0-41d8-9b3e-913c9aa6b695
  persistentVolumeReclaimPolicy: Delete
  storageClassName: csi-nas
```

Pay attention to the fields in bold and red. The parameters are described as follows:

Table 11-9 SFS volume configuration parameters

Parameter	Description
name	Name of the PV, which must be unique in the cluster.
storage	File storage size in the unit of Gi. Use the value of **spec.capacity.storage** of the FlexVolume PV.
driver	Storage driver used to attach the volume. Set the driver to **nas.csi.everest.io** for the file system.

Parameter	Description
everest.io/share-export-location	Shared path of the file system. Use the value of **spec.flexVolume.options.deviceMountPath** of the FlexVolume PV.
volumeHandle	File system ID. Use the value of **spec.flexVolume.options.volumeID** of the FlexVolume PV.
storageClassName	Name of the Kubernetes storage class. Set this field to **csi-nas**.

Configuration example of **a PV for an OBS volume**:

```
apiVersion: v1
kind: PersistentVolume
metadata:
  name: pv-obs-example
  annotations:
    pv.kubernetes.io/provisioned-by: everest-csi-provisioner
spec:
  accessModes:
  - ReadWriteMany
  capacity:
    storage: 1Gi
  csi:
    driver: obs.csi.everest.io
    fsType: s3fs
    volumeAttributes:
      everest.io/obs-volume-type: STANDARD
      everest.io/region: ap-southeast-1
      storage.kubernetes.io/csiProvisionerIdentity: everest-csi-provisioner
    volumeHandle: obs-normal-static-pv
  persistentVolumeReclaimPolicy: Delete
  storageClassName: csi-obs
```

Pay attention to the fields in bold and red. The parameters are described as follows:

Table 11-10 OBS volume configuration parameters

Parameter	Description
name	Name of the PV, which must be unique in the cluster.
storage	Storage capacity, in the unit of Gi. Set this parameter to the fixed value **1Gi**.
driver	Storage driver used to attach the volume. Set the driver to **obs.csi.everest.io** for the OBS volume.

Parameter	Description
fsType	File type. Value options are **obsfs** or **s3fs**. If the value is **s3fs**, an OBS bucket is created and mounted using s3fs. If the value is **obsfs**, an OBS parallel file system is created and mounted using obsfs. Set this parameter according to the value of **spec.flexVolume.options.posix** of the FlexVolume PV. If the value of **spec.flexVolume.options.posix** is **true**, set this parameter to **obsfs**. If the value is **false**, set this parameter to **s3fs**.
everest.io/obs-volume-type	Storage class, including **STANDARD** (standard bucket) and **WARM** (infrequent access bucket). Set this parameter according to the value of **spec.flexVolume.options.storage_class** of the FlexVolume PV. If the value of **spec.flexVolume.options.storage_class** is **standard**, set this parameter to **STANDARD**. If the value is **standard_ia**, set this parameter to **WARM**.
everest.io/region	Region where the OBS bucket is located. Use the value of **spec.flexVolume.options.region** of the FlexVolume PV.
volumeHandle	OBS bucket name. Use the value of **spec.flexVolume.options.volumeID** of the FlexVolume PV.
storageClassName	Name of the Kubernetes storage class. Set this field to **csi-obs**.

Configuration example of **a PV for an SFS Turbo volume**:

```
apiVersion: v1
kind: PersistentVolume
metadata:
  name: pv-efs-example
  annotations:
    pv.kubernetes.io/provisioned-by: everest-csi-provisioner
spec:
  accessModes:
  - ReadWriteMany
  capacity:
    storage: 10Gi
  csi:
    driver: sfsturbo.csi.everest.io
    fsType: nfs
    volumeAttributes:
      everest.io/share-export-location: 192.168.0.169:/
      storage.kubernetes.io/csiProvisionerIdentity: everest-csi-provisioner
    volumeHandle: 8962a2a2-a583-4b7f-bb74-fe76712d8414
  persistentVolumeReclaimPolicy: Delete
  storageClassName: csi-sfsturbo
```

Pay attention to the fields in bold and red. The parameters are described as follows:

Table 11-11 SFS Turbo volume configuration parameters

Parameter	Description
name	Name of the PV, which must be unique in the cluster.
storage	File system size. Use the value of **spec.capacity.storage** of the FlexVolume PV.
driver	Storage driver used to attach the volume. Set it to **sfsturbo.csi.everest.io**.
everest.io/share-export-location	Shared path of the SFS Turbo volume. Use the value of **spec.flexVolume.options.deviceMountPath** of the FlexVolume PV.
volumeHandle	SFS Turbo volume ID. Use the value of **spec.flexVolume.options.volumeID** of the FlexVolume PV.
storageClassName	Name of the Kubernetes storage class. Set this field to **csi-sfsturbo** for SFS Turbo volumes.

Step 3 Configure a YAML file of the PVC in the CSI format according to the PVC in the FlexVolume format and associate the PVC with the PV created in **Step 2**.

To be specific, run the following commands to configure the pvc-example.yaml file, which is used to create a PVC.

touch pvc-example.yaml

vi pvc-example.yaml

Configuration example of **a PVC for an EVS volume**:

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  labels:
    failure-domain.beta.kubernetes.io/region: ap-southeast-1
    failure-domain.beta.kubernetes.io/zone: <zone name>
  annotations:
    everest.io/disk-volume-type: SAS
    volume.beta.kubernetes.io/storage-provisioner: everest-csi-provisioner
  name: pvc-evs-example
  namespace: default
spec:
  accessModes:
  - ReadWriteOnce
  resources:
    requests:
      storage: 10Gi
  volumeName:  pv-evs-example
  storageClassName: csi-disk
```

Pay attention to the fields in bold and red. The parameters are described as follows:

Table 11-12 PVC configuration parameters for an EVS volume

Parameter	Description
failure-domain.beta.kubernetes.io/region	Region where the cluster is located. Use the same value as that of the FlexVolume PVC.
failure-domain.beta.kubernetes.io/zone	AZ where the EVS disk is deployed. Use the same value as that of the FlexVolume PVC.
everest.io/disk-volume-type	Storage class of the EVS disk. The value can be **SAS** or **SSD**. Set this parameter to the same value as that of the PV created in **Step 2**.
name	PVC name, which must be unique in the namespace. The value must be unique in the namespace. (If the PVC is dynamically created by a stateful application, the value of this parameter must be the same as the name of the FlexVolume PVC.)
namespace	Namespace to which the PVC belongs. Use the same value as that of the FlexVolume PVC.
storage	Requested capacity of the PVC, which must be the same as the storage size of the existing PV.
volumeName	Name of the PV. Set this parameter to the name of the static PV in **Step 2**.
storageClassName	Name of the Kubernetes storage class. Set this field to **csi-disk** for EVS disks.

Configuration example of **a PVC for an SFS volume**:

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  annotations:
    volume.beta.kubernetes.io/storage-provisioner: everest-csi-provisioner
  name: pvc-sfs-example
  namespace: default
spec:
  accessModes:
  - ReadWriteMany
  resources:
    requests:
      storage: 10Gi
  storageClassName: csi-nas
  volumeName: pv-sfs-example
```

Pay attention to the fields in bold and red. The parameters are described as follows:

Table 11-13 PVC configuration parameters for an SFS volume

Parameter	Description
name	PVC name, which must be unique in the namespace. The value must be unique in the namespace. (If the PVC is dynamically created by a stateful application, the value of this parameter must be the same as the name of the FlexVolume PVC.)
namespace	Namespace to which the PVC belongs. Use the same value as that of the FlexVolume PVC.
storage	Storage capacity, in the unit of Gi. The value must be the same as the storage size of the existing PV.
storageClassName	Set this field to **csi-nas**.
volumeName	Name of the PV. Set this parameter to the name of the static PV in **Step 2**.

Configuration example of **a PVC for an OBS volume**:

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  annotations:
    volume.beta.kubernetes.io/storage-provisioner: everest-csi-provisioner
    everest.io/obs-volume-type: STANDARD
    csi.storage.k8s.io/fstype: s3fs
  name: pvc-obs-example
  namespace: default
spec:
  accessModes:
  - ReadWriteMany
  resources:
    requests:
      storage: 1Gi
  storageClassName: csi-obs
  volumeName: pv-obs-example
```

Pay attention to the fields in bold and red. The parameters are described as follows:

Table 11-14 PVC configuration parameters for an OBS volume

Parameter	Description
everest.io/obs-volume-type	OBS volume type, which can be **STANDARD** (standard bucket) and **WARM** (infrequent access bucket). Set this parameter to the same value as that of the PV created in **Step 2**.
csi.storage.k8s.io/fstype	File type, which can be **obsfs** or **s3fs**. The value must be the same as that of **fsType** of the static OBS volume PV.

Parameter	Description
name	PVC name, which must be unique in the namespace. The value must be unique in the namespace. (If the PVC is dynamically created by a stateful application, the value of this parameter must be the same as the name of the FlexVolume PVC.)
namespace	Namespace to which the PVC belongs. Use the same value as that of the FlexVolume PVC.
storage	Storage capacity, in the unit of Gi. Set this parameter to the fixed value **1Gi**.
storageClassName	Name of the Kubernetes storage class. Set this field to **csi-obs**.
volumeName	Name of the PV. Set this parameter to the name of the static PV created in **Step 2**.

Configuration example of **a PVC for an SFS Turbo volume**:

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  annotations:
    volume.beta.kubernetes.io/storage-provisioner: everest-csi-provisioner
  name: pvc-efs-example
  namespace: default
spec:
  accessModes:
  - ReadWriteMany
  resources:
    requests:
      storage: 10Gi
  storageClassName: csi-sfsturbo
  volumeName: pv-efs-example
```

Pay attention to the fields in bold and red. The parameters are described as follows:

Table 11-15 PVC configuration parameters for an SFS Turbo volume

Parameter	Description
name	PVC name, which must be unique in the namespace. The value must be unique in the namespace. (If the PVC is dynamically created by a stateful application, the value of this parameter must be the same as the name of the FlexVolume PVC.)
namespace	Namespace to which the PVC belongs. Use the same value as that of the FlexVolume PVC.
storageClassName	Name of the Kubernetes storage class. Set this field to **csi-sfsturbo**.

Parameter	Description
storage	Storage capacity, in the unit of Gi. The value must be the same as the storage size of the existing PV.
volumeName	Name of the PV. Set this parameter to the name of the static PV created in **Step 2**.

Step 4 Upgrade the workload to use a new PVC.

For Deployments

1. Run the **kubectl create -f** commands to create a PV and PVC.

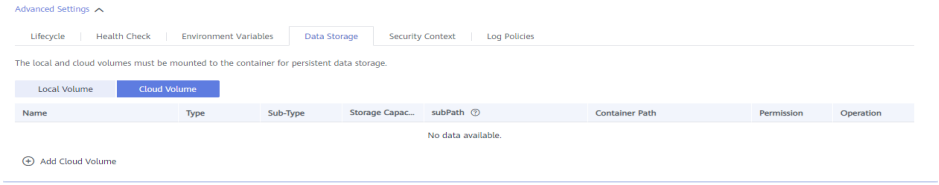
   kubectl create -f pv-example.yaml

   kubectl create -f pvc-example.yaml

   NOTE

   Replace the example file name **pvc-example.yaml** in the preceding commands with the names of the YAML files configured in **Step 2** and **Step 3**.

2. Go to the CCE console. On the workload upgrade page, click **Upgrade** > **Advanced Settings** > **Data Storage** > **Cloud Storage**.



3. Uninstall the old storage and add the PVC in the CSI format. Retain the original mounting path in the container.
4. Click **Submit**.
5. Wait until the pods are running.

For StatefulSets that use existing storage

1. Run the **kubectl create -f** commands to create a PV and PVC.

   kubectl create -f pv-example.yaml

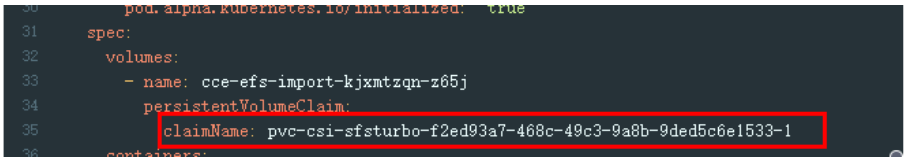
   kubectl create -f pvc-example.yaml

   NOTE

   Replace the example file name **pvc-example.yaml** in the preceding commands with the names of the YAML files configured in **Step 2** and **Step 3**.

2. Run the **kubectl edit** command to edit the StatefulSet and use the newly created PVC.

   kubectl edit sts sts-example -n xxx



NOTE

Replace **sts-example** in the preceding command with the actual name of the StatefulSet to upgrade. **xxx** indicates the namespace to which the StatefulSet belongs.

3. Wait until the pods are running.

NOTE

The current console does not support the operation of adding new cloud storage for StatefulSets. Use the kubectl commands to replace the storage with the newly created PVC.

For StatefulSets that use dynamically allocated storage

1. Back up the PV and PVC in the flexVolume format used by the StatefulSet.
   kubectl get pvc xxx -n {namespaces} -oyaml > pvc-backup.yaml
   kubectl get pv xxx -n {namespaces} -oyaml > pv-backup.yaml
2. Change the number of pods to **0**.
3. On the storage page, disassociate the flexVolume PVC used by the StatefulSet.
4. Run the **kubectl create -f** commands to create a PV and PVC.
   kubectl create -f pv-example.yaml
   kubectl create -f pvc-example.yaml

   NOTE

   Replace the example file name **pvc-example.yaml** in the preceding commands with the names of the YAML files configured in **Step 2** and **Step 3**.
5. Change the number of pods back to the original value and wait until the pods are running.

NOTE

The dynamic allocation of storage for StatefulSets is achieved by using **volumeClaimTemplates**. This field cannot be modified by Kubernetes. Therefore, data cannot be migrated by using a new PVC.

The PVC naming rule of the **volumeClaimTemplates** is fixed. When a PVC that meets the naming rule exists, this PVC is used.

Therefore, disassociate the original PVC first and then create a PVC with the same name in the CSI format.

6. (Optional) Recreate the stateful application to ensure that a CSI PVC is used when the application is scaled out. Otherwise, FlexVolume PVCs are used in scaling out.

- Run the following command to obtain the YAML file of the StatefulSet:

kubectl get sts xxx -n {namespaces} -oyaml > sts.yaml

- Run the following command to back up the YAML file of the StatefulSet:

cp sts.yaml sts-backup.yaml

- Modify the definition of **volumeClaimTemplates** in the YAML file of the StatefulSet.

vi sts.yaml

Configuration example of **volumeClaimTemplates for an EVS volume**:


```
volumeClaimTemplates:
  - metadata:
      name: pvc-161070049798261342
      namespace: default
      creationTimestamp: null
      annotations:
        everest.io/disk-volume-type: SAS
    spec:
      accessModes:
        - ReadWriteOnce
      resources:
        requests:
          storage: 10Gi
      storageClassName: csi-disk
```

The parameter value must be the same as the PVC of the EVS volume created in **Step 3**.

Configuration example of **volumeClaimTemplates for an SFS volume**:

```
volumeClaimTemplates:
  - metadata:
      name: pvc-161063441560279697
      namespace: default
      creationTimestamp: null
    spec:
      accessModes:
        - ReadWriteMany
      resources:
        requests:
          storage: 10Gi
      storageClassName: csi-nas
```

The parameter value must be the same as the PVC of the SFS volume created in **Step 3**.

Configuration example of **volumeClaimTemplates for an OBS volume**:

```
volumeClaimTemplates:
  - metadata:
      name: pvc-161070100417416148
      namespace: default
      creationTimestamp: null
      annotations:
        csi.storage.k8s.io/fstype: s3fs
        everest.io/obs-volume-type: STANDARD
    spec:
      accessModes:
        - ReadWriteMany
      resources:
        requests:
          storage: 1Gi
      storageClassName: csi-obs
```

The parameter value must be the same as the PVC of the OBS volume created in **Step 3**.

- Delete the StatefulSet.

kubectl delete sts xxx -n {namespaces}

- Create the StatefulSet.

kubectl create -f sts.yaml

Step 5 Check service functions.

1. Check whether the application is running properly.
2. Checking whether the data storage is normal.

NOTE

If a rollback is required, perform **Step 4**. Select the PVC in FlexVolume format and upgrade the application.

Step 6 Uninstall the PVC in the FlexVolume format.

If the application functions normally, unbind the PVC in the FlexVolume format on the storage management page.

You can also run the kubectl command to delete the PVC and PV of the FlexVolume format.

CAUTION

Before deleting a PV, change the persistentVolumeReclaimPolicy of the PV to **Retain**. Otherwise, the underlying storage will be reclaimed after the PV is deleted.

If the cluster has been upgraded before the storage migration, PVs may fail to be deleted. You can remove the PV protection field **finalizers** to delete PVs.

kubectl patch pv {pv_name} -p '{"metadata":{"finalizers":null}}'

----End

11.5 Using Custom Storage Classes

Background

When using storage resources in CCE, the most common method is to specify **storageClassName** to define the type of storage resources to be created when creating a PVC. The following configuration shows how to use a PVC to apply for an SAS (high I/O) EVS disk (block storage).

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: pvc-evs-example
  namespace: default
  annotations:
    everest.io/disk-volume-type: SAS
spec:
  accessModes:
  - ReadWriteOnce
  resources:
    requests:
      storage: 10Gi
  storageClassName: csi-disk
```

To specify the EVS disk type, you can configure the **everest.io/disk-volume-type** field. The value **SAS** is used as an example here, indicating the high I/O EVS disk type. Or you can choose **SSD** (ultra-high I/O).

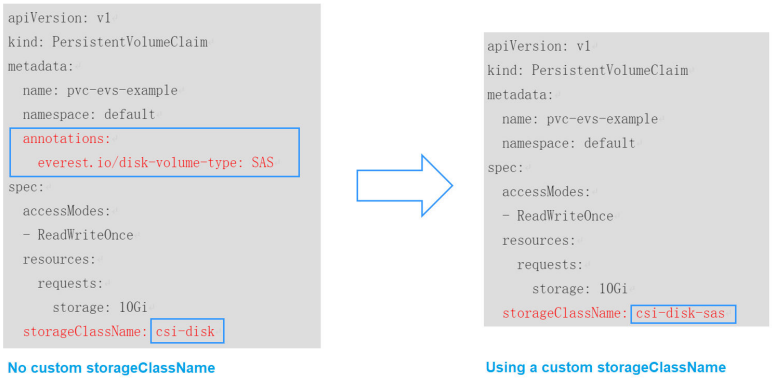
This configuration method may not work if you want to:

- Set **storageClassName** only, which is simpler than specifying the EVS disk type by using **everest.io/disk-volume-type**.
- Avoid modifying YAML files or Helm charts. Some users switch from self-built or other Kubernetes services to CCE and have written YAML files of many applications. In these YAML files, different types of storage resources are specified by different StorageClassNames. When using CCE, they need to modify a large number of YAML files or Helm charts to use storage resources, which is labor-consuming and error-prone.
- Set the default **storageClassName** for all applications to use the default storage class. In this way, you can create storage resources of the default type without needing to specify **storageClassName** in the YAML file.

Solution

This section describes how to set a custom storage class in CCE and how to set the default storage class. You can specify different types of storage resources by setting **storageClassName**.

- For the first scenario, you can define custom storageClassNames for SAS and SSD EVS disks. For example, define a storage class named **csi-disk-sas** for creating SAS disks. The following figure shows the differences before and after you use a custom storage class.



- For the second scenario, you can define a storage class with the same name as that in the existing YAML file without needing to modify **storageClassName** in the YAML file.
- For the third scenario, you can set the default storage class as described below to create storage resources without specifying **storageClassName** in YAML files.

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: pvc-evs-example
  namespace: default
spec:
  accessModes:
  - ReadWriteOnce
  resources:
    requests:
      storage: 10Gi
```


Creating a StorageClass Using a YAML File

As of now, CCE provides StorageClasses such as csi-disk, csi-nas, and csi-obs by default. When defining a PVC, you can use a **StorageClassName** to automatically create a PV of the corresponding type and automatically create underlying storage resources.

Run the following kubectl command to obtain the StorageClasses that CCE supports. Use the CSI add-on provided by CCE to create a StorageClass.

```
# kubectl get sc
NAME                PROVISIONER                     AGE
csi-disk            everest-csi-provisioner         17d         # EVS disk
csi-disk-topology   everest-csi-provisioner         17d         # EVS disks created with delay
csi-nas             everest-csi-provisioner         17d         # SFS 1.0
csi-sfs             everest-csi-provisioner         17d         # SFS 3.0
csi-obs             everest-csi-provisioner         17d         # OBS
csi-sfsturbo        everest-csi-provisioner         17d         # SFS Turbo
csi-local           everest-csi-provisioner         17d         # Local PV
csi-local-topology  everest-csi-provisioner         17d         # Local PV created with delay
```

Each StorageClass contains the default parameters used for dynamically creating a PV. The following is an example of StorageClass for EVS disks:

```
kind: StorageClass
apiVersion: storage.k8s.io/v1
metadata:
  name: csi-disk
provisioner: everest-csi-provisioner
parameters:
  csi.storage.k8s.io/csi-driver-name: disk.csi.everest.io
  csi.storage.k8s.io/fstype: ext4
  everest.io/disk-volume-type: SAS
  everest.io/passthrough: 'true'
reclaimPolicy: Delete
allowVolumeExpansion: true
volumeBindingMode: Immediate
```

Table 11-16 Key parameters

Parameter	Description
provisioner	Specifies the storage resource provider, which is the Everest add-on for CCE. Set this parameter to **everest-csi-provisioner**.
parameters	Specifies the storage parameters, which vary with storage types. For details, see **Table 11-17**.
reclaimPolicy	Specifies the value of **persistentVolumeReclaimPolicy** for creating a PV. The value can be **Delete** or **Retain**. If **reclaimPolicy** is not specified when a StorageClass object is created, the value defaults to **Delete**. • **Delete**: When a PVC is deleted, its associated underlying storage resources will be deleted and the PV resources will be removed. Exercise caution if you select this option. • **Retain**: When a PVC is deleted, both of the PV and its associated underlying storage resources will be retained and the PV is marked as released. If you manually delete the PV afterwards, the underlying storage resources will not be deleted. To bind the PV to a new PVC, you need to remove the original binding information from the PV.

Parameter	Description
allowVolumeExpansion	Specifies whether the PV of this StorageClass supports dynamic capacity expansion. The default value is **false**. Dynamic capacity expansion is implemented by the underlying storage add-on. This is only a switch.
volumeBindingMode	Specifies the volume binding mode, that is, the time when a PV is dynamically created. The value can be **Immediate** or **WaitForFirstConsumer**. • **Immediate**: After a PVC is created, the storage resources and PV will be created and associated with the PVC without delay. • **WaitForFirstConsumer**: After a PVC is created, it will not be immediately bound to a PV. Instead, the storage resources and PV will be generated and bound to the PVC only after the pod that requires the PVC is scheduled.
mountOptions	This field must be supported by the underlying storage. If this field is not supported but is specified, the PV creation will fail.

Table 11-17 Parameters

Volume Type	Parameter	Mandatory	Description
EVS	csi.storage.k8s.io/csi-driver-name	Yes	Driver type. If an EVS disk is used, the parameter value is fixed at **disk.csi.everest.io**.
	csi.storage.k8s.io/fstype	Yes	If an EVS disk is used, the parameter value can be **ext4**.
	everest.io/disk-volume-type	Yes	EVS disk type. All letters are in uppercase. • **SAS**: high I/O • **SSD**: ultra-high I/O • **GPSSD**: general-purpose SSD • **ESSD**: extreme SSD • **GPSSD2**: general-purpose SSD v2, which is supported when the Everest version is 2.4.4 or later and the **everest.io/disk-iops** and **everest.io/disk-throughput** annotations are configured
	everest.io/passthrough	Yes	The parameter value is fixed at **true**, which indicates that the EVS device type is **SCSI**. Other parameter values are not allowed.

Volume Type	Parameter	Mandatory	Description
	everest.io/disk-iops	No	Preconfigured IOPS, which is supported only by general-purpose SSD v2 and extreme SSD v2 EVS disks. • The IOPS of general-purpose SSD v2 EVS disks ranges from 3000 to 128000, and the maximum value is 500 times of the capacity (GiB). If the IOPS of general-purpose SSD v2 disks is greater than 3000, extra IOPS will be billed. For details, see **Price Calculator**. • The IOPS of extreme SSD v2 disks ranges from 100 to 256000, and the maximum value is 1000 times of the capacity (GiB). The IOPS of extreme SSD v2 disks will be billed separately. For details, see **Price Calculator**.
	everest.io/disk-throughput	No	Preconfigured throughput, which is supported only by general-purpose SSD v2 EVS disks. The value ranges from 125 MiB/s to 1000 MiB/s. The maximum value is a quarter of IOPS. If the throughput is greater than 125 MiB/s, extra throughput will be billed. For details, see **Price Calculator**.
SFS	csi.storage.k8s.io/csi-driver-name	Yes	Driver type. If SFS is used, the parameter value is fixed at **nas.csi.everest.io**.
	csi.storage.k8s.io/fstype	Yes	If SFS is used, the value can be **nfs**.
	everest.io/share-access-level	Yes	The parameter value is fixed at **rw**, indicating that the SFS data is readable and writable.
	everest.io/share-access-to	Yes	VPC ID of the cluster.
	everest.io/share-is-public	No	The parameter value is fixed at **false**, indicating that the file is shared to private. When you use SFS 3.0, there is no need to configure this parameter.

Volume Type	Parameter	Mandatory	Description
	everest.io/sfs-version	No	This parameter is only required for SFS 3.0 and its value is fixed at **sfs3.0**.
SFS Turbo	csi.storage.k8s.io/csi-driver-name	Yes	Driver type. If SFS Turbo is used, the parameter value is fixed at **sfsturbo.csi.everest.io**.
	csi.storage.k8s.io/fstype	Yes	If SFS Turbo is used, the value can be **nfs**.
	everest.io/share-access-to	Yes	VPC ID of the cluster.
	everest.io/share-expand-type	No	Extension type. The default value is **bandwidth**, indicating an enhanced file system. This parameter does not take effect.
	everest.io/share-source	Yes	The parameter value is fixed at **sfs-turbo**.
	everest.io/share-volume-type	No	SFS Turbo StorageClass. The default value is **STANDARD**, indicating standard and standard enhanced editions. This parameter does not take effect.
OBS	csi.storage.k8s.io/csi-driver-name	Yes	Driver type. If OBS is used, the parameter value is fixed at **obs.csi.everest.io**.
	csi.storage.k8s.io/fstype	Yes	Instance type, which can be **obsfs** or **s3fs**. • **obsfs**: a parallel file system • **s3fs**: object bucket
	everest.io/obs-volume-type	Yes	OBS StorageClass. • If **fsType** is set to **s3fs**, **STANDARD** (standard bucket) and **WARM** (infrequent access bucket) are supported. • This parameter is invalid when **fsType** is set to **obsfs**.

Custom Storage Classes

You can customize a high I/O storage class in a YAML file. For example, the name **csi-disk-sas** indicates that the disk type is SAS (high I/O).

```
apiVersion: storage.k8s.io/v1
kind: StorageClass
```



```
metadata:
  name: csi-disk-sas                    # Name of the high I/O storage class, which can be customized.
parameters:
  csi.storage.k8s.io/csi-driver-name: disk.csi.everest.io
  csi.storage.k8s.io/fstype: ext4
  everest.io/disk-volume-type: SAS          # High I/O EVS disk type, which cannot be customized.
  everest.io/passthrough: "true"
provisioner: everest-csi-provisioner
reclaimPolicy: Delete
volumeBindingMode: Immediate
allowVolumeExpansion: true                  # true indicates that capacity expansion is allowed.
```

For an ultra-high I/O storage class, you can set the class name to **csi-disk-ssd** to create SSD EVS disk (ultra-high I/O).

```
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: csi-disk-ssd                  # Name of the ultra-high I/O storage class, which can be customized.
parameters:
  csi.storage.k8s.io/csi-driver-name: disk.csi.everest.io
  csi.storage.k8s.io/fstype: ext4
  everest.io/disk-volume-type: SSD        # Ultra-high I/O EVS disk type, which cannot be customized.
  everest.io/passthrough: "true"
provisioner: everest-csi-provisioner
reclaimPolicy: Delete
volumeBindingMode: Immediate
allowVolumeExpansion: true
```

reclaimPolicy: indicates the recycling policies of the underlying cloud storage. The value can be **Delete** or **Retain**.

- **Delete**: When a PVC is deleted, both the PV and the EVS disk are deleted.
- **Retain**: When a PVC is deleted, the PV and underlying storage resources are not deleted. Instead, you must manually delete these resources. After that, the PV resource is in the **Released** state and cannot be bound to the PVC again.

NOTE

The reclamation policy configured here has no impact on the SFS Turbo storage and the subscribed SFS Turbo resources will not be reclaimed.

If high data security is required, you are advised to select **Retain** to prevent data from being deleted by mistake.

After the definition is complete, run the **kubectl create** commands to create storage resources.

```
# kubectl create -f sas.yaml
storageclass.storage.k8s.io/csi-disk-sas created
# kubectl create -f ssd.yaml
storageclass.storage.k8s.io/csi-disk-ssd created
```

Query the storage class again. Two more types of storage classes are displayed in the command output, as shown below.

```
# kubectl get sc
NAME                PROVISIONER                     AGE
csi-disk            everest-csi-provisioner         17d
csi-disk-sas        everest-csi-provisioner         2m28s
csi-disk-ssd        everest-csi-provisioner         16s
csi-disk-topology   everest-csi-provisioner         17d
csi-nas             everest-csi-provisioner         17d
csi-obs             everest-csi-provisioner         17d
csi-sfsturbo        everest-csi-provisioner         17d
```


Other types of storage resources can be defined in the similar way. You can use kubectl to obtain the YAML file and modify it as required.

- File storage

```
# kubectl get sc csi-nas -oyaml
kind: StorageClass
apiVersion: storage.k8s.io/v1
metadata:
  name: csi-nas
provisioner: everest-csi-provisioner
parameters:
  csi.storage.k8s.io/csi-driver-name: nas.csi.everest.io
  csi.storage.k8s.io/fstype: nfs
  everest.io/share-access-level: rw
  everest.io/share-access-to: 5e3864c6-e78d-4d00-b6fd-de09d432c632   # ID of the VPC to which the cluster belongs
  everest.io/share-is-public: 'false'
  everest.io/zone: xxxxx          # AZ
reclaimPolicy: Delete
allowVolumeExpansion: true
volumeBindingMode: Immediate
```

- Object storage

```
# kubectl get sc csi-obs -oyaml
kind: StorageClass
apiVersion: storage.k8s.io/v1
metadata:
  name: csi-obs
provisioner: everest-csi-provisioner
parameters:
  csi.storage.k8s.io/csi-driver-name: obs.csi.everest.io
  csi.storage.k8s.io/fstype: s3fs          # Object storage type. s3fs indicates an object bucket, and obsfs indicates a parallel file system.
  everest.io/obs-volume-type: STANDARD      # Storage class of the OBS bucket
reclaimPolicy: Delete
volumeBindingMode: Immediate
```

Specifying an Enterprise Project for Storage Classes

CCE allows you to specify an enterprise project when creating EVS disks and OBS PVCs. The created storage resources (EVS disks and OBS) belong to the specified enterprise project. **The enterprise project can be the enterprise project to which the cluster belongs or the default enterprise project.**

If you do not specify any enterprise project, the enterprise project in StorageClass is used by default. The created storage resources by using the csi-disk and csi-obs storage classes of CCE belong to the default enterprise project.

If you want the storage resources created from the storage classes to be in the same enterprise project as the cluster, you can customize a storage class and specify the enterprise project ID, as shown below.

NOTE

To use this function, the everest add-on must be upgraded to 1.2.33 or later.

```
kind: StorageClass
apiVersion: storage.k8s.io/v1
metadata:
  name: csi-disk-epid      #Customize a storage class name.
provisioner: everest-csi-provisioner
parameters:
  csi.storage.k8s.io/csi-driver-name: disk.csi.everest.io
  csi.storage.k8s.io/fstype: ext4
  everest.io/disk-volume-type: SAS
  everest.io/enterprise-project-id: 86bfc701-9d9e-4871-a318-6385aa368183  #Specify the enterprise project
```



```
ID.
  everest.io/passthrough: 'true'
reclaimPolicy: Delete
allowVolumeExpansion: true
volumeBindingMode: Immediate
```

Specifying a Default Storage Class

You can specify a storage class as the default class. In this way, if you do not specify **storageClassName** when creating a PVC, the PVC is created using the default storage class.

For example, to specify **csi-disk-ssd** as the default storage class, edit your YAML file as follows:

```
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: csi-disk-ssd
  annotations:
    storageclass.kubernetes.io/is-default-class: "true"   # Specifies the default storage class in a cluster. A
cluster can have only one default storage class.
parameters:
  csi.storage.k8s.io/csi-driver-name: disk.csi.everest.io
  csi.storage.k8s.io/fstype: ext4
  everest.io/disk-volume-type: SSD
  everest.io/passthrough: "true"
provisioner: everest-csi-provisioner
reclaimPolicy: Delete
volumeBindingMode: Immediate
allowVolumeExpansion: true
```

Delete the created csi-disk-ssd disk, run the **kubectl create** command to create a csi-disk-ssd disk again, and then query the storage class. The following information is displayed.

```
# kubectl delete sc csi-disk-ssd
storageclass.storage.k8s.io "csi-disk-ssd" deleted
# kubectl create -f ssd.yaml
storageclass.storage.k8s.io/csi-disk-ssd created
# kubectl get sc
NAME                PROVISIONER                AGE
csi-disk            everest-csi-provisioner    17d
csi-disk-sas        everest-csi-provisioner    114m
csi-disk-ssd (default)   everest-csi-provisioner    9s
csi-disk-topology   everest-csi-provisioner    17d
csi-nas             everest-csi-provisioner    17d
csi-obs             everest-csi-provisioner    17d
csi-sfsturbo        everest-csi-provisioner    17d
```

Verification

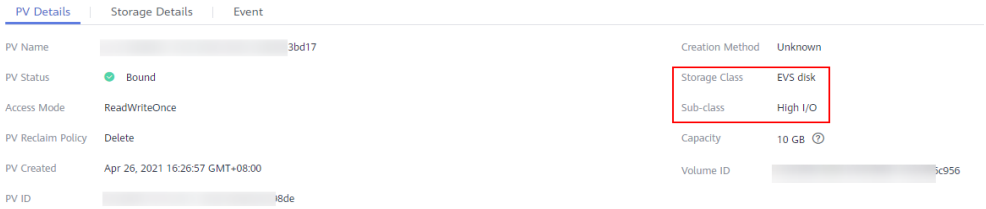
- Use **csi-disk-sas** to create a PVC.

  ```
  apiVersion: v1
  kind: PersistentVolumeClaim
  metadata:
    name:  sas-disk
  spec:
    accessModes:
    - ReadWriteOnce
    resources:
      requests:
        storage: 10Gi
    storageClassName: csi-disk-sas
  ```

  Create a storage class and view its details. As shown below, the object can be created and the value of **STORAGECLASS** is **csi-disk-sas**.


```
# kubectl create -f sas-disk.yaml
persistentvolumeclaim/sas-disk created
# kubectl get pvc
NAME       STATUS   VOLUME                                     CAPACITY   ACCESS MODES
STORAGECLASS   AGE
sas-disk   Bound    pvc-6e2f37f9-7346-4419-82f7-b42e79f7964c   10Gi       RWO           csi-disk-sas
24s
# kubectl get pv
NAME                                       CAPACITY   ACCESS MODES   RECLAIM POLICY   STATUS
CLAIM                  STORAGECLASS   REASON   AGE
pvc-6e2f37f9-7346-4419-82f7-b42e79f7964c   10Gi       RWO            Delete           Bound       default/
sas-disk         csi-disk-sas            30s
```

View the PVC details on the CCE console. On the PV details page, you can see that the disk type is high I/O.



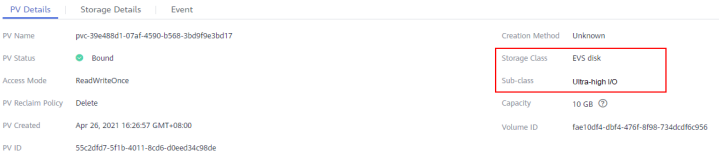
- If **storageClassName** is not specified, the default configuration is used, as shown below.

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name:  ssd-disk
spec:
  accessModes:
  - ReadWriteOnce
  resources:
    requests:
      storage: 10Gi
```

Create and view the storage resource. You can see that the storage class of PVC ssd-disk is csi-disk-ssd, indicating that csi-disk-ssd is used by default.

```
# kubectl create -f ssd-disk.yaml
persistentvolumeclaim/ssd-disk created
# kubectl get pvc
NAME       STATUS   VOLUME                                     CAPACITY   ACCESS MODES
STORAGECLASS   AGE
sas-disk   Bound    pvc-6e2f37f9-7346-4419-82f7-b42e79f7964c   10Gi       RWO           csi-disk-sas
16m
ssd-disk   Bound    pvc-4d2b059c-0d6c-44af-9994-f74d01c78731   10Gi       RWO           csi-disk-ssd
10s
# kubectl get pv
NAME                                       CAPACITY   ACCESS MODES   RECLAIM POLICY   STATUS
CLAIM                  STORAGECLASS   REASON   AGE
pvc-4d2b059c-0d6c-44af-9994-f74d01c78731   10Gi       RWO            Delete           Bound
default/ssd-disk       csi-disk-ssd            15s
pvc-6e2f37f9-7346-4419-82f7-b42e79f7964c   10Gi       RWO            Delete           Bound       default/
sas-disk         csi-disk-sas            17m
```

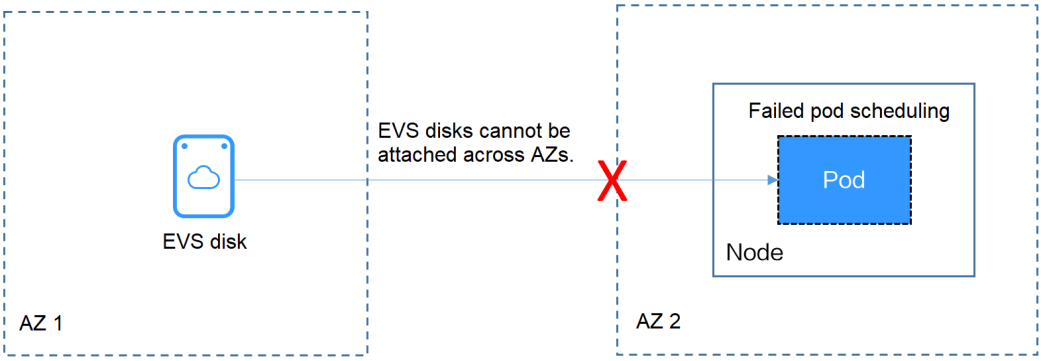
View the PVC details on the CCE console. On the PV details page, you can see that the disk type is ultra-high I/O.



11.6 Scheduling EVS Disks Across AZs Using csi-disk-topology

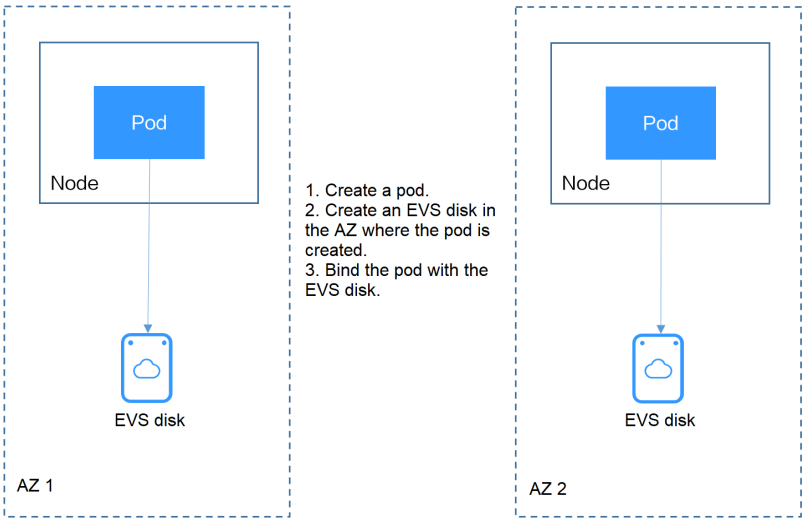
Background

EVS disks cannot be attached to a node deployed in another AZ. For example, the EVS disks in AZ 1 cannot be attached to a node in AZ 2. If the storage class csi-disk is used for StatefulSets, when a StatefulSet is scheduled, a PVC and a PV are created immediately (an EVS disk is created along with the PV), and then the PVC is bound to the PV. However, when the cluster nodes are located in multiple AZs, the EVS disk created by the PVC and the node to which the pods are scheduled may be in different AZs. As a result, the pods fail to be scheduled.



Solution

CCE provides a storage class named **csi-disk-topology**, which is a late-binding EVS disk type. When you use this storage class to create a PVC, no PV will be created in pace with the PVC. Instead, the PV is created in the AZ of the node where the pod will be scheduled. An EVS disk is then created in the same AZ to ensure that the EVS disk can be attached and the pod can be successfully scheduled.



Failed Pod Scheduling Due to csi-disk Used in Cross-AZ Node Deployment

Create a cluster with three nodes in different AZs.

Use the csi-disk storage class to create a StatefulSet and check whether the workload is successfully created.

```
apiVersion: apps/v1
kind: StatefulSet
metadata:
  name: nginx
spec:
  serviceName: nginx                    # Name of the headless Service
  replicas: 4
  selector:
    matchLabels:
      app: nginx
  template:
    metadata:
      labels:
        app: nginx
    spec:
      containers:
        - name: container-0
          image: nginx:alpine
          resources:
            limits:
              cpu: 600m
              memory: 200Mi
            requests:
              cpu: 600m
              memory: 200Mi
          volumeMounts:                 # Storage mounted to the pod
          - name:  data
            mountPath: /usr/share/nginx/html      # Mount the storage to /usr/share/nginx/html.
      imagePullSecrets:
        - name: default-secret
  volumeClaimTemplates:
  - metadata:
      name: data
      annotations:
        everest.io/disk-volume-type: SAS
    spec:
      accessModes:
      - ReadWriteOnce
      resources:
        requests:
          storage: 1Gi
      storageClassName: csi-disk
```

The StatefulSet uses the following headless Service.

```
apiVersion: v1
kind: Service       # Object type (Service)
metadata:
  name: nginx
  labels:
    app: nginx
spec:
  ports:
    - name: nginx     # Name of the port for communication between pods
      port: 80        # Port number for communication between pods
  selector:
    app: nginx        # Select the pod whose label is app:nginx.
  clusterIP: None     # Set this parameter to None, indicating the headless Service.
```

After the creation, check the PVC and pod status. In the following output, the PVC has been created and bound successfully, and a pod is in the Pending state.


```
# kubectl get pvc -owide
NAME          STATUS   VOLUME                                     CAPACITY   ACCESS MODES   STORAGECLASS
AGE   VOLUMEMODE
data-nginx-0   Bound    pvc-04e25985-fc93-4254-92a1-1085ce19d31e   1Gi        RWO            csi-disk
64s   Filesystem
data-nginx-1   Bound    pvc-0ae6336b-a2ea-4ddc-8f63-cfc5f9efe189   1Gi        RWO            csi-disk
47s   Filesystem
data-nginx-2   Bound    pvc-aa46f452-cc5b-4dbd-825a-da68c858720d   1Gi        RWO            csi-disk
30s   Filesystem
data-nginx-3   Bound    pvc-3d60e532-ff31-42df-9e78-015cacb18a0b   1Gi        RWO            csi-disk
14s   Filesystem

# kubectl get pod -owide
NAME      READY   STATUS    RESTARTS   AGE     IP           NODE           NOMINATED NODE   READINESS
GATES
nginx-0   1/1     Running   0          2m25s   172.16.0.12   192.168.0.121   <none>           <none>
nginx-1   1/1     Running   0          2m8s    172.16.0.136   192.168.0.211   <none>           <none>
nginx-2   1/1     Running   0          111s    172.16.1.7     192.168.0.240   <none>           <none>
nginx-3   0/1     Pending   0          95s     <none>         <none>          <none>           <none>
```

The event information of the pod shows that the scheduling fails due to no available node. Two nodes (in AZ 1 and AZ 2) do not have sufficient CPUs, and the created EVS disk is not in the AZ where the third node (in AZ 3) is located. As a result, the pod cannot use the EVS disk.

```
# kubectl describe pod nginx-3
Name:           nginx-3
...
Events:
  Type     Reason            Age   From               Message
  ----     ------            ----  ----               -------
  Warning  FailedScheduling  111s  default-scheduler  0/3 nodes are available: 3 pod has unbound
immediate PersistentVolumeClaims.
  Warning  FailedScheduling  111s  default-scheduler  0/3 nodes are available: 3 pod has unbound
immediate PersistentVolumeClaims.
  Warning  FailedScheduling  28s   default-scheduler  0/3 nodes are available: 1 node(s) had volume node
affinity conflict, 2 Insufficient cpu.
```

Check the AZ where the EVS disk created from the PVC is located. It is found that data-nginx-3 is in AZ 1. In this case, the node in AZ 1 has no resources, and only the node in AZ 3 has CPU resources. As a result, the scheduling fails. Therefore, there should be a delay between creating the PVC and binding the PV.

Storage Class for Delayed Binding

If you check the cluster storage class, you can see that the binding mode of csi-disk-topology is **WaitForFirstConsumer**, indicating that a PV is created and bound when a pod uses the PVC. That is, the PV and the underlying storage resources are created based on the pod information.

```
# kubectl get storageclass
NAME                PROVISIONER                  RECLAIMPOLICY   VOLUMEBINDINGMODE
ALLOWVOLUMEEXPANSION   AGE
csi-disk            everest-csi-provisioner      Delete          Immediate              true                   156m
csi-disk-topology   everest-csi-provisioner      Delete          WaitForFirstConsumer   true
156m
csi-nas             everest-csi-provisioner      Delete          Immediate              true                   156m
csi-obs             everest-csi-provisioner      Delete          Immediate              false                  156m
csi-sfsturbo        everest-csi-provisioner      Delete          Immediate              true                   156m
```

VOLUMEBINDINGMODE is displayed if your cluster is v1.19. It is not displayed in clusters of v1.17 or v1.15.

You can also view the binding mode in the csi-disk-topology details.


```
# kubectl describe sc csi-disk-topology
Name:                  csi-disk-topology
IsDefaultClass:        No
Annotations:           <none>
Provisioner:           everest-csi-provisioner
Parameters:            csi.storage.k8s.io/csi-driver-name=disk.csi.everest.io,csi.storage.k8s.io/
fstype=ext4,everest.io/disk-volume-type=SAS,everest.io/passthrough=true
AllowVolumeExpansion:  True
MountOptions:          <none>
ReclaimPolicy:         Delete
VolumeBindingMode:     WaitForFirstConsumer
Events:                <none>
```

Create PVCs of the csi-disk and csi-disk-topology classes. Observe the differences between these two types of PVCs.

- csi-disk

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name:  disk
  annotations:
    everest.io/disk-volume-type: SAS
spec:
  accessModes:
  - ReadWriteOnce
  resources:
    requests:
      storage: 10Gi
  storageClassName: csi-disk        # StorageClass
```

- csi-disk-topology

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name:  topology
  annotations:
    everest.io/disk-volume-type: SAS
spec:
  accessModes:
  - ReadWriteOnce
  resources:
    requests:
      storage: 10Gi
  storageClassName: csi-disk-topology        # StorageClass
```

View the PVC details. As shown below, the csi-disk PVC is in Bound state and the csi-disk-topology PVC is in Pending state.

```
# kubectl create -f pvc1.yaml
persistentvolumeclaim/disk created
# kubectl create -f pvc2.yaml
persistentvolumeclaim/topology created
# kubectl get pvc
NAME          STATUS    VOLUME                                     CAPACITY   ACCESS MODES
STORAGECLASS       AGE
disk          Bound     pvc-88d96508-d246-422e-91f0-8caf414001fc   10Gi       RWO            csi-disk
18s
topology      Pending                                                                         csi-disk-topology   2s
```

View details about the csi-disk-topology PVC. You can see that "waiting for first consumer to be created before binding" is displayed in the event, indicating that the PVC is bound after the consumer (pod) is created.

```
# kubectl describe pvc topology
Name:          topology
Namespace:     default
StorageClass:  csi-disk-topology
Status:        Pending
```



```
Volume:
Labels:        <none>
Annotations:   everest.io/disk-volume-type: SAS
Finalizers:    [kubernetes.io/pvc-protection]
Capacity:
Access Modes:
VolumeMode:    Filesystem
Used By:       <none>
Events:
  Type    Reason                Age               From                         Message
  ----    ------                ----              ----                         -------
  Normal  WaitForFirstConsumer  5s (x3 over 30s)  persistentvolume-controller  waiting for first consumer to be created before binding
```

Create a workload that uses the PVC. Set the PVC name to **topology**.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx-deployment
spec:
  selector:
    matchLabels:
      app: nginx
  replicas: 1
  template:
    metadata:
      labels:
        app: nginx
    spec:
      containers:
      - image: nginx:alpine
        name: container-0
        volumeMounts:
        - mountPath: /tmp                                # Mount path
          name: topology-example
      restartPolicy: Always
      volumes:
      - name: topology-example
        persistentVolumeClaim:
          claimName:  topology                       # PVC name
```

After the PVC is created, check the PVC details. You can see that the PVC is bound successfully.

```
# kubectl describe pvc topology
Name:          topology
Namespace:     default
StorageClass:  csi-disk-topology
Status:        Bound
....
Used By:       nginx-deployment-fcd9fd98b-x6tbs
Events:
  Type    Reason                 Age
From                                                                                              Message
  ----    ------                 ----
----                                                                                              -------
  Normal  WaitForFirstConsumer   84s (x26 over 7m34s)  persistentvolume-
controller                                                                        waiting for first consumer to be created before binding
  Normal  Provisioning           54s                   everest-csi-provisioner_everest-csi-
controller-7965dc48c4-5k799_2a6b513e-f01f-4e77-af21-6d7f8d4dbc98  External provisioner is provisioning volume for claim "default/topology"
  Normal  ProvisioningSucceeded  52s                   everest-csi-provisioner_everest-csi-
controller-7965dc48c4-5k799_2a6b513e-f01f-4e77-af21-6d7f8d4dbc98  Successfully provisioned volume pvc-9a89ea12-4708-4c71-8ec5-97981da032c9
```


Using csi-disk-topology in Cross-AZ Node Deployment

The following uses csi-disk-topology to create a StatefulSet with the same configurations used in the preceding example.

```
volumeClaimTemplates:
- metadata:
    name: data
    annotations:
      everest.io/disk-volume-type: SAS
  spec:
    accessModes:
    - ReadWriteOnce
    resources:
      requests:
        storage: 1Gi
    storageClassName: csi-disk-topology
```

After the creation, check the PVC and pod status. As shown in the following output, the PVC and pod can be created successfully. The nginx-3 pod is created on the node in AZ 3.

```
# kubectl get pvc -owide
NAME           STATUS   VOLUME                                     CAPACITY   ACCESS MODES
STORAGECLASS       AGE   VOLUMEMODE
data-nginx-0   Bound    pvc-43802cec-cf78-4876-bcca-e041618f2470   1Gi        RWO           csi-disk-
topology   55s   Filesystem
data-nginx-1   Bound    pvc-fc942a73-45d3-476b-95d4-1eb94bf19f1f   1Gi        RWO           csi-disk-
topology   39s   Filesystem
data-nginx-2   Bound    pvc-d219f4b7-e7cb-4832-a3ae-01ad689e364e   1Gi        RWO           csi-disk-
topology   22s   Filesystem
data-nginx-3   Bound    pvc-b54a61e1-1c0f-42b1-9951-410ebd326a4d   1Gi        RWO           csi-disk-
topology   9s    Filesystem

# kubectl get pod -owide
NAME      READY   STATUS    RESTARTS   AGE   IP            NODE            NOMINATED NODE   READINESS
GATES
nginx-0   1/1     Running   0          65s   172.16.1.8    192.168.0.240   <none>           <none>
nginx-1   1/1     Running   0          49s   172.16.0.13   192.168.0.121   <none>           <none>
nginx-2   1/1     Running   0          32s   172.16.0.137  192.168.0.211   <none>           <none>
nginx-3   1/1     Running   0          19s   172.16.1.9    192.168.0.240   <none>           <none>
```

11.7 Automatically Collecting JVM Dump Files That Exit Unexpectedly Using SFS 3.0

If you are using Java to develop services, you may encounter an out of memory (OOM) problem if the JVM heap space is insufficient. To address this issue, you can use SFS 3.0 file systems to store logs and mount the file systems to the relevant directories in containers. In the event of a JVM OOM, SFS 3.0 file systems can record logs.

Prerequisites

- A CCE standard cluster has been created. For details, see **Buying a CCE Standard/Turbo Cluster**.
- Before using SFS 3.0 file systems for CCE container storage, you need to configure a VPC endpoint to communicate with SFS 3.0. For details, see **Configure a VPC Endpoint**.

Procedure

Step 1 Create a PVC based on SFS 3.0.

```
cat << EOF | kubectl apply -f -
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: jvm-sfs-pvc
  namespace: default
  annotations: {}
spec:
  accessModes:
    - ReadWriteMany
  resources:
    requests:
      storage: 10Gi
  storageClassName: csi-sfs
EOF
```

Step 2 Create a Deployment using the following YAML to simulate Java OOM and dump the generated dump files to the PV associated with the SFS 3.0 file system.

```
cat << EOF | kubectl apply -f -
apiVersion: apps/v1
kind: Deployment
metadata:
  name: java-application
  namespace: default
spec:
  selector:
    matchLabels:
      app: java-application
  template:
    metadata:
      labels:
        app: java-application
    spec:
      containers:
      - name: java-application
        image: swr.cn-east-3.myhuaweicloud.com/container/java-oom-demo:v1  #The image in this document is only an example.
        imagePullPolicy: Always
        env:
        - name: POD_NAME     # Use metadata.name as the value of the POD_NAME environment variable.
          valueFrom:
            fieldRef:
              apiVersion: v1
              fieldPath: metadata.name
        - name: POD_NAMESPACE     #Use metadata.namespace as the value of the POD_NAMESPACE environment variable.
          valueFrom:
            fieldRef:
              apiVersion: v1
              fieldPath: metadata.namespace
        args:
        - java                          #Run the Java command.
        - -Xms80m                       #Configure the minimum heap size of the heap memory.
        - -Xmx80m                       #Configure the maximum heap size of the heap memory.
        - -XX:HeapDumpPath=/mnt/oom/logs  #Heap memory dump path when OOM occurs
        - -XX:+HeapDumpOnOutOfMemoryError #Capture the heap OOM error.
        - Mycode                        #Run the application.
        volumeMounts:
        - name: java-oom-pv
          mountPath: "/mnt/oom/logs"      # The container uses /mnt/oom/logs as the mount directory.
          subPathExpr: $(POD_NAMESPACE).$(POD_NAME)   #Create a subdirectory using $(POD_NAMESPACE).$(POD_NAME) and allow the OOM dump files to be generated to the subdirectory.
      imagePullSecrets:
        - name: default-secret
      volumes:
```



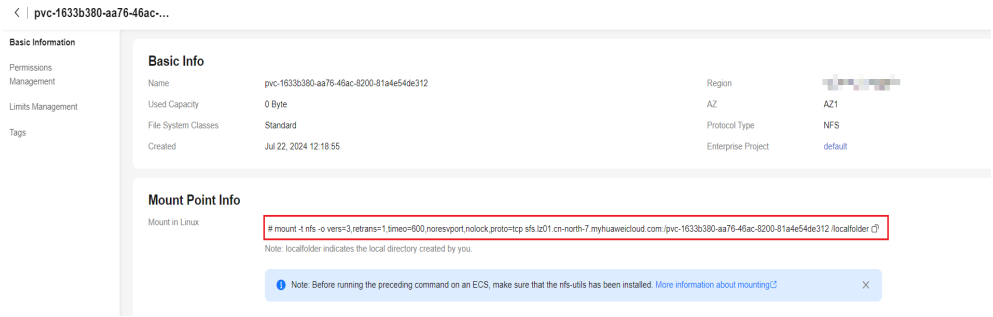
```
    - name: java-oom-pv
      persistentVolumeClaim:
        claimName: jvm-sfs-pvc        #PVC using the SFS file system, named jvm-sfs-pvc
EOF
```

Step 3 Wait until the container automatically restarts due to OOM.

```
# kubectl -n default get pod
NAME                              READY   STATUS    RESTARTS      AGE
java-application-84dc6f897f-hc9q7   1/1     Running   1 (31s ago)   97s
```

Step 4 Obtain the files generated by the Java program due to OOM.

1. Log in to the CCE console and click the cluster name to access the cluster console. In the navigation pane, choose **Storage**, click the **PVCs** tab, locate the row containing **jvm-sfs-pvc**, and click the name of the associated PV.
2. After the system automatically switches to the row containing the corresponding PV, click the name of the associated storage volume.
3. After the system automatically switches to the SFS console, copy the mounting command.



4. Log in to a cluster node, create a mount point, and run the mount command to mount the SFS volume to the node.

```
mkdir /test-jvm
mount -t nfs -o vers=3,timeo=600,noresvport,nolock,proto=tcp ***.com:/pvc-4ea9137e-4101-4610-a4d2-9f8bb37043a1 /test-jvm
```

5. Check the files in the mounted file system. The dump file **java_pid1.hprof** is present in the directory. To identify the line of code that triggers an OOM error, download **java_pid1.hprof** to the local host and use Eclipse Memory Analyzer Tool (MAT) to further analyze JVM stack information.

----End

11.8 Deploying Storage Volumes in Multiple AZs

Application Scenarios

- Deploying services in specific AZs within a cluster that has nodes running in multiple AZs
- Preventing faults caused by a lack of resources in a single AZ with multi-AZ deployment

Deploying storage volumes in multiple AZs reduces application interruptions during rollout and ensures the stability of key systems and applications in case of any faults.

Prerequisites

- You have created a cluster with the CCE Container Storage (Everest) add-on installed and the cluster version is 1.21 or later. If no cluster is available, create one by referring to **Buying a CCE Standard/Turbo Cluster**.
- Nodes in the cluster must be in at least three different AZs. If the current nodes are not in three different AZs, you need to **create new nodes** or **node pools** in AZs that have no such resources deployed.

Procedure

Step 1 Use kubectl to access the cluster. For details, see **Connecting to a Cluster Using kubectl**.

Step 2 Create a StorageClass YAML file.

```
vi storageclass.yaml
```

Enter the following content in the **storageclass.yaml** file: (The following shows only a template for StorageClass configuration. You can modify it as required.)

```
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: test-disk-topology-alltype
provisioner: everest-csi-provisioner
parameters:
  csi.storage.k8s.io/csi-driver-name: disk.csi.everest.io
  csi.storage.k8s.io/fstype: ext4
  everest.io/disk-volume-type: SAS #A high I/O EVS disk
  everest.io/passthrough: "true"
reclaimPolicy: Delete
allowVolumeExpansion: true
volumeBindingMode: WaitForFirstConsumer
```

Table 11-18 StorageClass parameters

Parameter	Description
provisioner	Specifies the storage resource provider, which is the Everest add-on for CCE. Set this parameter to **everest-csi-provisioner**.
parameters	Specifies the storage parameters, which vary with storage types. **NOTICE** **everest.io/disk-volume-type** indicates the cloud disk type, which can be any of the following: • **SAS**: high I/O • **SSD**: ultra-high I/O • **GPSSD**: general purpose SSD • **ESSD**: extreme SSD • **GPSSD2**: general purpose SSD v2, which is supported when the Everest version is 2.4.4 or later and the **everest.io/disk-iops** and **everest.io/disk-throughput** annotations are configured. • **ESSD2**: extreme SSD v2, which is supported when the Everest version is 2.4.4 or later and the **everest.io/disk-iops** annotation is configured.

Parameter	Description
reclaimPolicy	Specifies the value of **persistentVolumeReclaimPolicy** for creating a PV. The value can be **Delete** or **Retain**. If **reclaimPolicy** is not specified when a StorageClass object is created, the value defaults to **Delete**. • **Delete**: indicates that a dynamically provisioned PV will be automatically deleted when the PVC is deleted. • **Retain**: indicates that a dynamically provisioned PV will be retained when the PVC is deleted.
allowVolumeExpansion	Specifies whether the PV of this StorageClass supports dynamic capacity expansion. The default value is **false**. Dynamic capacity expansion is implemented by the underlying storage add-on. This is only a switch.
volumeBindingMode	Specifies when a PV is dynamically provisioned. The value can be **Immediate** or **WaitForFirstConsumer**. • **Immediate**: The PV is dynamically provisioned when a PVC is created. • **WaitForFirstConsumer**: The PV is dynamically provisioned when the PVC is used by the workload.

Step 3 Create the StorageClass.

```
kubectl create -f storageclass.yaml
```

Step 4 Create a StatefulSet YAML file.

```
vi statefulset.yaml
```

Enter the following content in the **statefulset.yaml** file: (The following shows only a template for the standard StatefulSet configuration. You can customize it as required.)

```
apiVersion: apps/v1
kind: StatefulSet
metadata:
  name: nginx
spec:
  replicas: 3
  serviceName: "nginx"
  selector:
    matchLabels:
      app: nginx
  template:
    metadata:
      labels:
        app: nginx
    spec:
      topologySpreadConstraints:
      - labelSelector:   # Used to search for matched pods and count the pods that match the label selector to determine the number of pods in the corresponding topology domain.
          matchLabels:
            app: nginx
        maxSkew: 1       # Maximum difference between the numbers of matched pods in any two topology domains in a given topology type.
        topologyKey: topology.kubernetes.io/zone     # Key of a node label
        whenUnsatisfiable: DoNotSchedule    # How the scheduler processes pods when the pods do not meet the spread constraints
```



```
    containers:
    - image: nginx:latest
      name: nginx
      env:
      - name: NGINX_ROOT_PASSWORD
        value: "nginx"
      volumeMounts:
      - name: disk-csi
        mountPath: /var/lib/nginx
    imagePullSecrets:
    - name: default-secret
    tolerations:
    - key: "app"
      operator: "Exists"
      effect: "NoSchedule"
  volumeClaimTemplates:    # EVS disks are automatically created based on the specified number of replicas for quick expansion.
  - metadata:
      name: disk-csi
    spec:
      accessModes: [ "ReadWriteOnce" ]   # EVS disks can only be mounted to and accessed by a single node in read/write mode, that is, ReadWriteOnce.
      storageClassName: test-disk-topology-alltype
      resources:
        requests:
          storage: 40Gi
```

Table 11-19 StatefulSet parameters

Parameter	Description
topologySpreadConstraints	Specifies the topology spread constraints, which are used to control how pods are spread across a cluster among topology domains, such as regions, AZs, nodes, and other custom topology domains. For details, see **Pod Topology Spread Constraints**.
topologySpreadConstraints.labelSelector	Used to search for matched pods. The number of pods that match this label selector is counted to determine the number of pods in the corresponding topology domain.
topologySpreadConstraints.maxSkew	Specifies the maximum difference between the numbers of matched pods in any two topology domains in a given topology type. The value must be greater than 0 and is used to indicate how much uneven distribution of pods is allowed.
topologySpreadConstraints.topologyKey	Specifies the key of a node label. If two nodes use this key and have the same label value, the scheduler treats them as being in the same topology domain and tries to schedule an equal number of pods to each domain.
topologySpreadConstraints.whenUnsatisfiable	Specifies how the scheduler processes pods when the pods do not meet the spread constraints. The value can be: • **DoNotSchedule** (Default): If a pod does not meet the spread constraints, it will not be scheduled. • **ScheduleAnyway**: If a pod does not meet the spread constraints, it will be scheduled to the node with the minimum skew preferentially.

Parameter	Description
volumeClaimTemplates	Specifies that EVS disks are automatically created based on the specified number of replicas for quick expansion.

Step 5 Create the StatefulSet.

```
kubectl create -f statefulset.yaml
```

----End

Verification

The following shows how to verify that the dynamically created PVs are in different AZs along with the pods.

Step 1 View the new PVs.

```
kubectl get pv
```

The command output is as follows: (The first three PVs are dynamically created with the pods.)

```
NAME          CAPACITY   ACCESS MODES   RECLAIM POLICY   STATUS   CLAIM
STORAGECLASS              VOLUMEATTRIBUTESCLASS   REASON   AGE
pvc-699eda75   40Gi       RWO            Delete           Bound    default/disk-csi-nginx-0   test-disk-topology-
alltype   <unset>                 132m
pvc-6c68f5a7   40Gi       RWO            Delete           Bound    default/disk-csi-nginx-1   test-disk-topology-
alltype   <unset>                 131m
pvc-8f74ce3a   40Gi       RWO            Delete           Bound    default/disk-csi-nginx-2   test-disk-topology-
alltype   <unset>                 131m
pvc-f738f8aa   10Gi       RWO            Delete           Bound    default/pvc                csi-disk
<unset>                 6d4h
```

Step 2 Check the AZs where the PVs are located based on the PV names.

```
kubectl describe pv pvc-699eda75 pvc-6c68f5a7 pvc-8f74ce3a | grep zone
```

The command output is as follows: (The three PVs are in different AZs to enable multi-AZ deployment of storage volumes.)

```
Labels:           failure-domain.beta.kubernetes.io/zone=cn-east-3d
    Term 0:        failure-domain.beta.kubernetes.io/zone in [cn-east-3d]
Labels:           failure-domain.beta.kubernetes.io/zone=cn-east-3b
    Term 0:        failure-domain.beta.kubernetes.io/zone in [cn-east-3b]
Labels:           failure-domain.beta.kubernetes.io/zone=cn-east-3c
    Term 0:        failure-domain.beta.kubernetes.io/zone in [cn-east-3c]
```

----End

12 Container

12.1 Recommended Configurations for Workloads

When deploying a workload in a CCE cluster, you need to configure the workload based on the actual service scenarios and environments to ensure that the workload can run stably and reliably. This section provides some recommended configurations and suggestions for workload deployment.

Specifying Pod Resources (Requests and Limits)

Requests and limits need to be configured based on the actual service scenarios. The requests are used for the scheduler to check available resources and record the allocated resources on each node. The allocated resources on a node are the sum of container requests defined in all pods on the node. You can calculate the available resources on a node using the following formula: Available resources on a node = Total resources on the node – Allocated resources on the node. If there are not enough available resources on a node to accommodate a pod's requests, the pod will not be scheduled on that node.

If the requests are not configured, the scheduler cannot determine the resource usage on a node and cannot schedule pods to suitable nodes. This can lead to a situation where a node becomes overloaded with a large number of pods, potentially causing issues with the node and impacting the actual services. It is recommended that you configure requests for all containers so that the scheduler can accurately monitor the resource usage on nodes and make appropriate scheduling decisions.

The following shows an example of how to configure the request and limit for an Nginx pod. The request specifies that the pod requires 0.5 CPU cores and 128 MiB of memory. During running, the pod can use resources beyond the request, but it cannot exceed the resource limit of 1 CPU core and 256 MiB of memory.

```
apiVersion: v1
kind: Pod
metadata:
  name: nginx-test
spec:
  containers:
  - name: container-1
```



```
    image: nginx
    resources: # Resource declaration
      resources:
        limits:
          cpu: 1000m
          memory: 256Mi
        requests:
          cpu: 500m
          memory: 128Mi
  imagePullSecrets:
    - name: default-secret
```

Configuring a Graceful Exit Period

The graceful exit period (**terminationGracePeriodSeconds**) is the time between a failed pod triggering the termination process and the pod being forcefully stopped. By default, if this parameter is not specified, the grace period is set to 30 seconds, with a minimum value of 1 second. During this grace period, the pod can be gracefully shut down, allowing it to perform operations such as saving its status, completing ongoing tasks, and closing network connections. It is crucial to configure **terminationGracePeriodSeconds** properly to ensure a smooth, orderly termination of an application.

If you want a pod to wait for 60 seconds before termination, allowing the pod to be properly cleared, you can include the following parameters in the pod definition:

```
kind: Deployment
apiVersion: apps/v1
metadata:
  name: nginx
spec:
  replicas: 1
  selector:
    matchLabels:
      app: nginx
      version: v1
  template:
    metadata:
      labels:
        app: nginx
        version: v1
    spec:
      containers:
        - name: container-1
          image: nginx
      imagePullSecrets:
        - name: default-secret
      terminationGracePeriodSeconds: 60
```

Configuring Tolerations

Tolerations allow pods to be scheduled on nodes even if there are taints present. For example, if an application heavily relies on the local state of a node, you may want it to remain on that node for an extended period during a network partition, waiting for the network to recover and avoiding eviction.

Sometimes, the Kubernetes node controller automatically adds taints to nodes. It is recommended that you add tolerations for the built-in taints **node.kubernetes.io/not-ready** (indicating the node is not ready) and **node.kubernetes.io/unreachable** (indicating the node controller cannot access the node). In the following example, a node has added the preceding tolerations,

and the pod will continue running on the node for 300 seconds before being evicted.

```
apiVersion: v1
kind: Pod
metadata:
  name: nginx-test
spec:
  containers:
    - name: container-1
      image: nginx
  imagePullSecrets:
    - name: default-secret
  tolerations:
    - key: node.kubernetes.io/not-ready
      operator: Exists
      effect: NoExecute
      tolerationSeconds: 300
    - key: node.kubernetes.io/unreachable
      operator: Exists
      effect: NoExecute
      tolerationSeconds: 300
```

Configuring a Rolling Update

In Kubernetes, the **strategy** field in a workload determines how resources like Deployments, StatefulSets, and DaemonSets are updated. To maintain service continuity during a workload upgrade, you can use rolling updates to control the number of available pods, minimizing downtime. For example, in a Deployment with multiple pods, you can specify the maximum number of old pods that can be unavailable and the maximum number of new pods that can be started and running until the update is complete. Rolling updates ensure service stability and availability while smoothly transitioning applications to new versions.

In the following example, a rolling update policy is configured, where both **maxUnavailable** and **maxSurge** are set to **25%**. This means that up to 25% of old pods can be unavailable and up to 25% of new pods can be started during the update.

```
kind: Deployment
apiVersion: apps/v1
metadata:
  name: nginx
spec:
  replicas: 10
  selector:
    matchLabels:
      app: nginx
      version: v1
  template:
    metadata:
      labels:
        app: nginx
        version: v1
    spec:
      containers:
        - name: container-1
          image: nginx
      imagePullSecrets:
        - name: default-secret
  strategy:
    type: RollingUpdate
    rollingUpdate:
      maxUnavailable: 25%
      maxSurge: 25%
```


Configuring a Restart Policy

The **restartPolicy** parameter is used to define the behavior after a pod terminates. You can customize the policy based on your specific services to enable automatic restarts when a pod exits.

The following is an example of configuring an Nginx pod to always restart automatically:

```
apiVersion: v1
kind: Pod
metadata:
  name: nginx-test
spec:
  containers:
  - name: nginx
    image: nginx
    restartPolicy: Always
  imagePullSecrets:
    - name: default-secret
```

The options of **restartPolicy** include:

- **Always**: The pod always restarts automatically after any termination.
- **OnFailure**: The pod automatically restarts if it exits with an error. (The process exit status is not 0).
- **Never**: The pod never restarts.

Configuring a Liveness Probe and a Readiness Probe

A liveness probe checks whether a pod is normal. In Kubernetes, if a pod is in the **Running** state, it does not mean that the pod can provide services properly. The pod may fail to provide services due to problems in processes such as deadlock. You can configure a liveness probe to avoid similar problems and restart the pod in a timely manner to restore your service.

A readiness probe detects whether a pod is ready to receive Service requests. If the pod is faulty, the readiness probe avoids forwarding new traffic to the pod.

```
apiVersion: v1
kind: Pod
metadata:
  name: tomcat
spec:
  containers:
  - name: tomcat
    image: tomcat
    livenessProbe:
      httpGet:
        path: /index.jsp
        port: 8080
      initialDelaySeconds: 3
      periodSeconds: 3
    readinessProbe:
      httpGet:
        path: /index.jsp
        port: 8080
  imagePullSecrets:
    - name: default-secret
```


12.2 Properly Allocating Container Computing Resources

If a node has sufficient memory resources, a container on this node can use more memory resources than requested, but no more than limited. If the memory allocated to a container exceeds the upper limit, the container is stopped first. If the container continuously uses memory resources more than limited, the container is terminated. If a stopped container is allowed to be restarted, kubelet will restart it, but other types of run errors will occur.

Scenario 1

The node's memory has reached the memory limit reserved for the node. As a result, OOM killer is triggered.

Solution

You can either scale up the node or migrate the pods on the node to other nodes.

Scenario 2

The upper limit of resources configured for the pod is too small. When the actual usage exceeds the limit, OOM killer is triggered.

Solution

Set a higher upper limit for the workload.

Example

A pod will be created and allocated memory that exceeds the limit. As shown in the following configuration file of the pod, the pod requests 50 MiB memory and the memory limit is set to 100 MiB.

Example YAML file (memory-request-limit-2.yaml):

```
apiVersion: v1
kind: Pod
metadata:
  name: memory-demo-2
spec:
  containers:
  - name: memory-demo-2-ctr
    image: vish/stress
    resources:
      requests:
        memory: 50Mi
      limits:
        memory: "100Mi"
    args:
    - -mem-total
    - 250Mi
    - -mem-alloc-size
    - 10Mi
    - -mem-alloc-sleep
    - 1s
```


The **args** parameters indicate that the container attempts to request 250 MiB memory, which exceeds the pod's upper limit (100 MiB).

Creating a pod:

```
kubectl create -f https://k8s.io/docs/tasks/configure-pod-container/memory-request-limit-2.yaml --namespace=mem-example
```

Viewing the details about the pod:

```
kubectl get pod memory-demo-2 --namespace=mem-example
```

In this stage, the container may be running or be killed. If the container is not killed, repeat the previous command until the container is killed.

```
NAME            READY     STATUS      RESTARTS   AGE
memory-demo-2   0/1       OOMKilled   1          24s
```

Viewing detailed information about the container:

```
kubectl get pod memory-demo-2 --output=yaml --namespace=mem-example
```

This output indicates that the container is killed because the memory limit is exceeded.

```
lastState:
  terminated:
    containerID: docker://7aae52677a4542917c23b10fb56fcb2434c2e8427bc956065183c1879cc0dbd2
    exitCode: 137
    finishedAt: 2020-02-20T17:35:12Z
    reason: OOMKilled
    startedAt: null
```

In this example, the container can be automatically restarted. Therefore, kubelet will start it again. You can run the following command several times to see how the container is killed and started:

```
kubectl get pod memory-demo-2 --namespace=mem-example
```

The preceding command output indicates how the container is killed and started back and forth:

```
$ kubectl get pod memory-demo-2 --namespace=mem-example
NAME            READY     STATUS      RESTARTS   AGE
memory-demo-2   0/1       OOMKilled   1          37s
$ kubectl get pod memory-demo-2 --namespace=mem-example
NAME            READY     STATUS    RESTARTS   AGE
memory-demo-2   1/1       Running   2          40s
```

Viewing the historical information of the pod:

```
kubectl describe pod memory-demo-2 --namespace=mem-example
```

The following command output indicates that the pod is repeatedly killed and started.

```
... Normal  Created   Created container with id 66a3a20aa7980e61be4922780bf9d24d1a1d8b7395c09861225b0eba1b1f8511
... Warning BackOff   Back-off restarting failed container
```

12.3 Upgrading Pods Without Interrupting Services

Application Scenarios

In a Kubernetes cluster, applications can be accessed externally through Deployments and LoadBalancer Services. When an application is updated or

upgraded, new pods are created in the Deployment. These new pods will gradually replace the old ones. During this process, services may be interrupted.

Solution

To prevent an application upgrade from interrupting services, configure Deployments and Services as follows:

- In a Deployment, upgrade pods in the **Rolling upgrade** mode. In this mode, pods are updated one by one, not all at once. In this way, you can control the update speed and the number of concurrent pods to ensure that services are not interrupted during the upgrade. For example, you can configure the **maxSurge** and **maxUnavailable** parameters to control the number of new pods created and the number of old pods deleted concurrently. Ensure that there is always a workload that can provide services during the upgrade.
- There are two types of service affinity in a LoadBalancer:
  - **Cluster-level** service affinity (**externalTrafficPolicy: Cluster**). In this mode, if there is no pod deployed on a node, the request is forwarded to pods on another node. During the cross-node forwarding, the source IP address may be lost.
  - **Node-level** service affinity (**externalTrafficPolicy: Local**). In this mode, requests are directly forwarded to the node where the pod resides. Cross-node forwarding is not involved. Therefore, the source IP address can be preserved. However, if the node where the pod resides changes during the rolling upgrade, the ELB backend server will change accordingly, which may cause service interruption. In this case, you can upgrade pods in place. This ensures that there is at least one pod running properly on the ELB backend node.

The following table lists the solution for ensuring service continuity during a pod upgrade.

Scenario	Service	Deployment
The source IP address does not need to be preserved.	Select the **Cluster-level** service affinity.	Select **Rolling upgrade** for **Upgrade Mode**, configure a graceful termination, and enable **Liveness probe** and **Ready probe**.
The source IP address needs to be preserved.	Select the **Node-level** service affinity.	Select **Rolling upgrade** for **Upgrade Mode**, configure a graceful termination, enable **Liveness probe** and **Ready probe**, and add **Node Affinity** policies. (Ensure that there is at least one pod running on each node during the update.)

Procedure

In this example, there are 200 replicas in the workload, and the workload is exposed through the LoadBalance Service. The rolling upgrade of workloads associated with Loadbalance or Ingress Services involves multiple Services. Therefore, you need to pay attention to the configuration of rolling upgrade parameters.

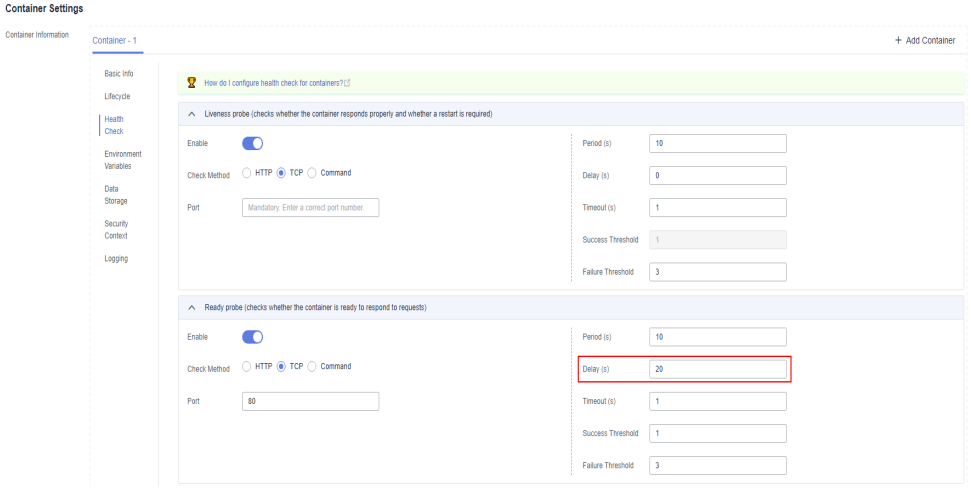
Step 1 Log in to the CCE console and click the cluster name to access the cluster console. In the navigation pane, choose **Workloads**.

Step 2 In the workload list, click **Upgrade** in the **Operation** column of the workload to be upgraded. The **Upgrade Workload** page is displayed.

1. Enable the liveness probe and ready probe. In the **Container Settings** area, click **Health Check** and enable **Liveness probe** and **Ready probe**. In this example, **TCP** is selected for **Check Method**. Configure the parameters based on your requirements. Parameters like **Period (s)**, **Delay (s)**, and **Timeout (s)** must be properly configured. Some applications take a long time to start. A small value of these parameters will lead to repeated restart.

   In this example, the ready probe delay is set to **20** to control the interval for rolling workloads in batches.

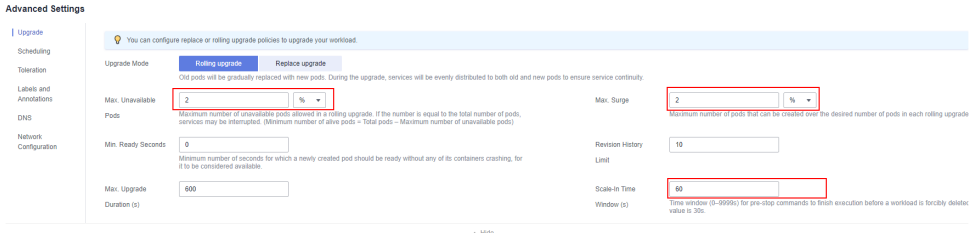
   Figure 12-1 Enabling the liveness probe and ready probe



2. Configure a rolling upgrade. In the **Advanced Settings** area, click **Upgrade** and select **Rolling upgrade** for **Upgrade Mode**. This ensures that the instances of the old versions are gradually replaced with the ones of the new versions.

   In this example, **maxUnavailable** is set to **2%**, and **maxSurge** is set to **2%** to control the workload rolling step. This, works with the ready probe delay, enables eight workloads to be upgraded every 20 seconds.

Figure 12-2 Configuring a rolling upgrade

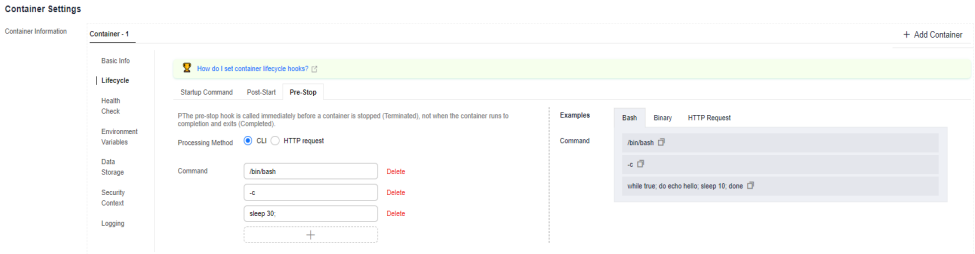


3. Configure a graceful termination.

   a. In the **Container Settings** area, click **Lifecycle** and configure pre-stop processing. Configure this parameter to the time required for the Service to process all remaining requests, most of which are persistent connection requests. You can, for example, set the workload to hibernate for 30s after receiving a deletion request so that the workload can have sufficient time to process the remaining requests to ensure proper service running.

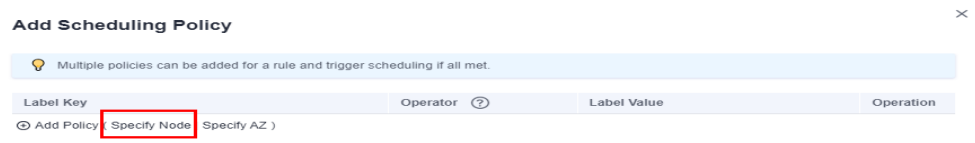
   b. In the **Advanced Settings** area, click **Upgrade**. Configure **Scale-In Time Window (terminationGracePeriodSeconds)** to specify the waiting time for command execution before the container is stopped. The scale-in time window must be greater than the pre-stop processing time. Add 30s to the command execution time before the container is stopped. If, for example, the pre-stop processing time is 30s, the scale-in time window should be 60s.

Figure 12-3 Entering the pre-stop command



4. Add node affinity policies. Add this kind of policy when **Node-level** is selected for a Service's **Service Affinity**. In the **Advanced Settings** area, click **Scheduling** and add **Node Affinity** policies. When adding a scheduling policy, specify the nodes that the workload requires affinity.

Figure 12-4 Adding node affinity policies



Step 3 After the configuration is complete, click **Upgrade Workload**.

On the **Pods** tab, after a newly created pod is displayed, stop the old one. This ensures that there is always a pod running in the workload.

----End

12.4 Modifying Kernel Parameters Using a Privileged Container

Prerequisites

To access a Kubernetes cluster from a client, you can use the Kubernetes command line tool kubectl. For details, see **Connecting to a Cluster Using kubectl**.

Procedure

Step 1 Create a DaemonSet in the background, select the Nginx image, enable the Privileged Container, configure the lifecycle, and add the **hostNetwork** field (value: **true**).

1. Create a **daemonSet** file.

   vi daemonSet.yaml

   An example YAML file is provided as follows:

   NOTICE

   The **spec.spec.containers.lifecycle** field indicates the command that will be run after the container is started.

```
kind: DaemonSet
apiVersion: apps/v1
metadata:
  name: daemonset-test
  labels:
    name: daemonset-test
spec:
  selector:
    matchLabels:
      name: daemonset-test
  template:
    metadata:
      labels:
        name: daemonset-test
    spec:
      hostNetwork: true
      containers:
      - name: daemonset-test
        image: nginx:alpine-perl
        command:
        - "/bin/sh"
        args:
        - "-c"
        - while :; do  time=$(date);done
        imagePullPolicy: IfNotPresent
        lifecycle:
          postStart:
```



```
        exec:
          command:
          - sysctl
          - "-w"
          - net.ipv4.tcp_tw_reuse=1
      securityContext:
        privileged: true
    imagePullSecrets:
    - name: default-secret
```

2. Create a DaemonSet.

   kubectl create –f daemonSet.yaml

Step 2 Check whether the DaemonSet is successfully created.

kubectl get daemonset *DaemonSet name*

In this example, run the following command:

kubectl get daemonset daemonset-test

Information similar to the following is displayed:

```
NAME              DESIRED   CURRENT   READY   UP-T0-DATE   AVAILABLE   NODE SELECTOR   AGE
daemonset-test    2         2         2       2            2           <node>          2h
```

Step 3 Query the container ID of DaemonSet on the node.

docker ps -a|grep *DaemonSet name*

In this example, run the following command:

docker ps -a|grep daemonset-test

Information similar to the following is displayed:

```
897b99faa9ce        3e094d5696c1                      "/bin/sh  -c while..."     31 minutes ago     Up  30
minutes  ault_fa7cc313-4ac1-11e9-a716-fa163e0aalba_0
```

Step 4 Access the container.

docker exec -it *containerid* **/bin/sh**

In this example, run the following command:

docker exec -it *897b99faa9ce* **/bin/sh**

Step 5 Check whether the configured command is executed after the container is started.

sysctl -a |grep net.ipv4.tcp_tw_reuse

If the following information is displayed, the system parameters are modified successfully:

```
net.ipv4.tcp_tw_reuse=1
```

----End

12.5 Using Init Containers to Initialize an Application

Concepts

An init container is a type of container that starts and exits before the application containers start. If there are multiple init containers, they will be started in the

defined sequence. The data generated in the init containers can be used by the application containers because storage volumes in a pod are shared.

Init containers can be used in multiple Kubernetes resources, such as Deployments, DaemonSets, and jobs. They perform initialization before application containers are started.

Application Scenarios

Before deploying a service, you can use an init container to make preparations before the service pod is deployed. After the preparations are complete, the init container runs to completion and exits, and the container to be deployed will be started.

- **Scenario 1: Wait for other modules to be ready.** For example, an application contains two containerized services: web server and database. The web server service needs to access the database service. However, when the application is started, the database service may have not been started. Therefore, web server may fail to access database. To solve this problem, you can use an init container in the pod where web server is running to check whether database is ready. The init container runs to completion only when database is accessible. Then, web server is started and initiates a formal access request to database.
- **Scenario 2: Initialize the configuration.** For example, the init container can check all existing member nodes in the cluster and prepare the cluster configuration information for the application container. After the application container is started, it can be added to the cluster using the configuration information.
- **Other scenarios**: For example, a pod is registered with a central database and application dependencies are downloaded.

For details, see **Init Containers**.

Procedure

Step 1 Edit the YAML file of the init container workload.

vi deployment.yaml

An example YAML file is provided as follows:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: mysql
spec:
  replicas: 1
  selector:
    matchLabels:
      name: mysql
  template:
    metadata:
      labels:
        name: mysql
    spec:
      initContainers:
      - name: getresource
        image: busybox
        command: ['sleep 20']
```



```
  containers:
  - name: mysql
    image: percona:5.7.22
    imagePullPolicy: Always
    ports:
    - containerPort: 3306
    resources:
      limits:
        memory: "500Mi"
        cpu: "500m"
      requests:
        memory: "500Mi"
        cpu: "250m"
    env:
    - name: MYSQL_ROOT_PASSWORD
      value: "mysql"
```

Step 2 Create an init container workload.

kubectl create -f deployment.yaml

Information similar to the following is displayed:

```
deployment.apps/mysql created
```

Step 3 Query the created Docker container on the node where the workload is running.

docker ps -a|grep mysql

The init container will exit after it runs to completion. The query result **Exited (0)** shows the exit status of the init container.

```
0dc822969e3f        percona             "docker-entrypoint..."   34 seconds ago       Up 33 seconds
ql_mysql-76598b8c64-mmgw9_default_522566ea-bda5-11e9-a219-fa163e8b288b_0
a745881214e7        busybox             "sh -c 'sleep 20'"       About a minute ago   Exited (0) 50 seconds ago
resource_mysql-76598b8c64-mmgw9_default_522566ea-bda5-11e9-a219-fa163e8b288b_0
615db9e60a80        cfe-pause:1l.23.1   "/pause"                 About a minute ago   Up About a minute
_mysql-76598b8c64-mmgw9_default_522566ea-bda5-11e9-a219-fa163e8b288b_0
```

----End

12.6 Setting Time Zone Synchronization

Case Scenarios

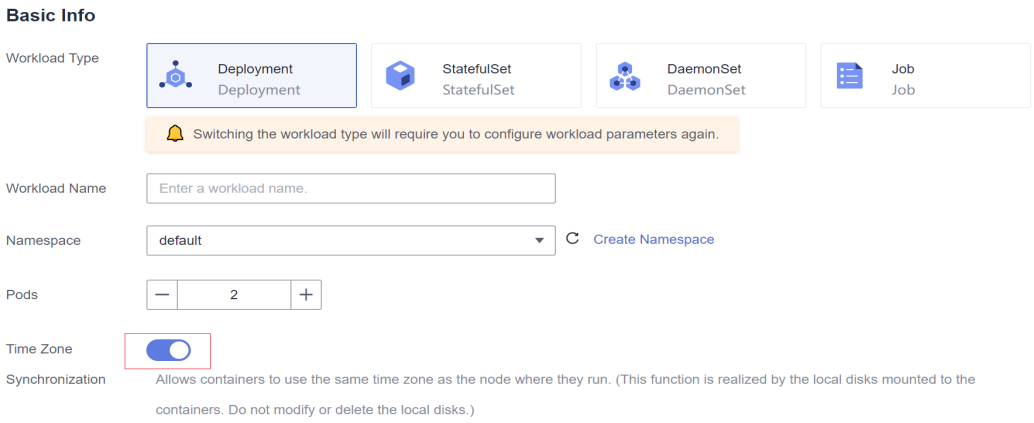
- **Scenario 1: Setting Time Zone Synchronization Between Containers and Nodes**
- **Scenario 2: Setting Time Zone Synchronization Among Containers, Container Logs, and Nodes**
- **Scenario 3: Setting Time Zone Synchronization Between Workloads and Nodes**

Scenario 1: Setting Time Zone Synchronization Between Containers and Nodes

Step 1 Log in to the CCE console.

Step 2 In the **Basic Info** area of the **Create Workload** page, enable **Time Zone Synchronization** so that the same time zone will be used for both the container and the node.

Figure 12-5 Enabling the time zone synchronization



Step 3 Log in to the node, go to the container, and check whether the time zone of the container is the same as that of the node.

date -R

Information similar to the following is displayed:

```
Tue, 04 Jun 2019 15::08:47  +0800
```

docker ps -a|grep *test*

Information similar to the following is displayed:

```
0edd74c66bdb        b2b9b536b744        "nginx -g 'daemon ..."   6 hours ago         Up 6 hours
                    k8s_container-0_test-7d7d7f4965-xwqkx_default_abf6df2e-85f7-11e9-93df-fa163ee0f9
1a_1
```

docker exec -it *oedd74c66bdb* **/bin/sh**

date -R

Information similar to the following is displayed:

```
Tue, 04 Jun 2019 15:09:20  +0800
```

----End

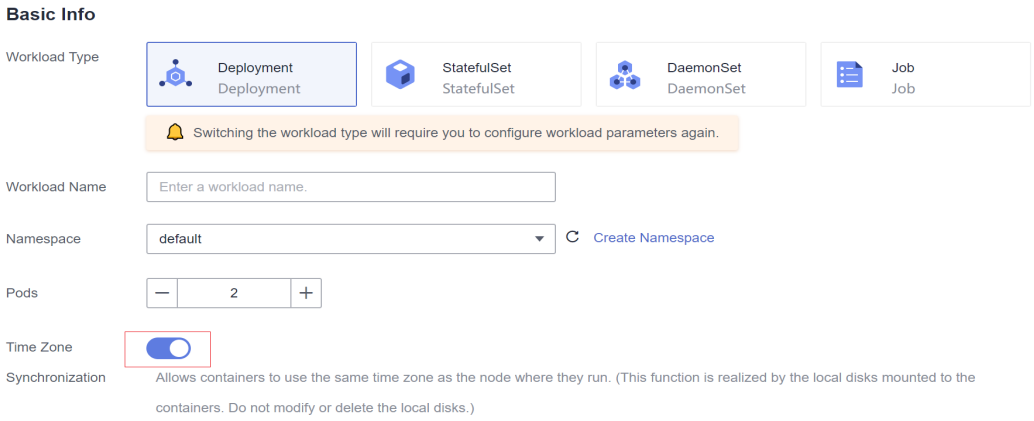
Scenario 2: Setting Time Zone Synchronization Among Containers, Container Logs, and Nodes

The difference between the time when the Java application prints logs and the container's standard time obtained in date -R mode is 8 hours.

Step 1 Log in to the CCE console.

Step 2 In the **Basic Info** area of the **Create Workload** page, enable **Time Zone Synchronization** so that the same time zone will be used for both the container and the node.

Figure 12-6 Enabling the time zone synchronization



Step 3 Log in to the node, go to the container, and modify the **catalina.sh** script.

cd /usr/local/tomcat/bin

vi catalina.sh

If you cannot run the **vi** command in the container, go to **Step 4** or run the **vi** command to add **-Duser.timezone=GMT+08** to the script, as shown in the following figure.

```
# Do this here so custom URL handles (specifically 'war:...') can be used in the security policy
JAVA_OPTS="$JAVA_OPTS -Djava.protocol.handler.pkgs=org.apache.catalina.webresources -Duser.timezone=GMT+08"
```

Step 4 Copy the script from the container to the node, add **-Duser.timezone=GMT+08** to the script, and then copy the script from the node to the container.

Run the following command to copy files in the container to the host machine:

docker cp mycontainer: /usr/local/tomcat/bin/catalina.sh /home/catalina.sh

Run the following command to copy files from the host machine to the container:

docker cp /home/catalina.sh mycontainer:/ usr/local/tomcat/bin/catalina.sh

Step 5 Restart the container.

docker restart *container_id*

Step 6 Check whether the time zone of the logs is the same as that of the node.

On the CCE console, click the workload name. On the workload details page displayed, click **Logs** in the upper right corner to view the log details. It takes about 5 minutes to load the logs.

----End

Scenario 3: Setting Time Zone Synchronization Between Workloads and Nodes

- Method 1: Set the time zone to CST when creating a container image.
- Method 2: If you do not want to modify the container, when creating a workload on the CCE console, mount the **/etc/localtime** directory of the local host to the **/etc/localtime** directory of the container.

Example:

```
kind: Deployment
apiVersion: apps/v1
metadata:
  name: test
  namespace: default
spec:
  replicas: 2
  selector:
    matchLabels:
      app: test
  template:
    metadata:
      labels:
        app: test
    spec:
      volumes:
        - name: vol-162979628557461404
          hostPath:
            path: /etc/localtime
            type: ''
      containers:
        - name: container-0
          image: 'nginx:alpine'
          volumeMounts:
            - name: vol-162979628557461404
              readOnly: true
              mountPath: /etc/localtime
          imagePullPolicy: IfNotPresent
      imagePullSecrets:
        - name: default-secret
```

12.7 Configuration Suggestions on Container Network Bandwidth Limit

Application Scenarios

Containers on the same node share the host network bandwidth. Limiting the network bandwidth of containers can effectively prevent mutual interference between containers and improve container network stability.

Constraints

The following table lists the bandwidth limitation specifications of pods.

Specifications	Tunnel	VPC	Cloud Native Network 2.0
Supported cluster versions	All versions	Clusters of v1.19.10 and later	Clusters of v1.19.10 and later
Egress bandwidth limitation	Supported	Supported	Supported

Specifications	Tunnel	VPC	Cloud Native Network 2.0
Ingress bandwidth limitation	Supported	Supported	Supported
Scenarios where bandwidth limitation is not supported	None	None	• Pod access to cloud service CIDR blocks such as 100.125.0.0/16 • Pod health check
Bandwidth limitation range	Only the rate limit in the unit of Mbit/s or Gbit/s is supported, for example, 100 Mbit/s and 1 Gbit/s. The minimum value is 1 Mbit/s and the maximum value is 4.29 Gbit/s.		

- Pod bandwidth limitation applies to regular containers (runC as the container runtime), not secure containers (Kata Containers as the container runtime).
- Pod bandwidth limitation does not apply to hostNetwork pods.

Procedure

Step 1 Edit a YAML file for a workload.

vi deployment.yaml

Set the network bandwidth for the pod in spec.template.metadata.**annotations** to limit the network traffic of the container. For details about the network bandwidth limit fields, see **Table 12-1**.

If the parameters are not specified, the network bandwidth is not limited by default.

An example is as follows:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx
spec:
  replicas: 1
  selector:
    matchLabels:
      app: nginx
  strategy:
    type: RollingUpdate
  template:
    metadata:
      labels:
        app: nginx
      annotations:
       # Ingress bandwidth
        kubernetes.io/ingress-bandwidth: 100M
       # Egress bandwidth
        kubernetes.io/egress-bandwidth: 1G
    spec:
```



```
  containers:
  - image: nginx
    imagePullPolicy: Always
    name: nginx
  imagePullSecrets:
  - name: default-secret
```

Table 12-1 Fields for limiting the network bandwidth of pods

Field	Description	Mandatory
kubernetes.io/ingress-bandwidth	Ingress bandwidth for a pod. Value range: 1k-1P. If this field is set to a value greater than 32 Gbit/s, the actual ingress bandwidth that a pod can use is 32 Gbit/s.	No
kubernetes.io/egress-bandwidth	Egress bandwidth for a pod. Value range: 1k-1P. If this field is set to a value greater than 32 Gbit/s, the actual egress bandwidth that a pod can use is 32 Gbit/s.	No

Step 2 Create a workload.

kubectl create -f deployment.yaml

Information similar to the following is displayed:

```
deployment.apps/nginx created
```

----End

12.8 Configuring the /etc/hosts File of a Pod Using hostAliases

Application Scenarios

If DNS or other related settings are inappropriate, you can use **hostAliases** to overwrite the resolution of the hostname at the pod level when adding entries to the **/etc/hosts** file of the pod.

Procedure

Step 1 Use kubectl to connect to the cluster.

Step 2 Create the **hostaliases-pod.yaml** file.

vi hostaliases-pod.yaml

The field in bold in the YAML file indicates the image name and tag. You can replace the example value as required.

```
apiVersion: v1
kind: Pod
```



```
metadata:
  name: hostaliases-pod
spec:
  hostAliases:
  - ip: 127.0.0.1
    hostnames:
    - foo.local
    - bar.local
  - ip: 10.1.2.3
    hostnames:
    - foo.remote
    - bar.remote
  containers:
    - name: cat-hosts
      image: tomcat:9-jre11-slim
      lifecycle:
        postStart:
          exec:
            command:
              - cat
              - /etc/hosts
  imagePullSecrets:
    - name: default-secret
```

Table 12-2 pod field description

Parameter	Mandatory	Description
apiVersion	Yes	API version number
kind	Yes	Type of the object to be created
metadata	Yes	Metadata definition of a resource object
name	Yes	Name of a pod
spec	Yes	Detailed description of the pod. For details, see **Table 12-3**.

Table 12-3 spec field description

Parameter	Mandatory	Description
hostAliases	Yes	Host alias
containers	Yes	For details, see **Table 12-4**.

Table 12-4 containers field description

Parameter	Mandatory	Description
name	Yes	Container name
image	Yes	Container image name
lifecycle	No	Lifecycle

Step 3 Create a pod.

kubectl create -f hostaliases-pod.yaml

If information similar to the following is displayed, the pod is created.

```
pod/hostaliases-pod created
```

Step 4 Query the pod status.

kubectl get pod hostaliases-pod

If the pod is in the **Running** state, the pod is successfully created.

```
NAME              READY     STATUS    RESTARTS   AGE
hostaliases-pod   1/1       Running   0          16m
```

Step 5 Check whether the **hostAliases** functions properly.

docker ps |grep hostaliases-pod

docker exec -ti *Container ID* /bin/sh

```
root@hostaliases-pod:/# cat /etc/hosts
# Kubernetes-managed hosts file.
127.0.0.1       localhost
::1     localhost ip6-localhost ip6-loopback
fe00::0 ip6-localnet
fe00::0 ip6-mcastprefix
fe00::1 ip6-allnodes
fe00::2 ip6-allrouters
10.0.0.25       hostaliases-pod

# Entries added by HostAliases.
127.0.0.1       foo.local       bar.local
10.1.2.3        foo.remote      bar.remote
```

----End

12.9 Configuring Domain Name Resolution for CCE Containers

This section describes how to configure domain name resolution for CCE containers.

Service

- Create a Service before you create a workload (Deployment or ReplicaSet). When the Kubernetes starts a container, it provides environment variables that point to all the Services that are running when the container is started. For example, if a Service named foo exists, all containers will obtain the following variables when they are initialized.

  ```
  FOO_SERVICE_HOST=<the host the Service is running on>
  FOO_SERVICE_PORT=<the port the Service is running on>
  ```


Therefore, you must create a Service first. Otherwise, the environment variables do not take effect. This restriction does not apply to DNS.

- CCE clusters provide the coredns add-on as the DNS server. The DNS server monitors the Kubernetes APIs for the new Services and creates a set of DNS records for each Service. If DNS is enabled throughout the cluster, all pods will be able to automatically resolve the names of Services.
- Do not specify a hostPort for a pod unless necessary. When a pod is bound to a hostPort, the number of locations to which the pod can be scheduled will be limited because each <*hostIP*, *hostPort*, *protocol*> must be unique. If you do not specify **hostIP** and **protocol**, Kubernetes uses 0.0.0.0 as the default host IP address and TCP as the default protocol.

If you only need to access the port for debugging, you can use apiserver proxies or kubectl port-forward.

If you want to open the pod port on the node, consider using the NodePort Service before using hostPort.

- Do not use hostNetwork. The reason is the same as that of using hostPort.
- When kube-proxy load balancing is not required, use headless Services (**ClusterIP** set to **None**) for service discovery.

DNS

By default, CCE provides a DNS add-on Service named coredns to automatically assign DNS domain names for other Services. If it is running in the cluster, run the following command to check the status:

```
kubectl get services coredns --namespace=kube-system
NAME       TYPE        CLUSTER-IP   EXTERNAL-IP   PORT(S)         AGE
kube-dns   ClusterIP   10.0.0.10    <none>        53/UDP,53/TCP   8m
```

If the pod is not running, you can run the **describe** command to check why the pod is not started. Assume that there is a Service that has a permanent IP address and a DNS server (coredns cluster add-on) that assigns domain name to the IP address. In this way, any pod in the cluster can communicate with the Service. You can run another application for testing. Enable a new pod, access the pod, and run the **curl** command to check whether the domain name of the Service can be correctly resolved. In some cases, the **curl** command cannot be executed due to the DNS search principles and configuration.

When a pod is created on the CCE console, not all dnsConfig configurations are opened and some default values of the pod domain name resolution parameters are used. You need to know well the default configurations. A typical case is **ndots**. If the number of dots is within the **ndots** threshold range, the domain name is considered as an internal domain name of the Kubernetes cluster and the **..svc.cluster.local** suffix is added to the domain name.

DNS Search Principles and Rules

DNS configuration file: **/etc/resolv.conf**

```
nameserver 10.247.x.x
search default.svc.cluster.local svc.cluster.local cluster.local
options ndots:3
```

Parameters:

- **nameserver**: domain name resolution server
- **search**: domain name suffix search rule. More search configurations indicate more matching times for domain name resolution. For example, if three suffixes are matched, at least six search operations are required because both IPv4 and IPv6 addresses need to be checked.
- **options**: domain name resolution option. Multiple KV values are available. A typical case is **ndots**. If the number of dots in the domain name to be accessed exceeds the value of **ndots**, the domain name is considered as a complete domain name and is directly parsed. If the number of dots is less than the value of **ndots**, the suffix **..svc.cluster.local** will be added.

Parameters in Kubernetes dnsConfig

- **nameservers**: a list of IP addresses that will be used as DNS servers for the pod. A maximum of three IP addresses can be specified. If pod's **dnsPolicy** is set to **None**, the list must contain at least one IP address, otherwise this property is optional. The servers listed will be combined to the base nameservers generated from the specified DNS policy with duplicate addresses removed.
- **searches**: a list of DNS search domains for hostname lookup in the pod. This property is optional. When specified, the provided list will be merged into the base search domain names generated from the chosen DNS policy. Duplicate domain names are removed. Kubernetes allows for at most 6 search domains.
- **options**: an optional list of objects where each object may have a **name** property (required) and a **value** property (optional). The contents in this property will be merged to the options generated from the specified DNS policy. Duplicate entries are removed.

For details, see **DNS for Services and Pods**.

Pod DNS Policies

DNS policies can be configured on a per-pod basis. Supported DNS policies are **Default**, **ClusterFirst**, and **None**.

- **Default**: The DNS configuration of a pod inherits from the host. That is, the DNS configuration of the pod is the same as that of the node.
- **ClusterFirst**: Unlike the **Default** policy, the **ClusterFirst** policy writes kube-dns (or CoreDNS) information to the DNS configuration of a pod in advance. **ClusterFirst** is the default pod policy. If **PodPolicy** is not specified for the pod, **dnsPolicy** is preset to **ClusterFirst**. However, **ClusterFirst** is mutually exclusive with **HostNetwork=true**. If **HostNetwork** is set to **true**, the **ClusterFirst** policy will be forcibly changed to the **Default** policy.
- **None**: This policy will clear the DNS configuration preset for a pod. If **dnsPolicy** is set to **None**, Kubernetes does not load any DNS configuration that is determined by its own logic in advance for the pod. Therefore, if you want to set **dnsPolicy** to **None**, you are advised to set **dnsConfig** to describe custom DNS parameters. This setting ensures that the pod has DNS configuration.

DNS configuration scenarios are provided as follows:

Scenario 1: Using a custom DNS

The following example allows you to use a custom DNS to resolve the application domain name configuration in pods. After application migration, you do not need to modify the configuration.

```
apiVersion: v1
kind: Pod
metadata:
  namespace: default
  name: dns-example
spec:
  containers:
    - name: test
      image: nginx
  dnsPolicy: "None"
  dnsConfig:
    nameservers:
      - 1.2.3.4
    searches:
      - ns1.svc.cluster.local
      - my.dns.search.suffix
    options:
      - name: ndots
        value: "2"
      - name: edns0
```

Scenario 2: Using the Kubernetes DNS add-on CoreDNS

The DNS service of Kubernetes is preferentially used for domain name resolution. If the resolution fails, the DNS service of an external cascading system is used for domain name resolution.

```
apiVersion: v1
kind: Pod
metadata:
  namespace: default
  name: dns-example
spec:
  containers:
    - name: test
      image: nginx
  dnsPolicy: ClusterFirst
```

Scenario 3: Using the public network domain name resolution

This mode applies to the scenario where the domain names in pods are to be accessed from public networks. In this case, the applications in the pods resolve domain names from an external DNS.

```
apiVersion: v1
kind: Pod
metadata:
  namespace: default
  name: dns-example
spec:
  containers:
    - name: test
      image: nginx
  dnsPolicy: Default
```

Scenario 4: Using hostNetwork

If **hostNetwork: true** is used to configure the networking in the pod, the network ports of the host machine are exposed to the application running in the pod. All network ports on the LAN where the host machine is located can be used to access the application.

```
apiVersion: extensions/v1beta1
kind: Deployment
```



```
metadata:
  name: nginx
spec:
  template:
    metadata:
      labels:
        app: nginx
    spec:
      hostNetwork: true
      dnsPolicy: ClusterFirstWithHostNet
      containers:
      - name: nginx
        image: nginx:1.7.9
        ports:
        - containerPort: 80
```

If **dnsPolicy: ClusterFirstWithHostNet** is not added, even if the pod uses the DNS of the host machine by default, other pods in the Kubernetes cluster cannot be accessed through the Service name in the container.

CoreDNS Configuration

1. Configuring the CoreDNS ConfigMap

The default CoreDNS configuration file is as follows:

```
Corefile: |
  .:53 {
      errors
      health
      kubernetes cluster.local in-addr.arpa ip6.arpa {
         pods insecure
         upstream
         fallthrough in-addr.arpa ip6.arpa
      }
      prometheus :9153
      forward . /etc/resolv.conf
      cache 30
      loop
      reload
      loadbalance
```

Parameters:

- **error**: Errors are recorded in stdout.
- **health**: The CoreDNS running status report can be obtained from **http://localhost:8080/health**.
- **kubernetes**: The CoreDNS returns a DNS query response based on the IP addresses of the Kubernetes Service and pod.
- **prometheus**: The measurement standard of CoreDNS can be found in the metrics in the format of http://localhost:9153/Prometheus. You can obtain monitoring data in Prometheus format from **http://localhost:9153/metrics**.
- **proxy** and **forward**: Any query that is not in the Kubernetes cluster domain is forwarded to the predefined resolver (/etc/resolv.conf). If the domain name cannot be resolved locally, query the upper-level address. By default, the **/etc/resolv.conf** configuration of the host machine is used.
- **cache**: The front-end cache is enabled.
- **loop**: Simple forwarding loops are detected. If a loop is detected, the CoreDNS process is stopped.
- **reload**: The changed Corefile can be automatically reloaded. After editing the ConfigMap, wait for two minutes for the modification to take effect.

- **loadbalance**: This is a round-robin DNS load balancer that randomizes the order of A, AAAA, and MX records in the answer.

2. Configuring an external DNS server

Some services are not in the Kubernetes environment and need to be accessed through the DNS. The suffix of the service name is **carey.com**.

```
carey.com:53 {
       errors
       cache 30
       proxy . 10.150.0.1
   }
```

Complete configuration file:

```
Corefile: |
  .:53 {
      errors
      health
      kubernetes cluster.local in-addr.arpa ip6.arpa {
         pods insecure
         upstream
         fallthrough in-addr.arpa ip6.arpa
      }
      prometheus :9153
      forward . /etc/resolv.conf
      cache 30
      loop
      reload
      loadbalance
  }
  carey.com:53 {
      errors
      cache 30
      proxy . 10.150.0.1
  }
```

Currently, CCE add-on management supports the configuration of stub-domains, which is more flexible and convenient than the direct editing of ConfigMaps. You do not need to configure the domain name resolution for pods.

12.10 Using Dual-Architecture Images (x86 and Arm) in CCE

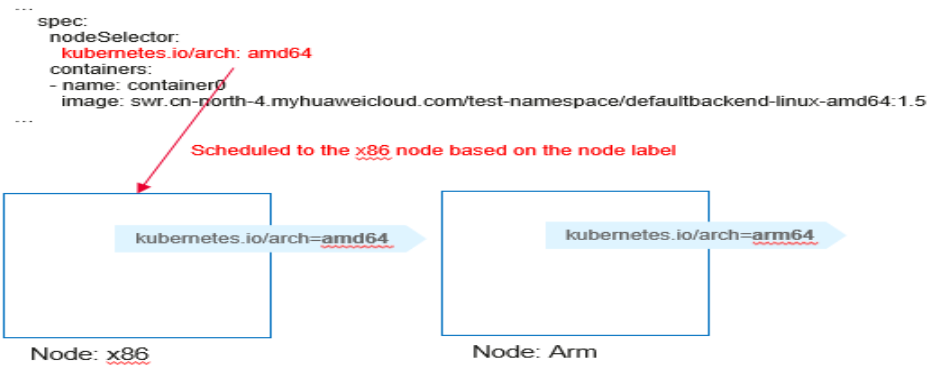
Background

CCE allows you to create x86 and Arm nodes in the same cluster. Due to different underlying architectures, Arm images (applications) cannot run on x86 nodes, and vice versa. As a result, workloads may fail to be deployed in the clusters containing x86 and Arm nodes.

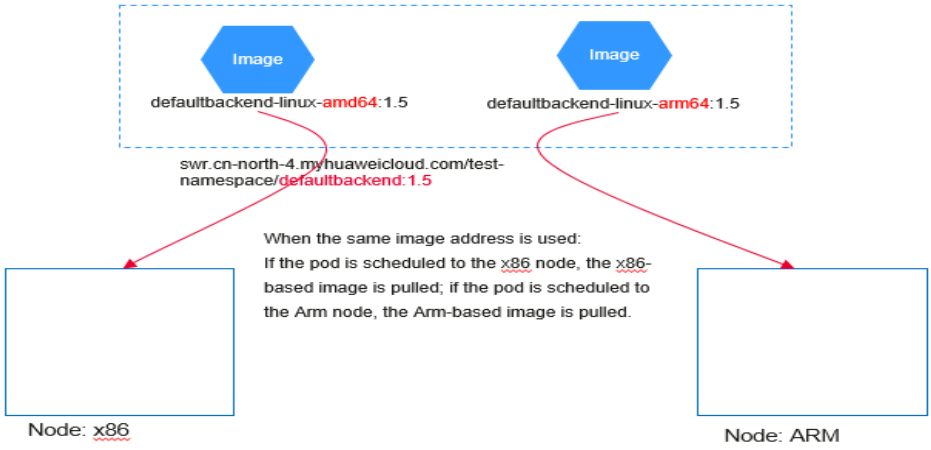
Solution

To address this issue, use either of the following methods:

- Set the service affinity when you create a workload so that the pod can be scheduled to an Arm node when the Arm-based image is used or to an x86 node when the x86-based image is used.



- Build a dual-architecture image that supports both x86 and Arm architectures. When a pod is scheduled to an Arm node, the Arm variant in the image is pulled. When a pod is scheduled to an x86 node, the x86 variant in the image is pulled. A dual-architecture image has two variants but has one unified access path. When deploying a workload, you only need to specify one image path without configuring the service affinity. In this case, the workload description file is simpler and easier to maintain.



Affinity Configuration Description

When creating a node, CCE automatically adds the **kubernetes.io/arch** label to the node to indicate the node architecture.

```
kubernetes.io/arch=amd64
```

The value **amd64** indicates the x86 architecture, and **arm64** indicates the Arm architecture.

When creating a workload, you can configure the node affinity to schedule pods to nodes using the corresponding architecture.

You can use **nodeSelector** in the YAML file to configure the architecture.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: test
spec:
  selector:
    matchLabels:
```



```
    app: test
template:
  metadata:
    labels:
      app: test
  spec:
    nodeSelector:
      kubernetes.io/arch: amd64
    containers:
    - name: container0
      image: swr.ap-southeast-1.myhuaweicloud.com/test-namespace/defaultbackend-linux-amd64:1.5
      resources:
        limits:
          cpu: 250m
          memory: 512Mi
        requests:
          cpu: 250m
          memory: 512Mi
    imagePullSecrets:
    - name: default-secret
```

Building a Dual-Architecture Image

NOTE

To create a dual-architecture image, ensure that the Docker client version is later than 18.03.

The essence of building a dual-architecture image is to build images based on the x86 and Arm architectures separately and then build the dual-architecture image manifest.

For example, the **defaultbackend-linux-amd64:1.5** and **defaultbackend-linux-arm64:1.5** are images based on the x86 and Arm architectures, respectively.

Upload the two images to SWR. For details about how to upload an image, see **Uploading an Image Through a Container Engine Client**.

```
# Add a tag to the original amd64 image defaultbackend-linux-amd64:1.5.
docker tag defaultbackend-linux-amd64:1.5  swr.ap-southeast-1.myhuaweicloud.com/test-namespace/defaultbackend-linux-amd64:1.5
# Add a tag to the original arm64 image defaultbackend-linux-arm64:1.5.
docker tag defaultbackend-linux-arm64:1.5  swr.ap-southeast-1.myhuaweicloud.com/test-namespace/defaultbackend-linux-arm64:1.5
# Push the amd64 image to the image repository.
docker push swr.ap-southeast-1.myhuaweicloud.com/test-namespace/defaultbackend-linux-amd64:1.5
# Push the arm64 image to the image repository.
docker push swr.ap-southeast-1.myhuaweicloud.com/test-namespace/defaultbackend-linux-arm64:1.5
```

Create a dual-architecture **manifest** file and upload it.

```
# Enable DOCKER_CLI_EXPERIMENTAL.
export DOCKER_CLI_EXPERIMENTAL=enabled
# Create the manifest image file.
docker manifest create --amend --insecure swr.ap-southeast-1.myhuaweicloud.com/test-namespace/defaultbackend:1.5 swr.ap-southeast-1.myhuaweicloud.com/test-namespace/defaultbackend-linux-arm64:1.5 swr.ap-southeast-1.myhuaweicloud.com/test-namespace/defaultbackend-linux-amd64:1.5
# Add arch information to the manifest image file.
docker manifest annotate swr.ap-southeast-1.myhuaweicloud.com/test-namespace/defaultbackend:1.5 swr.ap-southeast-1.myhuaweicloud.com/test-namespace/defaultbackend-linux-amd64:1.5 --arch amd64
docker manifest annotate swr.ap-southeast-1.myhuaweicloud.com/test-namespace/defaultbackend:1.5 swr.ap-southeast-1.myhuaweicloud.com/test-namespace/defaultbackend-linux-arm64:1.5 --arch arm64
# Push the manifest image file to the image repository.
docker manifest push -p --insecure swr.ap-southeast-1.myhuaweicloud.com/test-namespace/defaultbackend:1.5
```


In this way, you only need to use the image path **swr.ap-southeast-1.myhuaweicloud.com/test-namespace/defaultbackend:1.5** when creating a workload.

- When a pod is scheduled to an x86 node, the **swr.ap-southeast-1.myhuaweicloud.com/test-namespace/defaultbackend-linux-amd64:1.5** image is pulled.
- When a pod is scheduled to an Arm node, the **swr.ap-southeast-1.myhuaweicloud.com/test-namespace/defaultbackend-linux-arm64:1.5** image is pulled.

12.11 Locating Container Faults Using the Core Dump File

Application Scenarios

Linux allows you to create a core dump file if an application crashes, which contains the data the application had in memory at the time of the crash. You can analyze the file to locate the fault.

Generally, when a service application crashes, its container exits and is reclaimed and destroyed. Therefore, container core files need to be permanently stored on the host or cloud storage. This topic describes how to configure container core dumps.

Constraints

When a container core dump is persistently stored to OBS (parallel file system or object bucket), the default mount option **umask=0** is used. As a result, although the core dump file is generated, the core dump information cannot be written to the core file. You can configure the OBS mount option **umask=0077** to store core dump files to OBS. For details, see **Configuring OBS Mount Options**.

Enabling Core Dump on a Node

Log in to the node, run the following command to enable core dump, and set the path and format for storing core files:

echo "/tmp/cores/core.%h.%e.%p.%t" > /proc/sys/kernel/core_pattern

%h, **%e**, **%p**, and **%t** are placeholders, which are described as follows:

- **%h**: hostname (or pod name). You are advised to configure this parameter.
- **%e**: program file name. You are advised to configure this parameter.
- **%p**: (optional) process ID.
- **%t**: (optional) time of the core dump.

After the core dump function is enabled by running the preceding command, the generated core file is named in the format of **core.{*Host name*}.{*Program file name*}.{*Process ID*}.{*Time*}**.

You can also configure a pre-installation or post-installation script to automatically run this command when creating a node.

> **NOTE**
>
> EulerOS 2.3 Systemd has a **bug** that affects container core dump. To use core dump, perform the following operations:
>
> 1. In the **/usr/lib/systemd/system/docker.service** file on the node, change the value of **LimitCORE** to **infinity**.
> 2. Restart Docker.
> 3. Redeploy service containers.

Permanently Storing Core Dumps

A core file can be stored in your host (using a hostPath volume) or cloud storage (using a PVC). The following is an example YAML file for using a hostPath volume.

```
apiVersion: v1
kind: Pod
metadata:
  name: coredump
spec:
  volumes:
  - name: coredump-path
    hostPath:
      path: /home/coredump
  containers:
  - name: ubuntu
    image: ubuntu:12.04
    command: ["/bin/sleep","3600"]
    volumeMounts:
    - mountPath: /tmp/cores
      name: coredump-path
```

Create a pod using kubectl.

kubectl create -f pod.yaml

Verification

After the pod is created, access the container and trigger a segmentation fault of the current shell terminal.

```
$ kubectl get pod
NAME                      READY   STATUS    RESTARTS   AGE
coredump                  1/1     Running   0          56s
$ kubectl exec -it coredump -- /bin/bash
root@coredump:/# kill -s SIGSEGV $$
command terminated with exit code 139
```

Log in to the node and check whether a core file is generated in the **/home/coredump** directory. The following example indicates that a core file is generated.

```
# ls /home/coredump
core.coredump.bash.18.1650438992
```


12.12 Configuring Parameters to Delay the Pod Startup in a CCE Turbo Cluster

Application Scenarios

In a CCE Turbo cluster, the routing rules of the peer pod may take effect slowly in some specific scenarios like cross-VPC and private line interconnections. To avoid this problem, configure parameters to delay the pod startup.

You can also create enterprise routers to connect to the peer VPCs. For details, see **Connecting a Cluster to the Peer VPC Through an Enterprise Router**.

Constraints

Only the CCE Turbo clusters of the following versions support the configuration of this parameter:

- v1.19: v1.19.16-r40 or later
- v1.21: v1.21.11-r0 or later
- v1.23: v1.23.9-r0 or later
- v1.25: v1.25.4-r0 or later

Using kubectl

You can add annotations to a workload to configure whether to delay the pod startup.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx
spec:
  replicas: 10
  selector:
    matchLabels:
      app: nginx
  strategy:
    rollingUpdate:
      maxSurge: 25%
      maxUnavailable: 25%
    type: RollingUpdate
  template:
    metadata:
      labels:
        app: nginx
      annotations:
        cni.yangtse.io/readiness-delay-seconds: "20"
    spec:
      containers:
        - name: container-0
          image: nginx:alpine
          resources:
            limits:
              cpu: 100m
              memory: 200Mi
            requests:
              cpu: 100m
              memory: 200Mi
```



```
imagePullSecrets:
  - name: default-secret
```

In this example, the Deployment needs to be configured to access the IP addresses of the cross-VPC VMs. The maximum number of replicas of this Deployment is **10** and the maximum rolling upgrade surge is **25%**, which is, the maximum number of pods to be upgraded concurrently is 13. In the annotation, the pod startup delay is set to **20s**. This ensures that the cross-VPC network can be accessed normally after the pod is started.

Table 12-5 Configuring the annotation

Annotation	Default Value	Description	Value Range
cni.yangtse.io/readiness-delay-seconds	None	Indicates the waiting time for the pod health check.	0-60

12.13 Automatically Updating a Workload Version Using SWR Triggers

Application Scenarios

CCE and SWR work together to enable automatic application updates. Whenever images are updated, the applications that are built from them can be automatically updated. This could be realized by adding a trigger to the desired images.

Prerequisites

A containerized application has been created on CCE and a container image has been deployed in the application.

If no workload is created, log in to the CCE console and create one. For details, see **Creating a Deployment** or **Creating a StatefulSet**.

Procedure

Step 1 Log in to the SWR console.

Step 2 In the navigation pane, choose **My Images** and click the name of the target image.

Step 3 Click the **Triggers** tab and click **Add Trigger**. On the page displayed, configure the parameters by referring to **Table 12-6** and click **OK**.

Figure 12-7 Adding a trigger

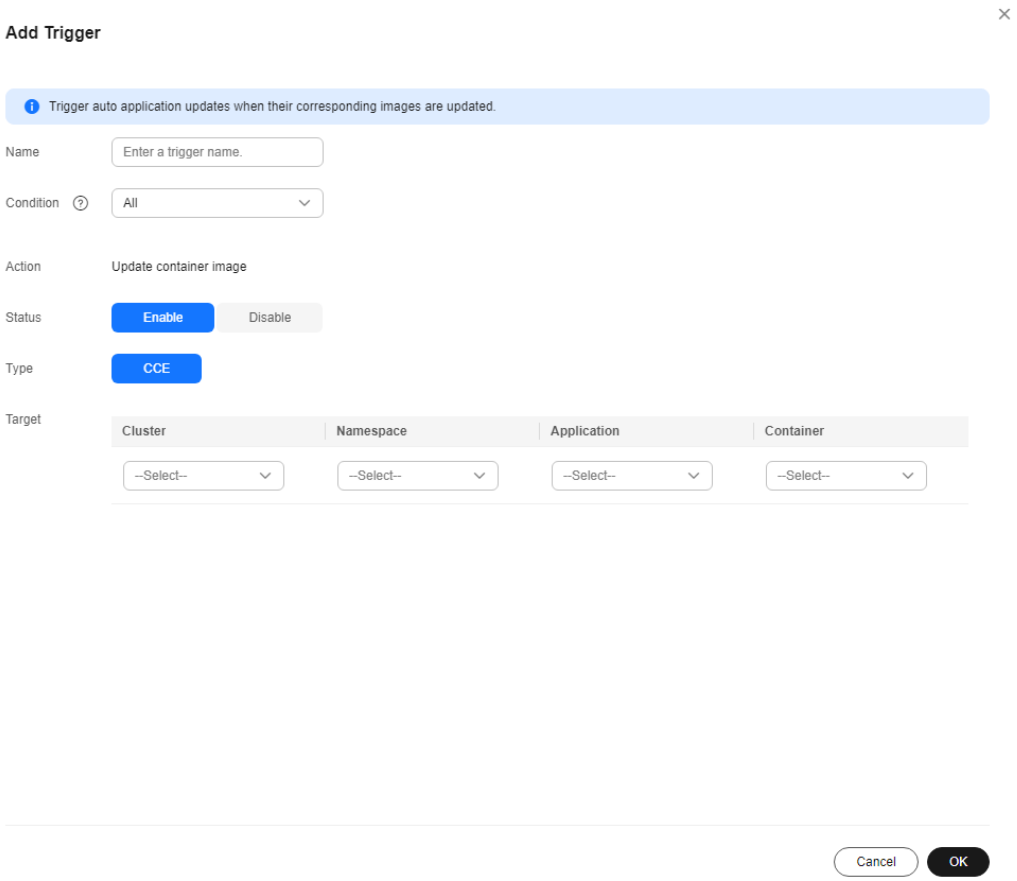


Table 12-6 Trigger

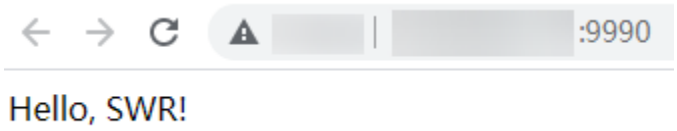
Parameter	Description
Name	The name of a trigger. The name can contain 1 to 64 characters, and must start with a letter. Only letters, digits, underscores (_), and hyphens (-) are allowed. The name cannot end with an underscore or hyphen. Consecutive underscores or hyphens are not allowed and an underscore cannot be placed next to a hyphen.

Parameter	Description
Condition	The following trigger conditions are supported: • **All**: Deployment is triggered when any image tags are generated or updated. • **Specified**: Deployment is triggered when a specific image tag is generated or updated. • **RegEx**: Deployment is triggered when an image tag that matches the regular expression is generated or updated. The regular expression rules are as follows: – *: matches any field that does not contain the path separator /. – **: matches any field that contains the path separator /. – ?: matches any single character except /. – {option 1, option 2, ...}: matches multiple options.
Action	Currently, only operation of updating images will be triggered. You need to specify the application to be updated and the container of the application.
Status	Select **Enable**.
Type	Select **CCE**.
Target	Select the application whose image is to be updated and its container.

----End

Example 1: The trigger condition is All.

A Deployment named **Nginx** is created using the Nginx v1 image. The Deployment provides service to external systems with a welcome page displaying **Hello, SWR!**

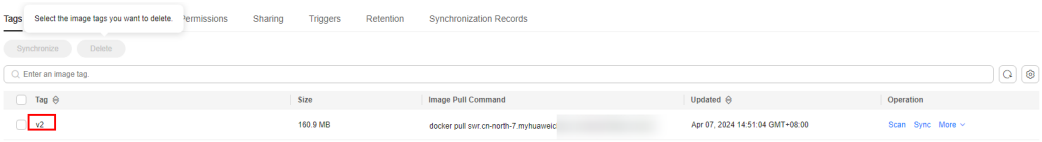


1. Add a trigger to the Nginx image.

   Set **Name** to **All_tags**, **Condition** to **All**, and select the application and all its containers that use the Nginx image.

2. The Nginx v2 image is pushed to SWR. The welcome page of the Deployment created using this new image should display **Hello, SoftWare Repository for Container!**

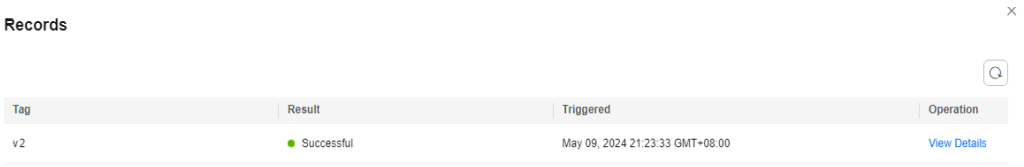
Figure 12-8 Image tag v2



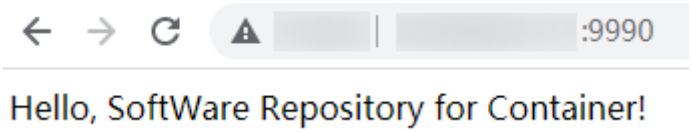
3. Check whether the Deployment is triggered successfully.

   On the **Triggers** tab, locate the trigger and click **Records** to check whether the trigger is successful.

Figure 12-9 Result

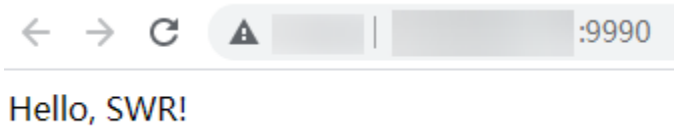


The welcome page of the Deployment displays **Hello, SoftWare Repository for Container!**



Example 2: The trigger condition is RegEx.

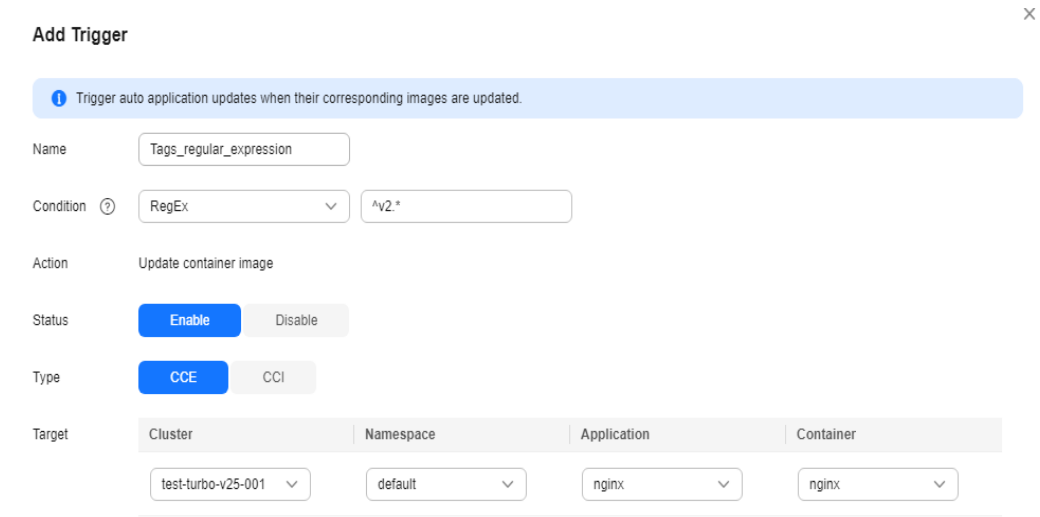
A Deployment named **nginx** is created using the Nginx image v0. The Deployment provides service to external systems with a welcome page displaying **Hello, SWR!**



1. Add a trigger to the Nginx image.

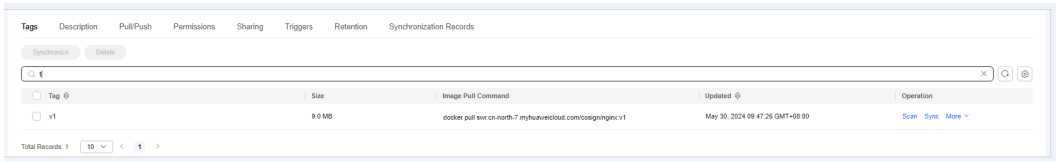
   Set **Name** to **Tags_regular_expression**, **Condition** to **RegEx**, enter the **^v2.*** regular expression, and select the application and all its containers that use the Nginx image.

Figure 12-10 Selecting RegEx



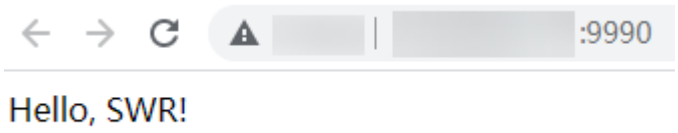
2. Push the Nginx image v1 to SWR. The welcome page of the Deployment created using this new image should display **Hello, SWR! (v1)**.

Figure 12-11 Image tag v1



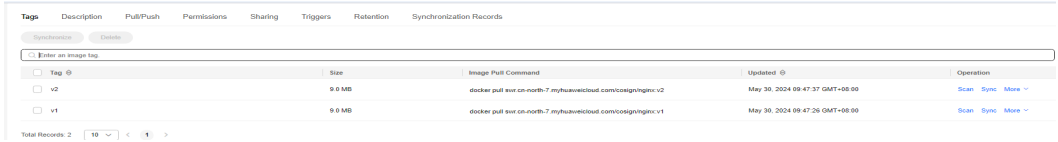
On the **Triggers** tab, click ⌄ to check the result. The workload redeployment of the Nginx image v1 is not triggered.

The workload access page still displayed **Hello, SWR!**.



3. Push the Nginx image v2 to SWR. The welcome page of the Deployment created using this new image should display **Hello, SWR! (v2)**.

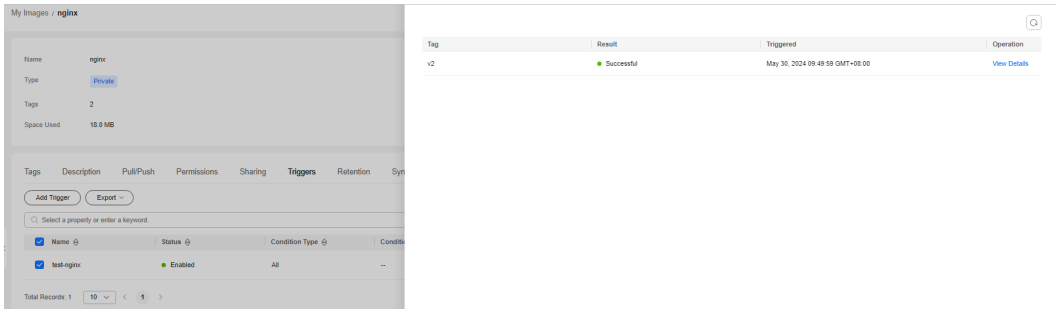
Figure 12-12 Image tag v2



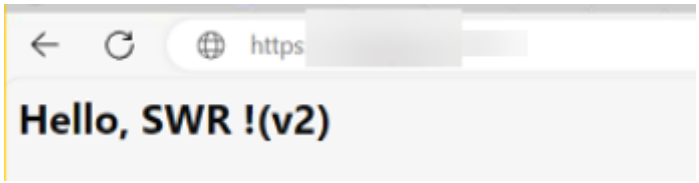
4. Check whether the Deployment is triggered successfully.

On the **Triggers** tab, click ⌄ to check the result. As shown in **Figure 12-13**, only the deployment of the Nginx image v2 is triggered.

Figure 12-13 Result



The welcome page of the Deployment displays **Hello, SWR! (v2)**.



13 Permission

13.1 Configuring kubeconfig for Fine-Grained Management on Cluster Resources

Application Scenarios

By default, the kubeconfig file provided by CCE for users has permissions bound to the **cluster-admin** role, which are equivalent to the permissions of user **root**. It is difficult to implement refined management on users with such permissions.

Purpose

Cluster resources are managed in a refined manner so that specific users have only certain permissions (such as adding, querying, and modifying resources).

Precautions

Ensure that kubectl is available on your host. If not, download it from **here** (corresponding to the cluster version or the latest version).

Configuration Method

NOTE

In the following example, only pods and Deployments in the **test** space can be viewed and added, and they cannot be deleted.

Step 1 Set the service account name to **my-sa** and namespace to **test**.

kubectl create sa **my-sa** -n **test**

```
[root@test-arm-54016 ~]#
[root@test-arm-54016 ~]# kubectl create sa my-sa -n test
serviceaccount/my-sa created
[root@test-arm-54016 ~]#
```

Step 2 Configure the role table and assign operation permissions to different resources.

vi **role-test.yaml**

The content is as follows:

NOTE

In this example, the permission rules include the read-only permission (get/list/watch) of pods in the **test** namespace, and the read (get/list/watch) and create permissions of deployments.

```
apiVersion: rbac.authorization.k8s.io/v1
kind: Role
metadata:
  annotations:
    rbac.authorization.kubernetes.io/autoupdate: "true"
  labels:
    kubernetes.io/bootstrapping: rbac-defaults
  name: myrole
  namespace: test
rules:
- apiGroups:
  - ""
  resources:
  - pods
  verbs:
  - get
  - list
  - watch
- apiGroups:
  - apps
  resources:
  - pods
  - deployments
  verbs:
  - get
  - list
  - watch
  - create
```

Create a Role.

```
kubectl create -f role-test.yaml
```

```
[root@test-arm-54016 ~]# kubectl create -f role-test.yaml
role.rbac.authorization.k8s.io/myrole created
[root@test-arm-54016 ~]#
```

Step 3 Create a RoleBinding and bind the service account to the role so that the user can obtain the corresponding permissions.

```
vi myrolebinding.yaml
```

The content is as follows:

```
apiVersion: rbac.authorization.k8s.io/v1
kind: RoleBinding
metadata:
  name: myrolebinding
  namespace: test
roleRef:
  apiGroup: rbac.authorization.k8s.io
  kind: Role
  name: myrole
subjects:
- kind: ServiceAccount
  name: my-sa
  namespace: test
```

Create a RoleBinding.

```
kubectl create -f myrolebinding.yaml
```



```
[root@test-arm-54016 ~]# kubectl create -f myrolebinding.yaml
rolebinding.rbac.authorization.k8s.io/myrolebinding created
[root@test-arm-54016 ~]#
```

The user information is configured. Now perform **Step 5** to **Step 7** to write the user information to the configuration file.

Step 4 Manually create a token that is valid for a long time for ServiceAccount.

```
vi my-sa-token.yaml
```

The content is as follows:

```
apiVersion: v1
kind: Secret
metadata:
  name: my-sa-token-secret
  namespace: test
  annotations:
    kubernetes.io/service-account.name: my-sa
type: kubernetes.io/service-account-token
```

Create a token:

```
kubectl create -f my-sa-token.yaml
```

Step 5 Configure the cluster information.

1. Decrypt the **ca.crt** file in the secret and export it.

```
kubectl get secret my-sa-token-secret -n test -oyaml |grep ca.crt: | awk '{print $2}' |base64 -d > /home/ca.crt
```

2. Set a cluster access mode. **test-arm** specifies the cluster to be accessed. **https://192.168.0.110:5443** specifies the apiserver IP address of the cluster. For details about how to obtain the IP address, see **Figure 13-1**. **/home/test.config** specifies the path for storing the configuration file.
   - If the internal API server address is used, run the following command:

     ```
     kubectl config set-cluster test-arm --server=https://192.168.0.110:5443  --certificate-authority=/home/ca.crt  --embed-certs=true --kubeconfig=/home/test.config
     ```

   - If the public API server address is used, run the following command:

     ```
     kubectl config set-cluster test-arm --server=https://192.168.0.110:5443 --kubeconfig=/home/test.config --insecure-skip-tls-verify=true
     ```

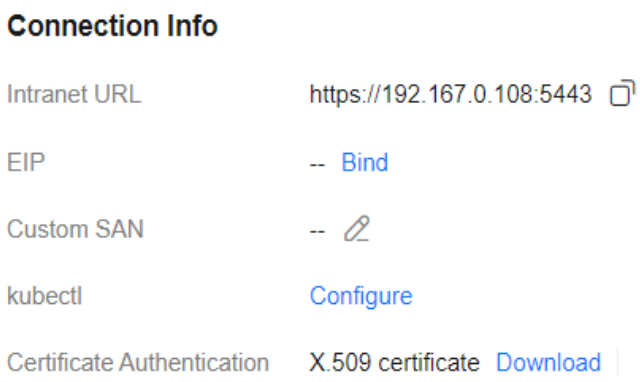
```
[root@test-arm-54016 home]# kubectl config set-cluster test-arm --server=https://10.0.1.100:5443  --certificate-authority=/home/ca.crt  --embed-certs=true --kubeconfig=/home/test.config
Cluster "test-arm" set.
[root@test-arm-54016 home]# _
```

NOTE

If you **perform operations on a node in the cluster** or **the node that uses the configuration is a cluster node**, do not set the path of kubeconfig to **/root/.kube/config**.

By default, the apiserver IP address of the cluster is a private IP address. After an EIP is bound, you can use the public network IP address to access the apiserver.

Figure 13-1 Obtaining the internal or public API server address



Step 6 Configure the cluster authentication information.

1. Obtain the cluster token. (If the token is obtained in GET mode, run **based64 -d** to decode the token.)

```
token=$(kubectl describe secret my-sa-token-secret -n test | awk '/token:/{print $2}')
```

2. Set the cluster user **ui-admin**.

```
kubectl config set-credentials ui-admin --token=$token --kubeconfig=/home/test.config
```

```
[root@test-arm-54016 home]# kubectl config set-credentials ui-admin --token=$token --kubeconfig=/home/test.config
User "ui-admin" set.
[root@test-arm-54016 home]#
```

Step 7 Configure the context information for cluster authentication access. **ui-admin@test** specifies the context name.

```
kubectl config set-context ui-admin@test --cluster=test-arm --user=ui-admin --kubeconfig=/home/test.config
```

```
[root@test-arm-54016 home]# kubectl config set-context ui-admin@test --cluster=test-arm --user=ui-admin --kubeconfig=/home/test.
config
Context "ui-admin@test" created.
[root@test-arm-54016 home]#
```

Step 8 Configure the context. For details about how to use the context, see **Verification**.

```
kubectl config use-context ui-admin@test --kubeconfig=/home/test.config
```

```
[paas@test-arm-54016 home]$ kubectl config use-context ui-admin@test --kubeconfig=/home/test.config
Switched to context "ui-admin@test".
[paas@test-arm-54016 home]$
```

NOTE

If you want to assign other users the above permissions to perform operations on the cluster, provide the generated configuration file **/home/test.config** to the user after performing step **Step 7**. The user must ensure that the host can access the API server address of the cluster. When performing step **Step 8** on the host and using kubectl, the user must set the kubeconfig parameter to the path of the configuration file.

----End

Verification

1. Pods in the **test** namespace cannot access pods in other namespaces.

```
kubectl get pod -n test --kubeconfig=/home/test.config
```

```
[paas@test-arm-54016 home]$ kubectl get pod -n test --kubeconfig=/home/test.config
NAME                        READY   STATUS             RESTARTS   AGE
test-pod-56cfcbf45b-l2q92   0/1     CrashLoopBackOff   27         91m
[paas@test-arm-54016 home]$
[paas@test-arm-54016 home]$ kubectl get pod --kubeconfig=/home/test.config
Error from server (Forbidden): pods is forbidden: User "system:serviceaccount:test:my-sa" cannot list resource "pods" in API gro
up "" in the namespace "default"
[paas@test-arm-54016 home]$
```


2. Pods in the **test** namespace cannot be deleted.

```
[paas@test-arm-54016 home]$ kubectl delete pod -n test test-pod-56cfcbf45b-12q92 --kubeconfig=/home/test.config
Error from server (Forbidden): pods "test-pod-56cfcbf45b-12q92" is forbidden: User "system:serviceaccount:test:my-sa" cannot del
ete resource "pods" in API group "" in the namespace "test"
[paas@test-arm-54016 home]$
```

Further Readings

For more information about users and identity authentication in Kubernetes, see **Authenticating**.

13.2 Configuring Namespace-level Permissions for an IAM User

Application Scenarios

In a containerized environment, various teams and departments have different resource access needs. If the permissions are set too broadly, it can lead to issues like cross-environment occupation, misoperations, and resource competition. To address these problems, it is crucial to have precise control over permissions.

CCE permissions management offers fine-grained control over permissions using IAM and Kubernetes RBAC. It supports IAM-based fine-grained permissions control and IAM token authentication. With cluster-level and namespace-level permissions control, users' access to specific resources can be effectively restricted, ensuring resource isolation and security.

Table 13-1 IAM and RBAC authorization

Authorization	Description
IAM authorization	IAM authorization for user groups is primarily concerned with managing access to cloud platform resources. Policies are used to control the permissions of each user group on specific resources. IAM emphasizes precise control over cloud resources.
RBAC authorization	RBAC authorization for user groups is role-based. Permissions are linked to roles, which are then assigned to user groups. RBAC authorization is typically employed for internal access control within applications. RBAC places greater emphasis on aligning roles with tasks.

This example describes how to manage member account permissions at the namespace level. For more information about CCE permissions management, see **Permissions**.

Solution

Assume that there are an R&D and test team and an O&M team. The two teams need to access cluster A created by member account A and have different resource access requirements, which are listed in **Table 13-2**.

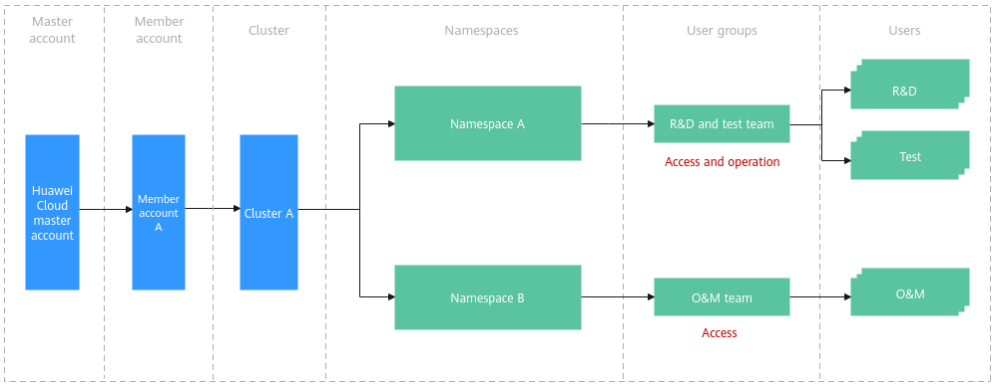
Table 13-2 Resource access requirements

Team	Permission	Policy Content
R&D and test team	Namespace A of cluster A	Access and operations on resources in Namespace A for software development and testing
O&M team	Namespace B of cluster A	Access resources in Namespace B for software development and testing

The details are as follows:

1. Create different user groups for different teams.
2. Assign different permissions to these user groups, which means, perform IAM and RBAC authorization.

Figure 13-2 Solution details



Notes and Constraints

- Before granting permissions to user groups, you need to get familiar with the system policies listed in **Permissions** for CCE. To grant permissions for other services, you need to learn about all **system-defined permissions** supported by IAM.
- Users with the **Security Administrator** permission, which includes all permissions except IAM role switching, can manage authorization settings on the namespace permissions page on the CCE console. They can also view the current user group and its permissions. The **admin** user group, for example, has this permission by default.

Step 1: Create Users and User Groups

Member account A creates users and user groups for the R&D and test team and the O&M team, to make user and resource management easier. In this example,

three users are created: development, test, and O&M users. You can create additional users as needed.

Step 1 Log in to the **management console**.

Step 2 Hover the cursor on the username in the upper right corner and choose **Identity and Access Management** from the drop-down list.

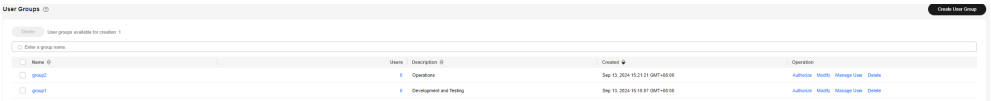
Step 3 In the navigation pane, choose **User Groups**. In the upper right corner on the displayed page, click **Create User Group**.

On the displayed page, enter a user group name and click **OK**.

In this example, you need to create two user groups, for example, **group1** (for the R&D and test team) and **group2** (for the O&M team).

The two new user groups are displayed in the user group list.

Figure 13-3 Viewing the new user groups



Step 4 In the navigation pane, choose **Users**. In the upper right corner on the displayed page, click **Create User**.

Configure parameters in **Set User Details** as required and click **Next**. For details, see **Figure 13-4**.

Select the user group to which the user is to be added and click **Create**.

In this example, three users are created for the R&D, test, and O&M personnel. The R&D and test users are added to **group1**, and the O&M user is added to **group2**.

The three new users are displayed in the user list, as shown in **Figure 13-5**.

Figure 13-4 Creating a user

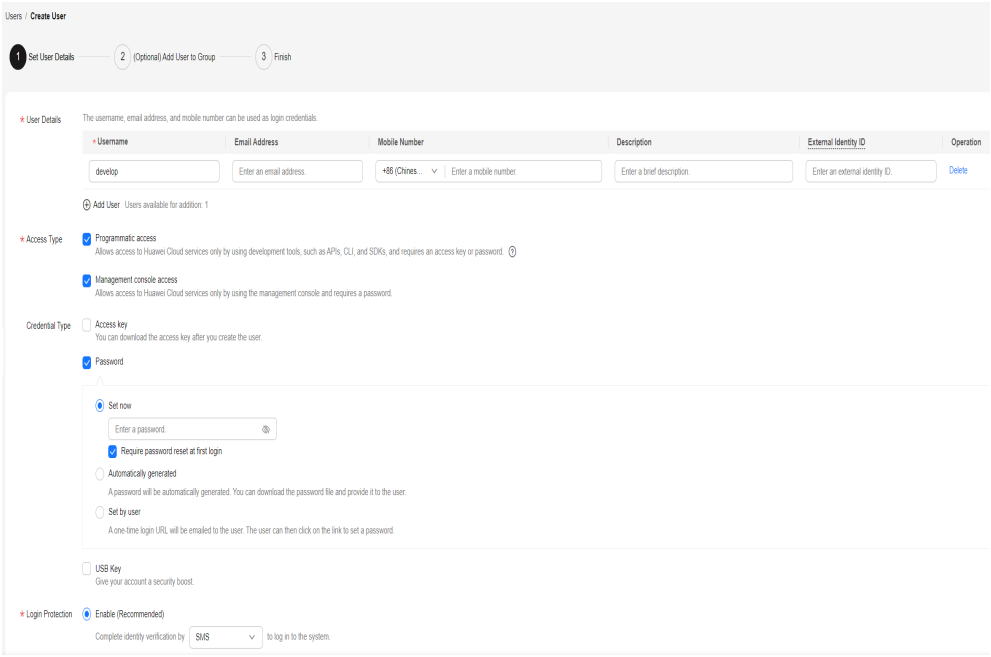
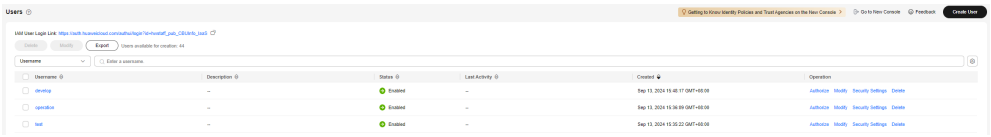


Figure 13-5 Viewing the new users



----End

Step 2: Perform IAM Authorization for the User Groups

Member account A grants IAM permissions to user groups **group1** and **group2** and manages user group permissions based on cloud services.

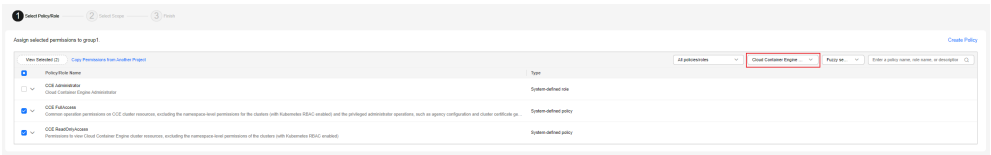
Step 1 In the navigation pane, choose **User Groups**, locate the user group to be authorized, and click **Authorize**.

Step 2 On the displayed page, select **Cloud Container Engine (CCE)** in the upper right corner.

Select a policy as required. For more information about **CCE FullAccess** and **CCE ReadOnlyAccess** policies, see **System-defined Policies**.

In this example, select the **CCE FullAccess** and **CCE ReadOnlyAccess** policies for **group1**, and select the **CCE ReadOnlyAccess** policy for **group2**.

Figure 13-6 IAM authorization



Step 3 Click **Next**, select a more refined scope as required (for example, **All resources**), and click **OK**.

Table 13-3 Authorization scopes

Solution	Description
All resources	IAM users will be able to use all resources, including those in enterprise projects, region-specific projects, and global services under your account based on assigned permissions.
Enterprise projects	IAM users will be able to use resources in the selected enterprise projects based on assigned permissions. For example, an enterprise project may contain resources that are deployed in different regions. After you associate the enterprise project with the IAM users, they can access the resources in this enterprise project based on the assigned permissions. IAM users will be able to use resources in the selected enterprise projects based on assigned permissions.
Region-specific projects	IAM users will be able to use resources in the selected region-specific projects based on assigned permissions. IAM users will be able to use resources in the selected region-specific projects based on assigned permissions.

----End

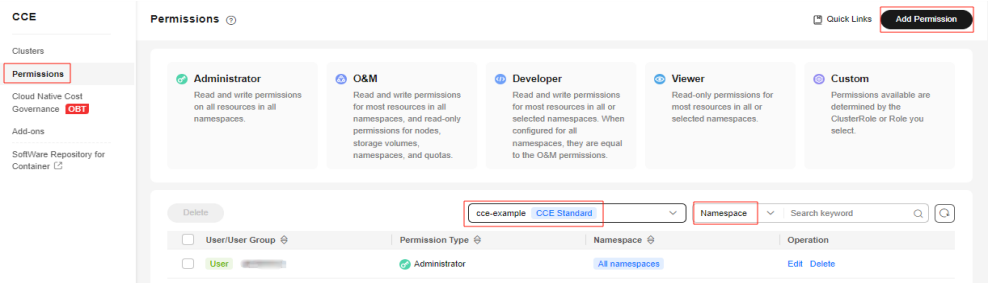
Step 3: Perform RBAC Authorization for the User Groups

Member account A performs RBAC authorization on the two user groups for namespace-level permissions management. This ensures that user groups with different roles have the minimum permissions, improving system security and management efficiency.

Step 1 Click  in the upper left corner and choose **Cloud Container Engine** to access the CCE console.

Step 2 In the navigation pane, choose **Permissions**. In the right pane, select a **cluster** to be authorized and a **namespace** and click **Add Permission** in the upper right corner.

Figure 13-7 Performing operations on the **Permissions** page



Step 3 On the displayed page, confirm the cluster name, select the user or user group to be authorized, and select a namespace to be used for cluster authorization. In this example, select the **default** namespace for **group1** and the **test** namespace for **group2**.

You can select a permission type based on your requirements. For details about permission types, see **Namespace Permissions (Kubernetes RBAC-based)**. In this example, you can select **Custom**.

1. Click **Add Custom Role**.
2. Configure the custom role. **Table 13-4** lists the custom role parameters of **group1** and **group2**.

Figure 13-8 Adding a custom role

Table 13-4 Description

Parameter	Example	Description
Name	group1: example1 group2: example2	Name of a custom role

Parameter	Example	Description
Type	group1: Role group2: Role	Custom roles are classified into ClusterRole and Role. Each ClusterRole or Role contains a group of rules that represent related permissions. For details, see **Using RBAC Authorization**. – **ClusterRole**: a cluster-level resource that can be used to configure cluster access permissions. – **Role**: used to configure access permissions in a namespace. When creating a Role, specify the namespace to which the Role belongs. In this example, you only need to configure namespace permissions. Therefore, you can choose **Role**.
Rule	group1: – get, list, watch: persistentvolume-claims – *: resources except persistentvolume-claims group2: – get, list, watch: *	The information on the left indicates the permissions to be granted. The right part indicates the resources to which the permissions are granted. You can configure this parameter based on the actual requirements.

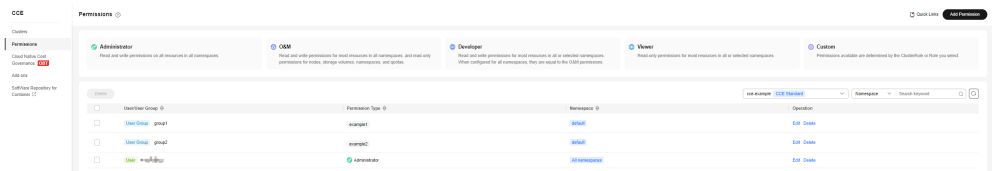
3. Click **OK**.

Step 4 On the **Add Permission** page, select the newly created role for **Custom** and click **OK**.

In this example, two permissions, **example1** and **example2**, need to be created and assigned to **group1** and **group2**, respectively.

The new permissions are displayed in the permissions list.

Figure 13-9 Viewing the permissions list



----End

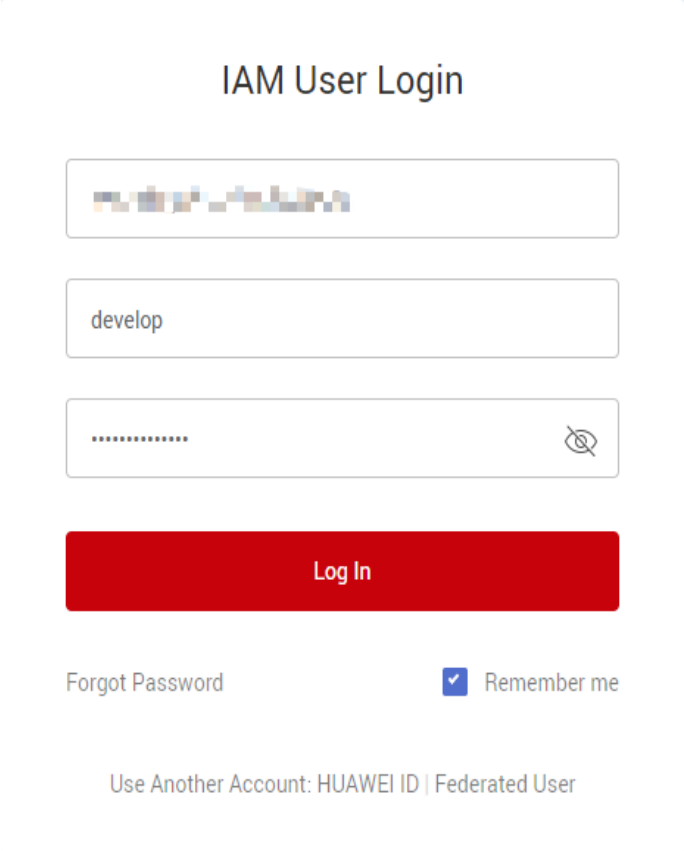
Step 4: Verify Permissions

Log in to the management console as the user created using **Step 1: Create Users and User Groups** and check whether the user has the required permissions. This section uses the **develop** user created previously as an example to verify whether the permissions have been configured.

Step 1 Bind a mobile number following instructions and verify the login. Whether or not a mobile number needs to be linked to an account depends on the choice made during the initial setup of basic user information.

Reset the password following instructions (required for the first login).

Figure 13-10 Logging in to the management console

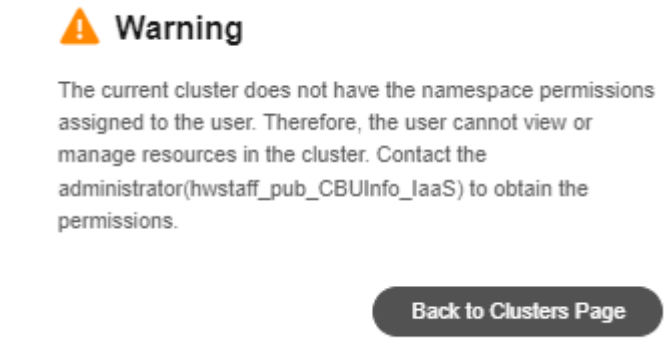


Step 2 Click in the upper left corner and choose **Cloud Container Engine** to access the CCE console.

Step 3 Check whether the **develop** user can access other clusters except **cce-example**.

Click the name of another cluster. If you see a message stating that the user does not have the necessary permissions, it means the user cannot access other clusters.

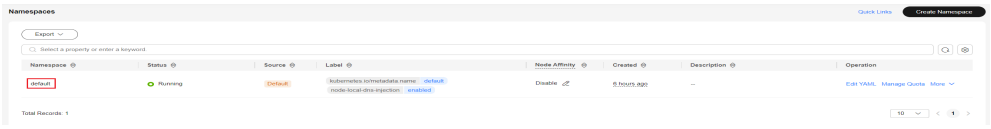
Figure 13-11 No permissions



Step 4 Check whether the **develop** user can access the **cce-example** cluster.

Click the name of the **cce-example** cluster to access the cluster console. In the navigation pane, choose **Namespace**. In the right pane, only the **default** namespace (namespace for which permissions are configured) is displayed.

Figure 13-12 Viewing namespaces

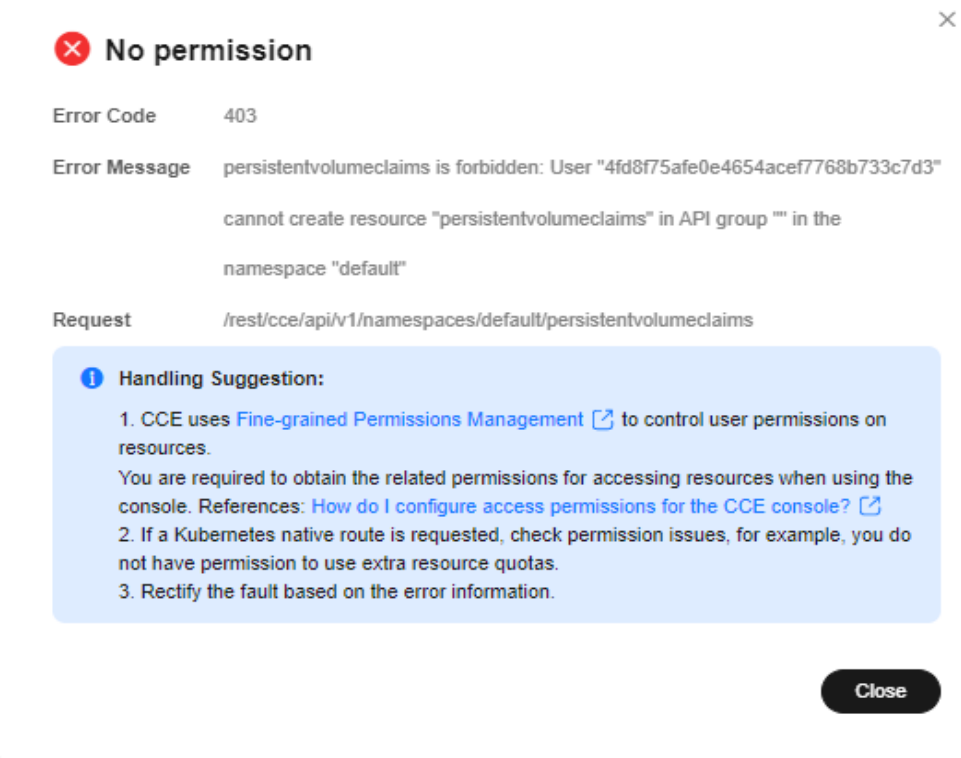


Step 5 Check whether the **develop** user can create a PVC.

In the navigation pane, choose **Storage**. In the right pane, click the **PVs** tab and click **Create PVC** in the upper right corner.

In the window that slides out from the right, configure related parameters and click **Create**. A message is displayed, indicating that the user does not have the permissions. The **develop** user only has permissions to view the PVCs, but does not have permissions to perform any operations on them because of the permissions configured in **Step 3: Perform RBAC Authorization for the User Groups**.

Figure 13-13 PVC creation failed due to insufficient permissions

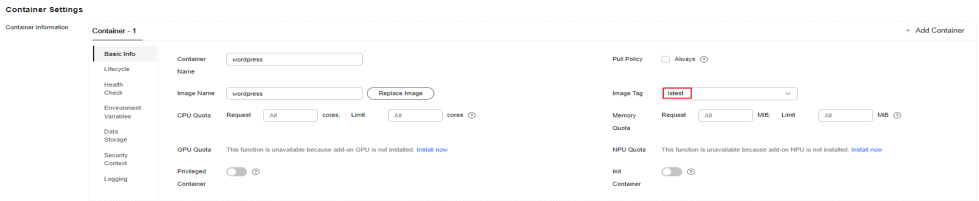


Step 6 Check whether the **develop** user can upgrade a workload.

In the navigation pane, choose **Workloads**. In the workload list, locate the row containing the **wordpress1** workload and click **Upgrade**.

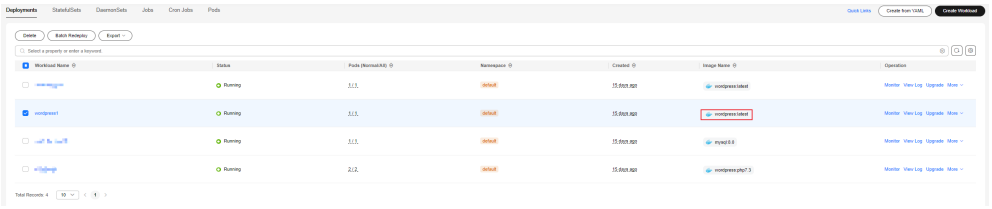
Change the original image tag from **php7.3** to **latest** and click **Upgrade Workload**.

Figure 13-14 Changing the image tag of a workload



In the workload list, check whether the image tag of **wordpress1** has been changed to **latest**. If it is, the workload has been upgraded, and the operation permissions of the **develop** user have been configured successfully.

Figure 13-15 wordpress1 after upgrade



----End

Step 5: Clear Resources

If a user group no longer requires permissions, you can delete the permissions of the user group using member account A or even delete the created user and user group.

Step 1 Delete RBAC authorization.

Log in as member account A.

Click  in the upper left corner and choose **Cloud Container Engine** to access the CCE console.

In the navigation pane, choose **Permissions**. On the page displayed, select a **cluster** and a **namespace**.

In the permissions list, locate the row containing the target permission and click **Delete**. In the dialog box displayed, click **Yes**.

Step 2 Delete a user group.

Hover the cursor on the username in the upper right corner and choose **Identity and Access Management** from the drop-down list.

In the navigation pane, choose **User Groups**. In the right pane, locate the row containing the target user group and click **Delete**.

In the displayed dialog box, enter **DELETE** and click **OK**.

Step 3 Delete a user.

In the navigation pane, choose **Users**. In the right pane, locate the row containing the target user and click **Delete**. You can also click **Edit** to disable the user and enable it again as required.

In the displayed dialog box, enter **DELETE** and click **OK**.

----End

13.3 Performing RBAC Authentication on a Namespace Using kubectl Commands

Background

CCE permissions are classified into cluster permissions and namespace permissions. Namespace permissions are based on Kubernetes RBAC and can be used to grant permissions on resources in clusters and namespaces.

Currently, the CCE console provides four types of namespace-level ClusterRole permissions by default: cluster-admin, admin, edit, and view. However, these permissions apply to resources in the namespace regardless of resource types (pods, Deployments, and Services).

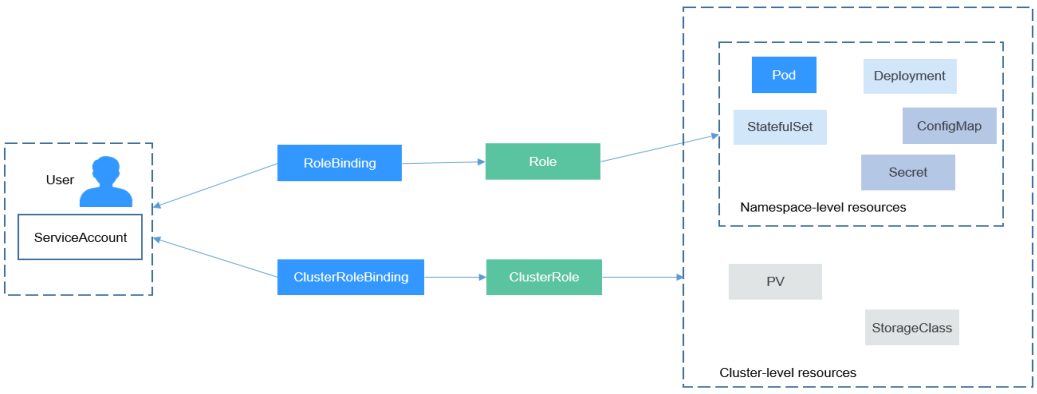
Solution

Kubernetes RBAC enables you to easily control permissions on namespace resources.

- Role: defines a set of rules for accessing Kubernetes resources in a namespace.
- RoleBinding: defines the relationship between users and roles.
- ClusterRole: defines a set of rules for accessing Kubernetes resources in a cluster (including all namespaces).
- ClusterRoleBinding: defines the relationship between users and cluster roles.

Role and ClusterRole specify actions that can be performed on specific resources. RoleBinding and ClusterRoleBinding bind roles to specific users, user groups, or ServiceAccounts. See the following figure.

Figure 13-16 Role binding



The user in the preceding figure can be an IAM user or user group in CCE. You can efficiently control permissions on namespace resources through RoleBindings.

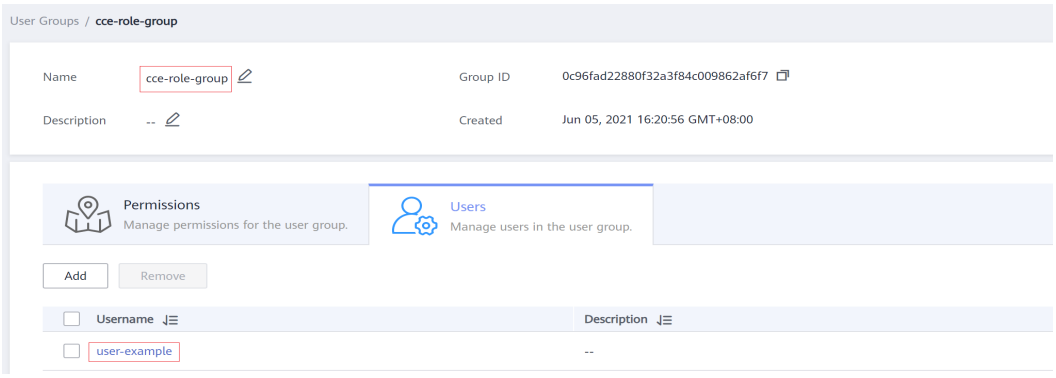
The section describes how to use Kubernetes RBAC to grant user **user-example** with the permission for viewing pods. (This is the only permission the user has.)

Prerequisites

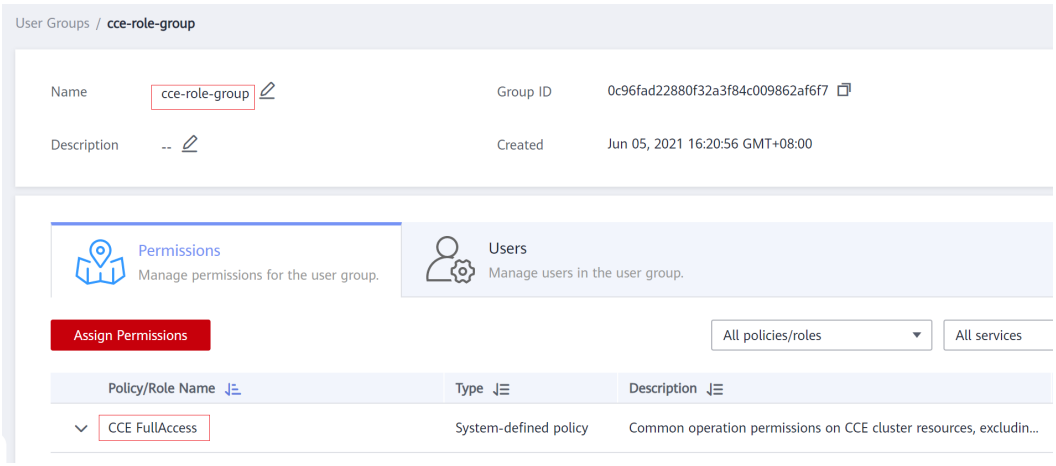
RBAC is supported only on clusters of v1.11.7-r2 or later.

Creating an IAM User and User Group

Log in to the IAM console and create an IAM user named **user-example** and a user group named **cce-role-group**. For details about how to create an IAM user and user group, see **Creating an IAM User and Logging In** and **Creating a User Group and Assigning Permissions**.



Grant the **CCE FullAccess** permission to the **cce-role-group** user group. For details about how to grant permissions to a user group, see **Creating a User Group and Assigning Permissions**.



CCE FullAccess has the permissions for cluster operations (such as cluster creation), but does not have the permissions to operate Kubernetes resources (such as viewing pods).

Creating a Cluster

Log in to CCE and create a cluster.

NOTICE

Do not use IAM user **user-example** to create a cluster because CCE automatically assigns the cluster-admin permissions of all namespaces in the cluster to the user who creates the cluster. That is, the user can fully control the resources in the cluster and all its namespaces.

Log in to the CCE console as IAM user **user-example**, **download the kubectl configuration file in the cluster and access the cluster**, and run the following command to obtain the pod information. (The output shows that **user-example** does not have the permission to view the pods or other resources.) This indicates that **user-example** does not have the permissions to operate Kubernetes resources.

```
# kubectl get pod
Error from server (Forbidden): pods is forbidden: User "0c97ac3cb280f4d91fa7c0096739e1f8" cannot list resource "pods" in API group "" in the namespace "default"
# kubectl get deploy
Error from server (Forbidden): deployments.apps is forbidden: User "0c97ac3cb280f4d91fa7c0096739e1f8" cannot list resource "deployments" in API group "apps" in the namespace "default"
```

Creating a Role and RoleBinding

Log in to the CCE console, **download the kubectl configuration file in the cluster and access the cluster**, and create a Role and RoleBinding.

NOTE

Log in as the account used to create the cluster because CCE automatically assigns the cluster-admin permissions to the account, which means that the account has the permissions to create Roles and RoleBindings. Alternatively, you can use IAM users who have the permissions to create Roles and RoleBindings.

The procedure for creating a Role is very simple. To be specific, specify a namespace and then define rules. The rules in the following example are to allow GET and LIST operations on pods in the default namespace.

```
kind: Role
apiVersion: rbac.authorization.k8s.io/v1
metadata:
  namespace: default                    # Namespace
  name: role-example
rules:
- apiGroups: [""]
  resources: ["pods"]                   # The pod can be accessed.
  verbs: ["get", "list"]                # The GET and LIST operations can be performed.
```

- **apiGroups** indicates the API group to which the resource belongs.
- **resources** indicates the resources that can be operated. Pods, Deployments, ConfigMaps, and other Kubernetes resources are supported.
- **verbs** indicates the operations that can be performed. **get** indicates querying a specific object, and **list** indicates listing all objects of a certain type. Other value options include **create**, **update**, and **delete**.

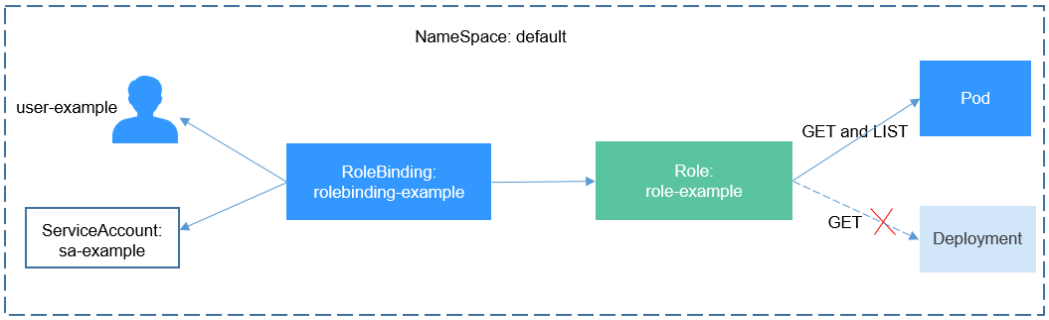
For details, see **Using RBAC Authorization**.

After creating a Role, you can bind the Role to a specific user, which is called RoleBinding. The following shows an example:


```
kind: RoleBinding
apiVersion: rbac.authorization.k8s.io/v1
metadata:
  name: RoleBinding-example
  namespace: default
  annotations:
    CCE.com/IAM: 'true'
roleRef:
  kind: Role
  name: role-example
  apiGroup: rbac.authorization.k8s.io
subjects:
- kind: User
  name: 0c97ac3cb280f4d91fa7c0096739e1f8    # IAM user ID
  apiGroup: rbac.authorization.k8s.io
```

The **subjects** section binds a Role with an IAM user so that the IAM user can obtain the permissions defined in the Role, as shown in the following figure.

Figure 13-17 Binding a role to a user



You can also specify a user group in the **subjects** section. In this case, all users in the user group obtain the permissions defined in the Role.

```
subjects:
- kind: Group
  name: 0c96fad22880f32a3f84c009862af6f7    # User group ID
  apiGroup: rbac.authorization.k8s.io
```

Verification

Use IAM user **user-example** to connect to the cluster and view the pods. The pods can be viewed.

```
# kubectl get pod
NAME                                READY   STATUS    RESTARTS   AGE
nginx-658dff48ff-7rkph              1/1     Running   0          4d9h
nginx-658dff48ff-njdhj              1/1     Running   0          4d9h
# kubectl get pod nginx-658dff48ff-7rkph
NAME                    READY   STATUS    RESTARTS   AGE
nginx-658dff48ff-7rkph  1/1     Running   0          4d9h
```

Try querying Deployments and Services in the namespace. The output shows **user-example** does not have the corresponding permissions. Try querying the pods in namespace kube-system. The output shows **user-example** does not have the corresponding permission, either. This indicates that the IAM user **user-example** has only the GET and LIST Pod permissions in the default namespace, which is the same as expected.

```
# kubectl get deploy
Error from server (Forbidden): deployments.apps is forbidden: User "0c97ac3cb280f4d91fa7c0096739e1f8"
```



```
cannot list resource "deployments" in API group "apps" in the namespace "default"
# kubectl get svc
Error from server (Forbidden): services is forbidden: User "0c97ac3cb280f4d91fa7c0096739e1f8" cannot list
resource "services" in API group "" in the namespace "default"
# kubectl get pod --namespace=kube-system
Error from server (Forbidden): pods is forbidden: User "0c97ac3cb280f4d91fa7c0096739e1f8" cannot list
resource "pods" in API group "" in the namespace "kube-system"
```


14 Release

14.1 Overview

Background

When switching between old and new services, you may be challenged in ensuring the system service continuity. If a new service version is directly released to all users at a time, it can be risky because once an online accident or bug occurs, the impact on users is great. It could take a long time to fix the issue. Sometimes, the version has to be rolled back, which severely affects user experience.

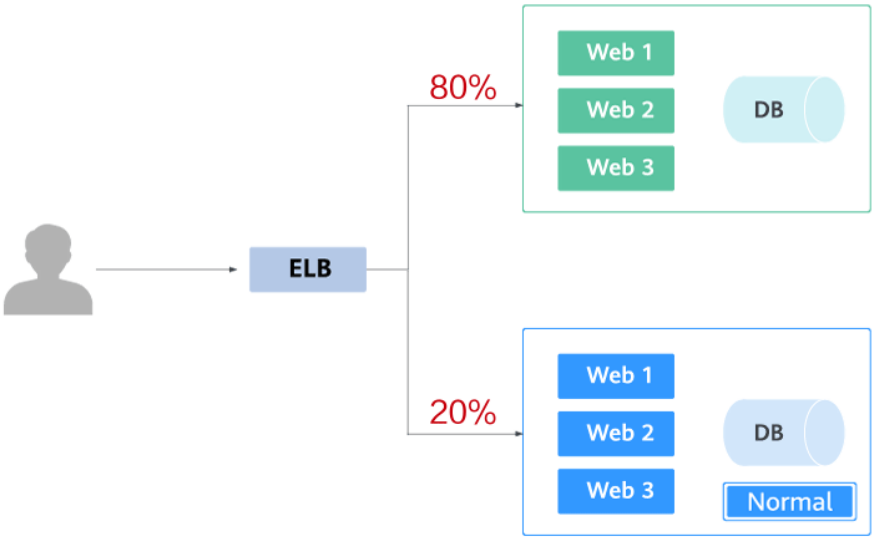
Solution

Several release policies are developed for service upgrade: grayscale release, blue-green deployment, A/B testing, rolling upgrade, and batch suspension of release. Traffic loss or service unavailability caused by releases can be avoided as much as possible.

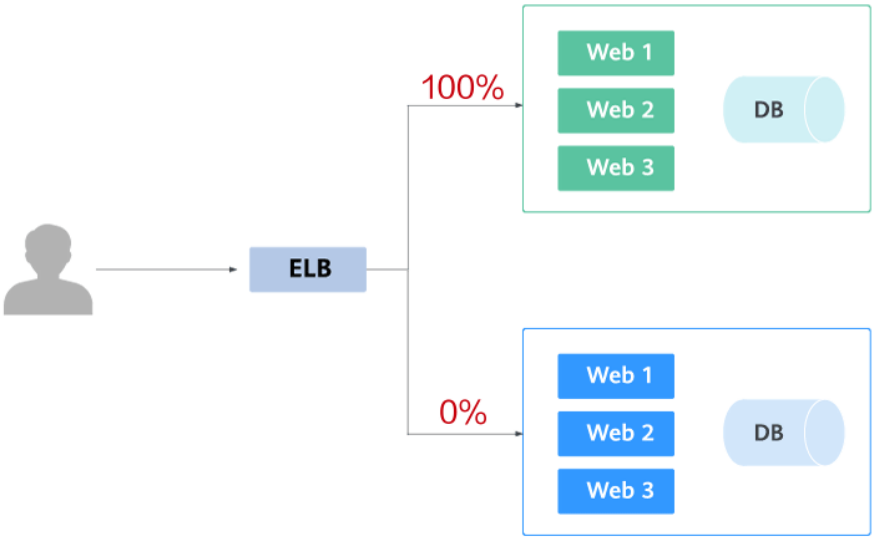
This document describes the principles and practices of grayscale release and blue-green deployment.

- Grayscale release, also called canary release, is a smooth iteration mode for version upgrade. During the upgrade, some users use the new version, while other users continue to use the old version. After the new version is stable and ready, it gradually takes over all the live traffic. In this way, service risks brought by the release of the new version can be minimized, the impact of faults can be reduced, and quick rollback is supported.

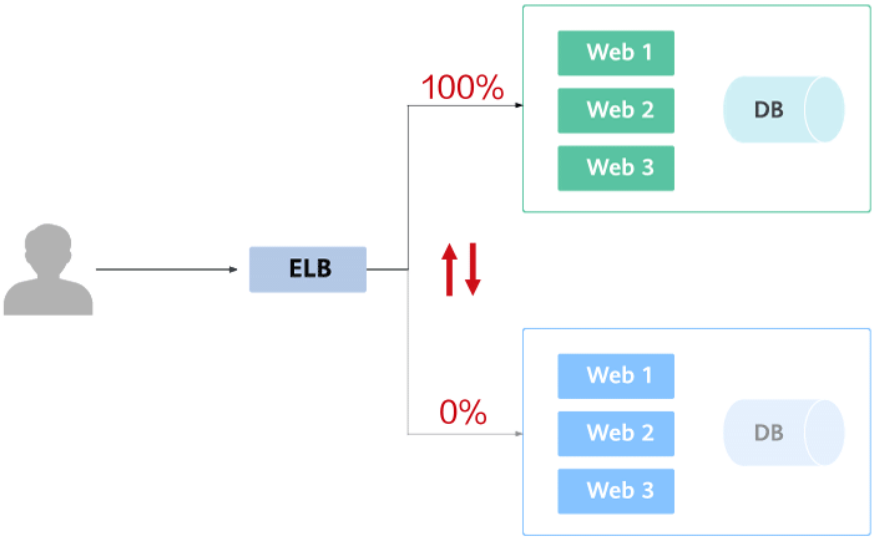
  The following figure shows the general process of grayscale release. First, divide 20% of all service traffic to the new version. If the service version runs normally, gradually increase the traffic proportion and continue to test the performance of the new version. If the new version is stable, switch all traffic to it and bring the old version offline.



If an exception occurs in the new version when 20% of the traffic goes to the new version, you can quickly switch back to the old version.



- Blue-green deployment provides a zero-downtime, predictable manner for releasing applications to reduce service interruption during the release. A new version is deployed while the old version is retained. The two versions are online at the same time. The new and old versions work in hot backup mode. The route weight is switched (0 or 100) to enable different versions to go online or offline. If a problem occurs, the version can be quickly rolled back.



Realizing Grayscale Release or Blue-Green Deployment

Kubernetes-native features can be used to implement simple grayscale release or blue-green deployment. For example, you can change the value of the label that determines the service version in the selector of a Service to change the pod backing the Service. In this way, the service can be directly switched from one version to another. If you have complex grayscale release or blue-green deployment requirements, you can deploy service meshes and open-source tools, such as Nginx Ingress and Traefik, to the cluster. You can obtain detailed instructions in the following sections:

- **Using Services to Implement Simple Grayscale Release and Blue-Green Deployment**
- **Using Nginx Ingress to Implement Grayscale Release and Blue-Green Deployment**

Table 14-1 Implementation mode comparison

Implementation	Application Scenario	Feature	Disadvantage
Service	Simple release requirements and small-scale test scenarios	No need to introduce too many plug-ins or complex configurations	Manual operations and poor automation

Implementation	Application Scenario	Feature	Disadvantage
Nginx Ingress	No special requirements.	• Only the annotation supported by Nginx Ingress needs to be configured. • Header-based, cookie-based, and service weight-based traffic division policies are supported.	The nginx-ingress add-on needs to be installed in the cluster, which consumes resources.

Both Services and Nginx Ingresses use open source Kubernetes capabilities to implement grayscale release and blue-green deployment. In this process, CCE allows you to easily perform the following operations:

- All resources can be created, viewed, and modified on the console, which is more intuitive than the kubectl command line tool.
- LoadBalancer Services are supported by the ELB service. When creating a Service, you can use an existing ELB instance or create a new one.
- The nginx-ingress add-on can be installed in just a few clicks, and ELB load balancers can be created and interconnected during the installation.

14.2 Using Services to Implement Simple Grayscale Release and Blue-Green Deployment

To implement grayscale release for a CCE cluster, deploy other open-source tools, such as Nginx Ingress, to the cluster or deploy services to a service mesh. These solutions are difficult to implement. If your grayscale release requirements are simple and you do not want to introduce too many plug-ins or complex configurations, you can refer to this section to implement simple grayscale release and blue-green deployment based on native Kubernetes features.

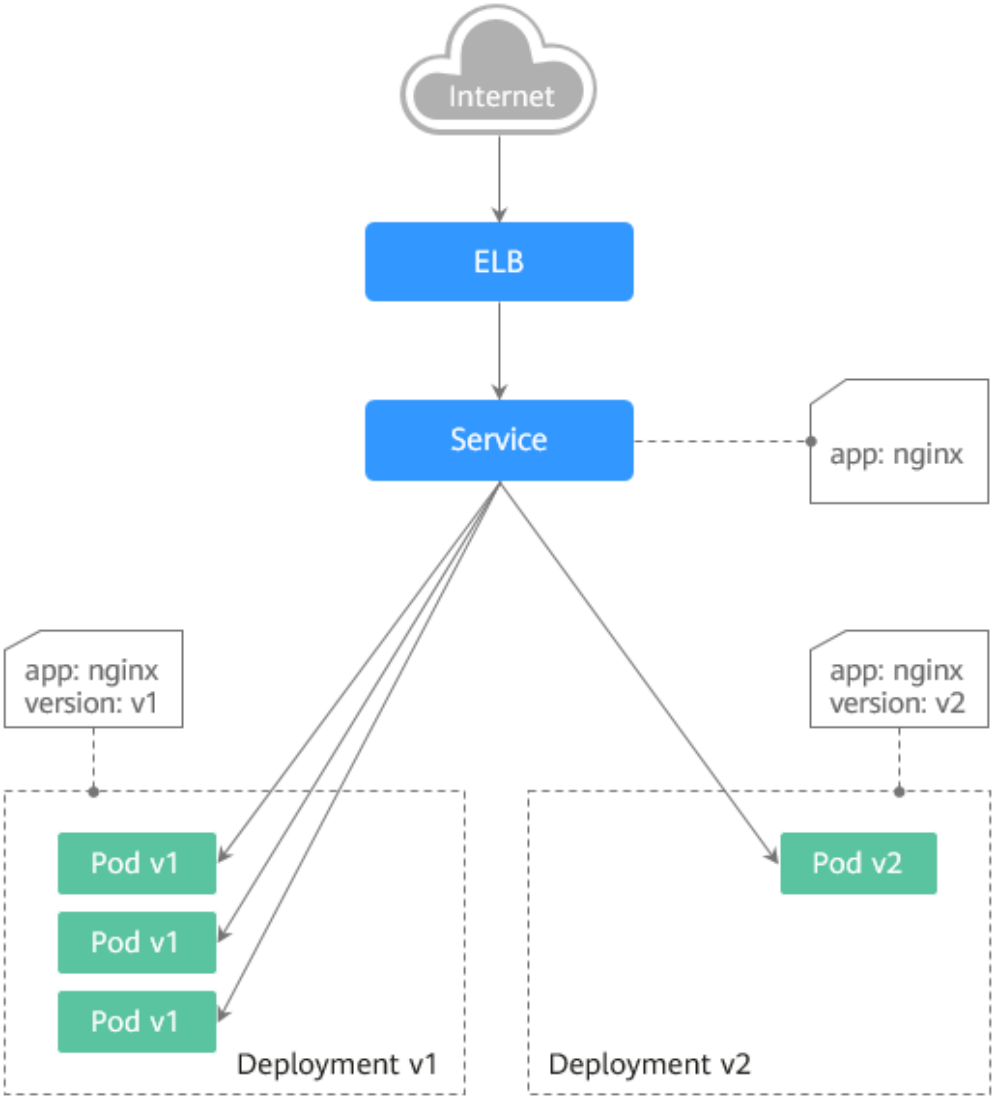
Principles

Users usually use Kubernetes objects such as Deployments and StatefulSets to deploy services. Each workload manages a group of pods. The following figure uses Deployment as an example.

Generally, a Service is created for each workload. The Service uses the selector to match the backend pod. Other Services or objects outside the cluster can access the pods backing the Service. If a pod needs to be exposed, set the Service type to LoadBalancer. The ELB load balancer functions as the traffic entrance.

- **Grayscale release principles**

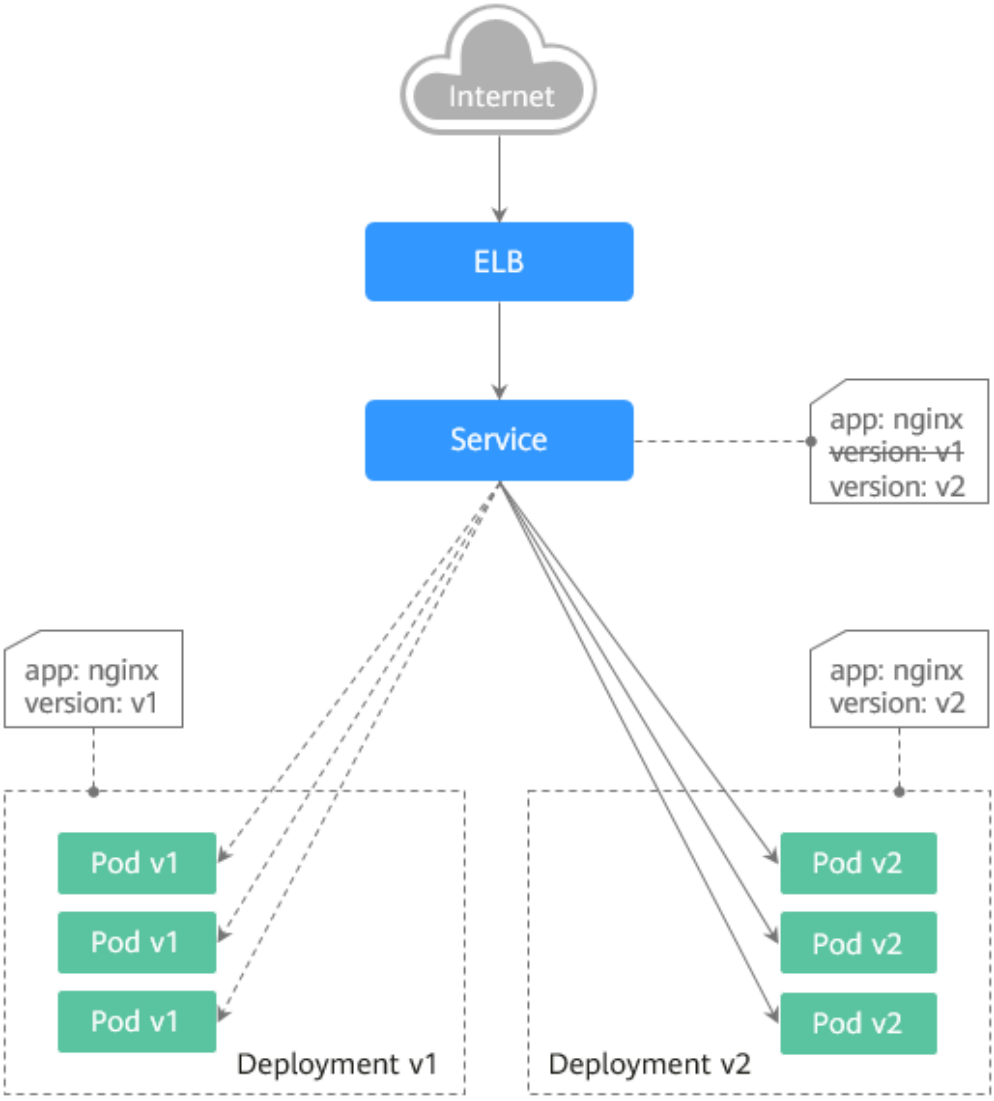
  Take a Deployment as an example. A Service, in most cases, will be created for each Deployment. However, Kubernetes does not require that Services and Deployments correspond to each other. A Service uses a selector to match backend pods. If pods of different Deployments are selected by the same selector, a Service corresponds to multiple versions of Deployments. You can adjust the number of replicas of Deployments of different versions to adjust the weights of services of different versions to achieve grayscale release. The following figure shows the process:



- **Blue-green deployment principles**

  Take a Deployment as an example. Two Deployments of different versions have been deployed in the cluster, and their pods are labeled with the same key but different values to distinguish versions. A Service uses the selector to select the pod of a Deployment of a version. In this case, you can change the

value of the label that determines the version in the Service selector to change the pod backing the Service. In this way, you can directly switch the service traffic from one version to another. The following figure shows the process:



Prerequisites

The Nginx image has been uploaded to SWR. The Nginx images have two versions: v1 and v2. The welcome pages are **Nginx-v1** and **Nginx-v2**.

Resource Creation

You can use YAML to deploy Deployments and Services in either of the following ways:

- On the **Create Deployment** page, click **Create YAML** on the right and edit the YAML file in the window.
- Save the sample YAML file in this section as a file and use kubectl to specify the YAML file. For example, run the **kubectl create -f xxx.yaml** command.

Step 1: Deploy Services of Two Versions

Two versions of Nginx services are deployed in the cluster to provide external access through ELB.

Step 1 Create a Deployment of the first version. The following uses nginx-v1 as an example. Example YAML:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx-v1
spec:
  replicas: 2             # Number of replicas of the Deployment, that is, the number of pods
  selector:               # Label selector
    matchLabels:
      app: nginx
      version: v1
  template:
    metadata:
      labels:             # Pod label
        app: nginx
        version: v1
    spec:
      containers:
      - image: {your_repository}/nginx:v1 # The image used by the container is nginx:v1.
        name: container-0
        resources:
          limits:
            cpu: 100m
            memory: 200Mi
          requests:
            cpu: 100m
            memory: 200Mi
      imagePullSecrets:
      - name: default-secret
```

Step 2 Create a Deployment of the second version. The following uses nginx-v2 as an example. Example YAML:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx-v2
spec:
  replicas: 2             # Number of replicas of the Deployment, that is, the number of pods
  selector:               # Label selector
    matchLabels:
      app: nginx
      version: v2
  template:
    metadata:
      labels:             # Pod label
        app: nginx
        version: v2
    spec:
      containers:
      - image: {your_repository}/nginx:v2   # The image used by the container is nginx:v2.
        name: container-0
        resources:
          limits:
            cpu: 100m
            memory: 200Mi
          requests:
            cpu: 100m
            memory: 200Mi
      imagePullSecrets:
      - name: default-secret
```


You can log in to the CCE console to view the deployment status.

----End

Step 2: Implement Grayscale Release

Step 1 Create a LoadBalancer Service for the Deployment. Do not specify the version in the selector. Enable the Service to select the pods of the Deployments of two versions. Example YAML:

```
apiVersion: v1
kind: Service
metadata:
  annotations:
    kubernetes.io/elb.id: 586c97da-a47c-467c-a615-bd25a20de39c    # ID of the ELB load balancer. Replace it with the actual value.
  name: nginx
spec:
  ports:
  - name: service0
    port: 80
    protocol: TCP
    targetPort: 80
  selector:            # The selector does not contain version information.
    app: nginx
  type: LoadBalancer   # Service type (LoadBalancer)
```

Step 2 Run the following command to test the access:

for i in {1..10}; do curl <EXTERNAL_IP>**; done;**

<EXTERNAL_IP> indicates the IP address of the ELB load balancer.

The command output is as follows (Half of the responses are from the Deployment of version v1, and the other half are from version v2):

```
Nginx-v2
Nginx-v1
Nginx-v1
Nginx-v1
Nginx-v2
Nginx-v1
Nginx-v2
Nginx-v1
Nginx-v2
Nginx-v2
```

Step 3 Use the console or kubectl to adjust the number of replicas of the Deployments. Change the number of replicas to 4 for v1 and 1 for v2.

kubectl scale deployment/nginx-v1 --replicas=4

kubectl scale deployment/nginx-v2 --replicas=1

Step 4 Run the following command to test the access again:

for i in {1..10}; do curl <EXTERNAL_IP>**; done;**

<EXTERNAL_IP> indicates the IP address of the ELB load balancer.

In the command output, among the 10 access requests, only two responses are from the v2 version. The response ratio of the v1 and v2 versions is the same as the ratio of the number of replicas of the v1 and v2 versions, that is, 4:1. Grayscale release is implemented by controlling the number of replicas of services of different versions.


```
Nginx-v1
Nginx-v1
Nginx-v1
Nginx-v1
Nginx-v2
Nginx-v1
Nginx-v2
Nginx-v1
Nginx-v1
Nginx-v1
```

NOTE

If the ratio of v1 to v2 is not 4:1, you can set the number of access times to a larger value, for example, 20. Theoretically, the more the times, the closer the response ratio between v1 and v2 is to 4:1.

----End

Step 3: Implement Blue-Green Deployment

Step 1 Create a LoadBalancer Service for a deployed Deployment and specify that the v1 version is used. Example YAML:

```
apiVersion: v1
kind: Service
metadata:
  annotations:
    kubernetes.io/elb.id: 586c97da-a47c-467c-a615-bd25a20de39c    # ID of the ELB load balancer. Replace it with the actual value.
  name: nginx
spec:
  ports:
  - name: service0
    port: 80
    protocol: TCP
    targetPort: 80
  selector:            # Set the version to v1 in the selector.
    app: nginx
    version: v1
  type: LoadBalancer    # Service type (LoadBalancer)
```

Step 2 Run the following command to test the access:

for i in {1..10}; do curl <EXTERNAL_IP>**; done;**

<EXTERNAL_IP> indicates the IP address of the ELB load balancer.

The command output is as follows (all responses are from the v1 version):

```
Nginx-v1
Nginx-v1
Nginx-v1
Nginx-v1
Nginx-v1
Nginx-v1
Nginx-v1
Nginx-v1
Nginx-v1
Nginx-v1
```

Step 3 Use the console or kubectl to modify the selector of the Service so that the v2 version is selected.

kubectl patch service nginx -p '{"spec":{"selector":{"version":"v2"}}}'

Step 4 Run the following command to test the access again:

for i in {1..10}; do curl <EXTERNAL_IP>**; done;**

<EXTERNAL_IP> indicates the IP address of the ELB load balancer.

The returned results show that are all responses are from the v2 version. The blue-green deployment is successfully implemented.

```
Nginx-v2
Nginx-v2
Nginx-v2
Nginx-v2
Nginx-v2
Nginx-v2
Nginx-v2
Nginx-v2
Nginx-v2
Nginx-v2
```

----End

14.3 Using Nginx Ingress to Implement Grayscale Release and Blue-Green Deployment

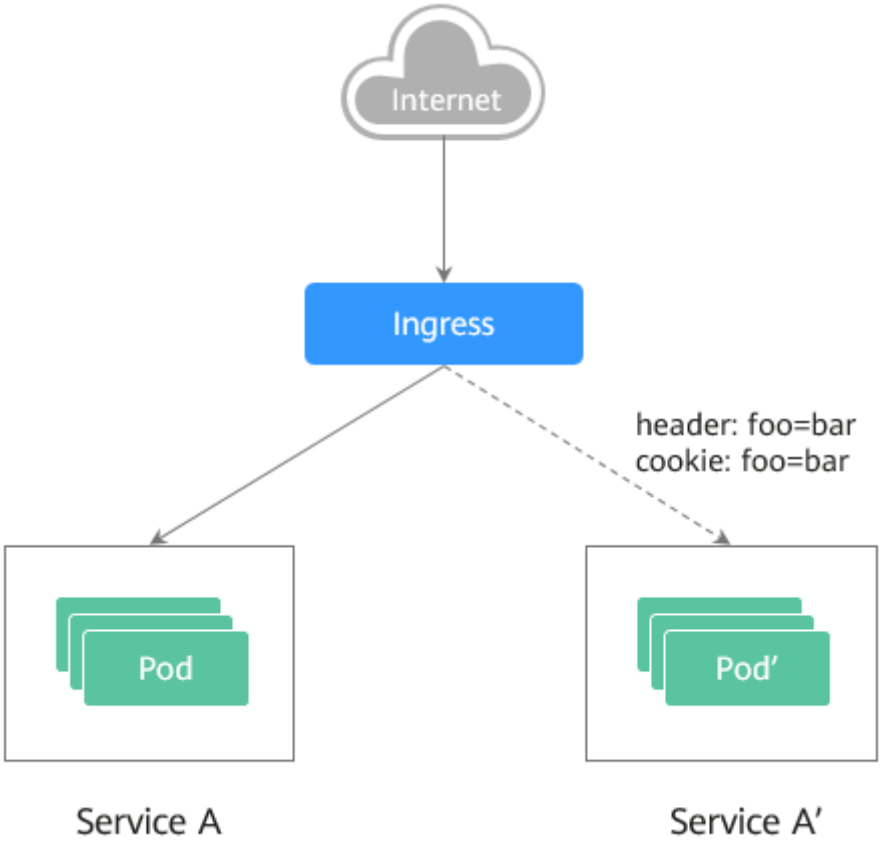
This section describes the scenarios and practices of using Nginx Ingress to implement grayscale release and blue-green deployment.

Application Scenarios

Nginx Ingress supports three traffic division policies based on the header, cookie, and service weight. Based on these policies, the following two release scenarios can be implemented:

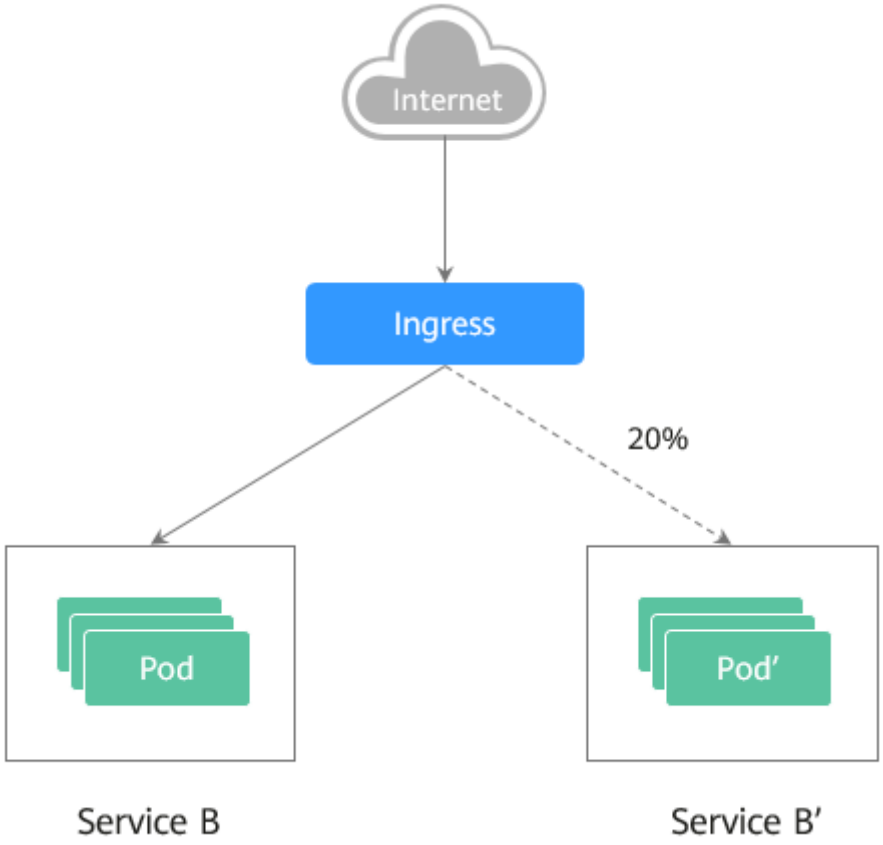
- **Scenario 1: Split some user traffic to the new version.**

  Assume that Service A that provides layer-7 networking is running. A new version is ready to go online, but you do not want to replace the original Service A. You want to forward the user requests whose header or cookie contains **foo=bar** to the new version of Service A. After the new version runs stably for a period of time, you can gradually bring the new version online and smoothly bring the old version offline. The following figure shows the process:



- **Scenario 2: Split a certain proportion of traffic to the new version.**

  Assume that Service B that provides layer-7 services is running. After some problems are resolved, a new version of Service B needs to be released. However, you do not want to replace the original Service B. Instead, you want to switch 20% traffic to the new version of Service B. After the new version runs stably for a period of time, you can switch all traffic from the old version to the new version and smoothly bring the old version offline.



Annotations

Nginx Ingress supports release and testing in different scenarios by configuring annotations for grayscale release, blue-green deployment, and A/B testing. The implementation process is as follows: Create two ingresses for the service. One is a common ingress, and the other is an ingress with the annotation **nginx.ingress.kubernetes.io/canary: "true"**, which is called a canary ingress. Configure a traffic division policy for the canary ingress. The two ingresses cooperate with each other to implement release and testing in multiple scenarios. The annotation of Nginx Ingress supports the following rules:

- **nginx.ingress.kubernetes.io/canary-by-header**

  Header-based traffic division, which is applicable to grayscale release. If the request header contains the specified header name and the value is **always**, the request is forwarded to the backend service defined by the canary ingress. If the value is **never**, the request is not forwarded and a rollback to the source version can be performed. If other values are used, the annotation is ignored and the request traffic is allocated according to other rules based on the priority.

- **nginx.ingress.kubernetes.io/canary-by-header-value**

  This rule must be used together with canary-by-header. You can customize the value of the request header, including but not limited to **always** or **never**. If the value of the request header matches the specified custom value, the request is forwarded to the corresponding backend service defined by the canary ingress. If the values do not match, the annotation is ignored and the request traffic is allocated according to other rules based on the priority.

- **nginx.ingress.kubernetes.io/canary-by-header-pattern**

  This rule is similar to canary-by-header-value. The only difference is that this annotation uses a regular expression, not a fixed value, to match the value of the request header. If this annotation and canary-by-header-value exist at the same time, this one will be ignored.

- **nginx.ingress.kubernetes.io/canary-by-cookie**

  Cookie-based traffic division, which is applicable to grayscale release. Similar to canary-by-header, this annotation is used for cookies. Only **always** and **never** are supported, and the value cannot be customized.

- **nginx.ingress.kubernetes.io/canary-weight**

  Traffic is divided based on service weights, which is applicable to blue-green deployment. This annotation indicates the percentage of traffic allocated by the canary ingress. The value ranges from 0 to 100. For example, if the value is set to **100**, all traffic is forwarded to the backend service backing the canary ingress.

NOTE

- The preceding annotation rules are evaluated based on the priority. The priority is as follows: canary-by-header -> canary-by-cookie -> canary-weight.
- When an ingress is marked as a canary ingress, all non-canary annotations except **nginx.ingress.kubernetes.io/load-balance** and **nginx.ingress.kubernetes.io/upstream-hash-by** are ignored.
- For more information, see **Annotations**.

Prerequisites

- To use Nginx Ingress to implement grayscale release of a cluster, install the nginx-ingress add-on as the Ingress Controller and expose a unified traffic entrance externally. For details, see **Installing the Add-on**.
- The Nginx image has been uploaded to SWR. The Nginx images have two versions. The welcome pages are **Old Nginx** and **New Nginx**.

Resource Creation

You can use YAML to deploy Deployments and Services in either of the following ways:

- On the **Create Deployment** page, click **Create YAML** on the right and edit the YAML file in the window.
- Save the sample YAML file in this section as a file and use kubectl to specify the YAML file. For example, run the **kubectl create -f xxx.yaml** command.

Step 1: Deploy Services of Two Versions

Two versions of Nginx are deployed in the cluster, and Nginx Ingress is used to provide layer-7 domain name access for external systems.

Step 1 Create a Deployment and Service for the first version. This section uses old-nginx as an example. Example YAML:

```
apiVersion: apps/v1
kind: Deployment
metadata:
```



```
  name: old-nginx
spec:
  replicas: 2
  selector:
    matchLabels:
      app: old-nginx
  template:
    metadata:
      labels:
        app: old-nginx
    spec:
      containers:
      - image: {your_repository}/nginx:old  # The image used by the container is nginx:old.
        name: container-0
        resources:
          limits:
            cpu: 100m
            memory: 200Mi
          requests:
            cpu: 100m
            memory: 200Mi
      imagePullSecrets:
      - name: default-secret

---

apiVersion: v1
kind: Service
metadata:
  name: old-nginx
spec:
  selector:
    app: old-nginx
  ports:
  - name: service0
    targetPort: 80
    port: 8080
    protocol: TCP
  type: NodePort
```

Step 2 Create a Deployment and Service for the second version. This section uses new-nginx as an example. Example YAML:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: new-nginx
spec:
  replicas: 2
  selector:
    matchLabels:
      app: new-nginx
  template:
    metadata:
      labels:
        app: new-nginx
    spec:
      containers:
      - image: {your_repository}/nginx:new  # The image used by the container is nginx:new.
        name: container-0
        resources:
          limits:
            cpu: 100m
            memory: 200Mi
          requests:
            cpu: 100m
            memory: 200Mi
      imagePullSecrets:
      - name: default-secret
```



```
---

apiVersion: v1
kind: Service
metadata:
  name: new-nginx
spec:
  selector:
    app: new-nginx
  ports:
  - name: service0
    targetPort: 80
    port: 8080
    protocol: TCP
  type: NodePort
```

You can log in to the CCE console to view the deployment status.

Step 3 Create an ingress to expose the service and point to the service of the old version. Example YAML:

```
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: gray-release
  namespace: default
  annotations:
    kubernetes.io/elb.port: '80'
spec:
  rules:
    - host: www.example.com
      http:
        paths:
          - path: /
            backend:
              service:
                name: old-nginx      # Set the back-end service to old-nginx.
                port:
                  number: 80
            property:
              ingress.beta.kubernetes.io/url-match-mode: STARTS_WITH
            pathType: ImplementationSpecific
  ingressClassName: nginx   # Nginx ingress is used.
```

Step 4 Run the following command to verify the access:

```
curl -H "Host: www.example.com"  http://<EXTERNAL_IP>
```

In the preceding command, <EXTERNAL_IP> indicates the external IP address of the Nginx ingress.

Expected outputs:

```
Old Nginx
```

----End

Step 2: Launch the New Version of the Service in Grayscale Release Mode

Set the traffic division policy for the service of the new version. CCE supports the following policies for grayscale release and blue-green deployment:

Header-based, **cookie-based**, and **weight-based** traffic division rules

Grayscale release can be implemented based on all these policies. Blue-green deployment can be implemented by adjusting the new service weight to 100%. For details, see the following examples.

CAUTION

Pay attention to the following:

- Only one canary ingress can be defined for the same service so that the backend service supports a maximum of two versions.
- Even if the traffic is completely switched to the canary ingress, the old version service must still exist. Otherwise, an error is reported.

- **Header-based rules**

  In the following example, only the request whose header contains **Region** set to **bj** or **gz** can be forwarded to the service of the new version.

  a. Create a canary ingress, set the backend service to the one of the new versions, and add annotations.

```
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: canary-ingress
  namespace: default
  annotations:
    nginx.ingress.kubernetes.io/canary: "true"                    # Enable canary.
    nginx.ingress.kubernetes.io/canary-by-header: "Region"
    nginx.ingress.kubernetes.io/canary-by-header-pattern: "bj|gz"    # Requests whose header contains Region with the value bj or gz are forwarded to the canary ingress.
    kubernetes.io/elb.port: '80'
spec:
  rules:
    - host: www.example.com
      http:
        paths:
          - path: /
            backend:
              service:
                name: new-nginx      # Set the back-end service to new-nginx.
                port:
                  number: 80
            property:
              ingress.beta.kubernetes.io/url-match-mode: STARTS_WITH
            pathType: ImplementationSpecific
  ingressClassName: nginx   # Nginx ingress is used.
```

  b. Run the following command to test the access:

```
$ curl -H "Host: www.example.com" -H "Region: bj" http://<EXTERNAL_IP>
New Nginx
$ curl -H "Host: www.example.com" -H "Region: sh" http://<EXTERNAL_IP>
Old Nginx
$ curl -H "Host: www.example.com" -H "Region: gz" http://<EXTERNAL_IP>
New Nginx
$ curl -H "Host: www.example.com" http://<EXTERNAL_IP>
Old Nginx
```

  In the preceding command, <EXTERNAL_IP> indicates the external IP address of the Nginx ingress.

  Only requests whose header contains **Region** with the value **bj** or **gz** are responded by the service of the new version.

- **Cookie-based rules**

  In the following example, only the request whose cookie contains **user_from_bj** can be forwarded to the service of the new version.

  a. Create a canary ingress, set the backend service to the one of the new versions, and add annotations.

> **NOTE**
>
> If you have created a canary ingress in the preceding steps, delete it and then perform this step to create a canary ingress.

```
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: canary-ingress
  namespace: default
  annotations:
    nginx.ingress.kubernetes.io/canary: "true"                      # Enable canary.
    nginx.ingress.kubernetes.io/canary-by-cookie: "user_from_bj"    # Requests whose cookie
contains user_from_bj are forwarded to the canary ingress.
    kubernetes.io/elb.port: '80'
spec:
  rules:
    - host: www.example.com
      http:
        paths:
          - path: /
            backend:
              service:
                name: new-nginx      # Set the back-end service to new-nginx.
                port:
                  number: 80
            property:
              ingress.beta.kubernetes.io/url-match-mode: STARTS_WITH
            pathType: ImplementationSpecific
  ingressClassName: nginx   # Nginx ingress is used.
```

b. Run the following command to test the access:

```
$ curl -s -H "Host: www.example.com" --cookie "user_from_bj=always" http://
<EXTERNAL_IP>
New Nginx
$ curl -s -H "Host: www.example.com" --cookie "user_from_gz=always" http://
<EXTERNAL_IP>
Old Nginx
$ curl -s -H "Host: www.example.com" http://<EXTERNAL_IP>
Old Nginx
```

In the preceding command, <EXTERNAL_IP> indicates the external IP address of the Nginx ingress.

Only requests whose cookie contains **user_from_bj** with the value **always** are responded by the service of the new version.

- **Service weight-based rules**

  Example 1: Only 20% of the traffic is allowed to be forwarded to the service of the new version to implement grayscale release.

  a. Create a canary ingress and add annotations to import 20% of the traffic to the backend service of the new version.

  > **NOTE**
  >
  > If you have created a canary ingress in the preceding steps, delete it and then perform this step to create a canary ingress.

```
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: canary-ingress
  namespace: default
  annotations:
    nginx.ingress.kubernetes.io/canary: "true"         # Enable canary.
    nginx.ingress.kubernetes.io/canary-weight: "20"    # Forward 20% of the traffic to the canary
ingress.
    kubernetes.io/elb.port: '80'
```



```
spec:
  rules:
    - host: www.example.com
      http:
        paths:
          - path: /
            backend:
              service:
                name: new-nginx      # Set the back-end service to new-nginx.
                port:
                  number: 80
            property:
              ingress.beta.kubernetes.io/url-match-mode: STARTS_WITH
            pathType: ImplementationSpecific
  ingressClassName: nginx   # Nginx ingress is used.
```

b. Run the following command to test the access:

```
$ for i in {1..20}; do curl -H "Host: www.example.com" http://<EXTERNAL_IP>; done;
Old Nginx
Old Nginx
Old Nginx
New Nginx
Old Nginx
New Nginx
Old Nginx
New Nginx
Old Nginx
Old Nginx
Old Nginx
Old Nginx
Old Nginx
New Nginx
Old Nginx
Old Nginx
Old Nginx
Old Nginx
Old Nginx
Old Nginx
```

In the preceding command, <EXTERNAL_IP> indicates the external IP address of the Nginx ingress.

It can be seen that there is a 4/20 probability that the service of the new version responds, which complies with the setting of the service weight of 20%.

NOTE

After traffic is divided based on the weight (20%), the probability of accessing the new version is close to 20%. The traffic ratio may fluctuate within a small range, which is normal.

Example 2: Allow all traffic to be forwarded to the service of the new version to implement blue-green deployment.

a. Create a canary ingress and add annotations to import 100% of the traffic to the backend service of the new version.

NOTE

If you have created a canary ingress in the preceding steps, delete it and then perform this step to create a canary ingress.

```
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: canary-ingress
  namespace: default
  annotations:
```



```
    nginx.ingress.kubernetes.io/canary: "true"          # Enable canary.
    nginx.ingress.kubernetes.io/canary-weight: "100"    # All traffic is forwarded to the canary
ingress.
    kubernetes.io/elb.port: '80'
spec:
  rules:
    - host: www.example.com
      http:
        paths:
          - path: /
            backend:
              service:
                name: new-nginx       # Set the back-end service to new-nginx.
                port:
                  number: 80
            property:
              ingress.beta.kubernetes.io/url-match-mode: STARTS_WITH
            pathType: ImplementationSpecific
  ingressClassName: nginx   # Nginx ingress is used.
```

b. Run the following command to test the access:

```
$ for i in {1..10}; do curl -H "Host: www.example.com" http://<EXTERNAL_IP>; done;
New Nginx
New Nginx
New Nginx
New Nginx
New Nginx
New Nginx
New Nginx
New Nginx
New Nginx
New Nginx
```

In the preceding command, <EXTERNAL_IP> indicates the external IP address of the Nginx ingress.

All access requests are responded by the service of the new version, and the blue-green deployment is successfully implemented.

15 Batch Computing

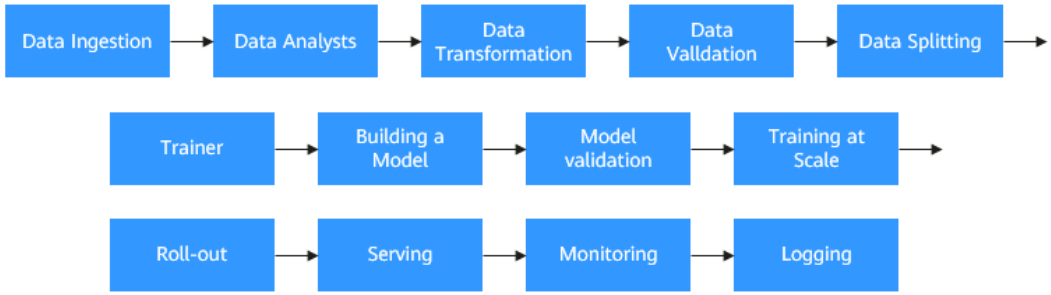
15.1 Deploying and Using Kubeflow in a CCE Cluster

15.1.1 Deploying Kubeflow

Background

Building an end-to-end AI computing platform based on Kubernetes is complex. More than a dozen of phases is required. Apart from the familiar model training phase, the process also includes data collection, preprocessing, resource management, feature extraction, data verification, model management, model release, and monitoring. If AI algorithm engineers want to run a model training task, they have to build an entire AI computing platform first. Imagine how time- and labor-consuming that is and how much knowledge and experience it requires.

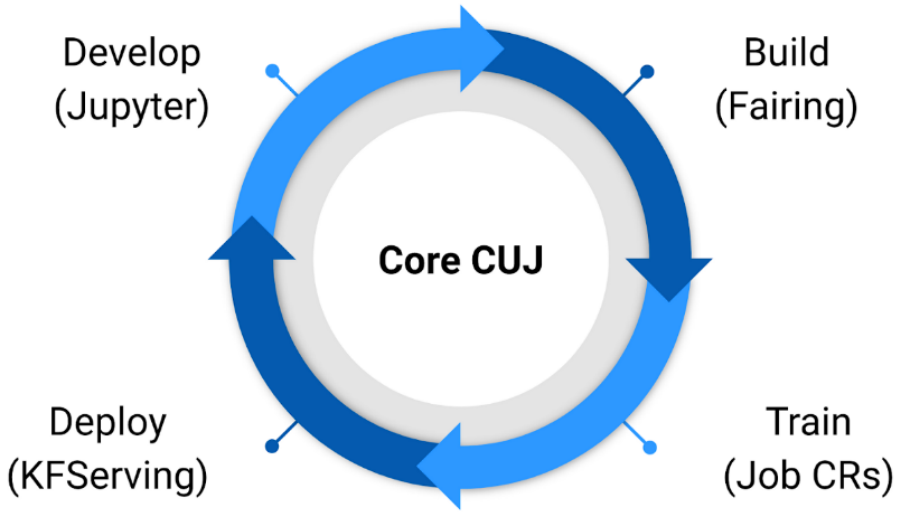
Figure 15-1 Phrases for training a model



Kubeflow was released in 2017, which is built on containers and Kubernetes. It aims to provide data scientists, machine learning engineers, and system O&M personnel with a platform for agile deployment, development, training, release, and management of machine learning services. It leverages the advantages of cloud native technologies to enable users to quickly and easily deploy, use, and manage the most popular machine learning software.

Kubeflow 1.0 is now available, providing capabilities in development, building, training, and deployment that cover the entire process of machine learning and deep learning for enterprise users.

The following shows an example.



With Kubeflow 1.0, you first develop a model using Jupyter, and then set up containers using tools such as Fairing (SDK). Next, you create Kubernetes resources to train the model. After the training is complete, you create and deploy servers for inference using KFServing. This is how you use Kubeflow to establish an end-to-end agile process of a machine learning task. This process can be fully automated using pipelines, which help achieve DevOps in the AI field.

Prerequisites

- A cluster named clusterA has been created on CCE. The cluster has an available GPU node that has two or more GPUs.
- EIPs have been bound to the nodes, and the kubectl command line tool has been configured. For details, see **Connecting to a Cluster Using kubectl**.

Installing Kustomize

Kustomize is an open-source tool used to manage the configuration of applications running in Kubernetes clusters. It allows you to modify application configuration. Starting with Kubeflow 1.3, all components should be deployed only using Kustomize.

Step 1 Install Kustomize. Kubeflow is incompatible with earlier versions of Kustomize. Therefore, only Kustomize 5 and later versions are supported. In this example, Kubeflow 5.1.0 is used.

```
curl -o install_kustomize.sh "https://raw.githubusercontent.com/kubernetes-sigs/kustomize/master/hack/install_kustomize.sh"
sh install_kustomize.sh 5.1.0 .
```


The installation may take 3 to 5 minutes, and the information similar to the following will be displayed:

```
v5.1.0
kustomize installed to /root/kubeflow/./kustomize
```

Step 2 Move kustomize to the **/bin** directory so that the **kustomize** command can be used globally.

```
cp kustomize /bin/
```

----End

Installing Kubeflow

Perform the steps in this section to install all official Kubeflow components. After the installation, you can access the Kubeflow central dashboard. For details, see **Connecting to Kubeflow**.

Step 1 Install Kubeflow 1.7.0.

```
wget https://github.com/kubeflow/manifests/archive/refs/tags/v1.7.0.zip
unzip v1.7.0.zip
```

Step 2 Use Kustomize to create a YAML file for deploying Kubeflow.

```
cd ./manifests-1.7.0/
kustomize build example -o example.yaml
```

Step 3 Configure storage resources required by Kubeflow.

- katib-mysql
- mysql-pv-claim
- minio-pv-claim
- authservice-pvc

Some storage resources need to be configured during the installation. The storage configuration in the official example cannot take effect in CCE. This may result in the preceding PVC fail to be created. Therefore, create a PVC with the same name in the cluster in advance. In this example, the EVS disk is used. You can change the storage type as required.

Create the **pvc.yaml** file. The following is an example:

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: katib-mysql
  namespace: kubeflow
  annotations:
    everest.io/disk-volume-type: SAS    # EVS disk type
  labels:
    failure-domain.beta.kubernetes.io/region: <your_region>   # Region of the node where the application is to be deployed
    failure-domain.beta.kubernetes.io/zone: <your_zone>      # AZ of the node where the application is to be deployed
spec:
  accessModes:
    - ReadWriteOnce
  resources:
    requests:
      storage: 10Gi
  storageClassName: csi-disk
---
apiVersion: v1
kind: PersistentVolumeClaim
```



```
metadata:
  name: mysql-pv-claim
  namespace: kubeflow
  annotations:
    everest.io/disk-volume-type: SAS    # EVS disk type
  labels:
    failure-domain.beta.kubernetes.io/region: <your_region>   # Region of the node where the application is
to be deployed
    failure-domain.beta.kubernetes.io/zone: <your_zone>       # AZ of the node where the application is to be
deployed
spec:
  accessModes:
    - ReadWriteOnce
  resources:
    requests:
      storage: 20Gi
  storageClassName: csi-disk
---
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: minio-pvc
  namespace: kubeflow
  annotations:
    everest.io/disk-volume-type: SAS    # EVS disk type
  labels:
    failure-domain.beta.kubernetes.io/region: <your_region>   # Region of the node where the application is
to be deployed
    failure-domain.beta.kubernetes.io/zone: <your_zone>       # AZ of the node where the application is to be
deployed
spec:
  accessModes:
    - ReadWriteOnce
  resources:
    requests:
      storage: 20Gi
  storageClassName: csi-disk
---
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: authservice-pvc
  namespace: istio-system
  annotations:
    everest.io/disk-volume-type: SAS    # EVS disk type
  labels:
    failure-domain.beta.kubernetes.io/region: <your_region>   # Region of the node where the application is
to be deployed
    failure-domain.beta.kubernetes.io/zone: <your_zone>       # AZ of the node where the application is to be
deployed
spec:
  accessModes:
    - ReadWriteOnce
  resources:
    requests:
      storage: 10Gi
  storageClassName: csi-disk
```

Create a PVC.

```
kubectl apply -f pvc.yaml
```

Step 4 Create related resources.

```
kubectl apply -f example.yaml
```

NOTE

Official images may fail to be pulled due to network problems, and the ImagePullBackOff or FailedPullImage error may occur in the workload. In this case, add a proper image proxy.

Step 5 Check whether pods in all namespaces are running.

```
kubectl get pod -A
```

If an unexpected problem occurs during resource creation, rectify it by referring to **Common Issues**.

----End

Common Issues

- In some scenarios where CRD resources do not exist, the following information is displayed:

  ```
  error: resource mapping not found for name: "<RESOURCE_NAME>" namespace: "<SOME_NAMESPACE>" from "STDIN": no matches for kind "<CRD_NAME>" in version "<CRD_FULL_NAME>"
  ensure CRDs are installed first
  ```

  Solution:

  This is because kustomization creates CRs ahead of CRDs. If you encounter this error message, create the resource again.

- When a workload is created, an error message is displayed, indicating that there are too many pods on the node. The error message is displayed as follows:

  ```
  0/x nodes are available: x Too many pods.
  ```

  Solution:

  This message indicates that the number of schedulable pods on the node exceeds the node's upper limit. To solve this problem, increase the number of nodes.

- The **training-operator** workload cannot run properly. The error message in the log is displayed as follows:

  ```
  Waited for 1.039518449s due to client-side throttling, not priority and fairness, request: GET:https://10.247.0.1:443/apis/xxx/xx?timeout=32s
  ```

  Solution:

  Run the following command to check the statuses of the unavailable APIServices in the cluster:

  ```
  kubectl get apiservice
  ```

  If there is no APIService in the **FALSE** state, the **training-operator** workload will run 1 to 2 minutes later.

15.1.2 Training a TensorFlow Model

After Kubeflow is deployed, it is easy to use the ps-worker mode to train TensorFlow models. This section describes an official TensorFlow training example provided by Kubeflow. For details, see **TensorFlow Training (TFJob)**.

Running the Mnist Example

Step 1 Deploy the TFJob resource to start training.

Create the **tf-mnist.yaml** file. The following is an example:

```
apiVersion: "kubeflow.org/v1"
kind: TFJob
metadata:
  name: tfjob-simple
  namespace: kubeflow
spec:
```



```
tfReplicaSpecs:
  Worker:
    replicas: 2
    restartPolicy: OnFailure
    template:
      spec:
        containers:
          - name: tensorflow
            image: kubeflow/tf-mnist-with-summaries:latest
            command:
              - "python"
              - "/var/tf_mnist/mnist_with_summaries.py"
```

Step 2 Create the TFJob.

```
kubectl apply -f tf-mnist.yaml
```

Step 3 View the logs after the worker running is complete.

```
kubectl -n kubeflow logs tfjob-simple-worker-0
```

Information similar to the following is displayed:

```
...
Accuracy at step 900: 0.964
Accuracy at step 910: 0.9653
Accuracy at step 920: 0.9665
Accuracy at step 930: 0.9681
Accuracy at step 940: 0.9664
Accuracy at step 950: 0.9667
Accuracy at step 960: 0.9694
Accuracy at step 970: 0.9683
Accuracy at step 980: 0.9687
Accuracy at step 990: 0.966
Adding run metadata for 999
```

Step 4 Delete the TFJob.

```
kubectl delete -f tf-mnist.yaml
```

----End

Using a GPU

The training can be performed in the GPU scenario. In this scenario, the cluster must contain GPU nodes and proper drivers must be installed.

Step 1 Specify the GPU resources in the TFJob.

Create the **tf-gpu.yaml** file. The following is an example:

This example runs in the TensorFlow distributed architecture. The ResNet50 model in the convolutional neural network (CNN) is used to train randomly generated images. A total of **32** (**batch_size**) images are trained each time, and the images are trained **100** times in total. Additionally, the performance (**image/sec**) of each training is recorded.

```
apiVersion: "kubeflow.org/v1"
kind: "TFJob"
metadata:
  name: "tf-smoke-gpu"
spec:
  tfReplicaSpecs:
    PS:
      replicas: 1
      template:
        metadata:
          creationTimestamp: null
```



```
    spec:
      containers:
        - args:
            - python
            - tf_cnn_benchmarks.py
            - --batch_size=32
            - --model=resnet50
            - --variable_update=parameter_server
            - --flush_stdout=true
            - --num_gpus=1
            - --local_parameter_device=cpu
            - --device=cpu
            - --data_format=NHWC
          image: docker.io/kubeflow/tf-benchmarks-cpu:v20171202-bdab599-dirty-284af3
          name: tensorflow
          ports:
            - containerPort: 2222
              name: tfjob-port
          resources:
            limits:
              cpu: "1"
          workingDir: /opt/tf-benchmarks/scripts/tf_cnn_benchmarks
      restartPolicy: OnFailure
  Worker:
    replicas: 1
    template:
      metadata:
        creationTimestamp: null
      spec:
        containers:
          - args:
              - python
              - tf_cnn_benchmarks.py
              - --batch_size=32
              - --model=resnet50
              - --variable_update=parameter_server
              - --flush_stdout=true
              - --num_gpus=1
              - --local_parameter_device=cpu
              - --device=gpu
              - --data_format=NHWC
            image: docker.io/kubeflow/tf-benchmarks-gpu:v20171202-bdab599-dirty-284af3
            name: tensorflow
            ports:
              - containerPort: 2222
                name: tfjob-port
            resources:
              limits:
                nvidia.com/gpu: 1       # Number of GPUs
            workingDir: /opt/tf-benchmarks/scripts/tf_cnn_benchmarks
        restartPolicy: OnFailure
```

Step 2 Create the TFJob.

```
kubectl apply -f tf-gpu.yaml
```

Step 3 After the worker runs the job (about 5 minutes if a GPU is used), run the following command to view the result.

```
kubectl logs tf-smoke-gpu-worker-0
```

Information similar to the following is displayed:

```
...
INFO|2023-09-02T12:04:25|/opt/launcher.py|27| Running warm up
INFO|2023-09-02T12:08:55|/opt/launcher.py|27| Done warm up
INFO|2023-09-02T12:08:55|/opt/launcher.py|27| Step      Img/sec loss
INFO|2023-09-02T12:08:56|/opt/launcher.py|27| 1 images/sec: 68.8 +/- 0.0 (jitter = 0.0) 8.777
INFO|2023-09-02T12:09:00|/opt/launcher.py|27| 10        images/sec: 70.4 +/- 0.4 (jitter = 1.8) 8.557
INFO|2023-09-02T12:09:04|/opt/launcher.py|27| 20        images/sec: 70.5 +/- 0.3 (jitter = 1.5) 8.090
INFO|2023-09-02T12:09:09|/opt/launcher.py|27| 30        images/sec: 70.3 +/- 0.3 (jitter = 1.6) 8.041
```



```
INFO|2023-09-02T12:09:13|/opt/launcher.py|27| 40        images/sec: 70.1 +/- 0.2 (jitter = 1.7) 9.464
INFO|2023-09-02T12:09:18|/opt/launcher.py|27| 50        images/sec: 70.1 +/- 0.2 (jitter = 1.6) 7.797
INFO|2023-09-02T12:09:23|/opt/launcher.py|27| 60        images/sec: 70.1 +/- 0.2 (jitter = 1.6) 8.595
INFO|2023-09-02T12:09:27|/opt/launcher.py|27| 70        images/sec: 70.0 +/- 0.2 (jitter = 1.7) 7.853
INFO|2023-09-02T12:09:32|/opt/launcher.py|27| 80        images/sec: 69.9 +/- 0.2 (jitter = 1.7) 7.849
INFO|2023-09-02T12:09:36|/opt/launcher.py|27| 90        images/sec: 69.8 +/- 0.2 (jitter = 1.7) 7.911
INFO|2023-09-02T12:09:41|/opt/launcher.py|27| 100       images/sec: 69.7 +/- 0.1 (jitter = 1.7) 7.853
INFO|2023-09-02T12:09:41|/opt/launcher.py|27| ----------------------------------------------------------------
INFO|2023-09-02T12:09:41|/opt/launcher.py|27| total images/sec: 69.68
INFO|2023-09-02T12:09:41|/opt/launcher.py|27| ----------------------------------------------------------------
INFO|2023-09-02T12:09:42|/opt/launcher.py|80| Finished: python tf_cnn_benchmarks.py --batch_size=32 --
model=resnet50 --variable_update=parameter_server --flush_stdout=true --num_gpus=1 --
local_parameter_device=cpu --device=gpu --data_format=NHWC --job_name=worker --ps_hosts=tf-smoke-
gpu-ps-0.default.svc:2222 --worker_hosts=tf-smoke-gpu-worker-0.default.svc:2222 --task_index=0
INFO|2023-09-02T12:09:42|/opt/launcher.py|84| Command ran successfully sleep for ever.
```

The training performance of a single GPU is **69.68** images per second.

----End

15.1.3 Using Kubeflow and Volcano to Train an AI Model

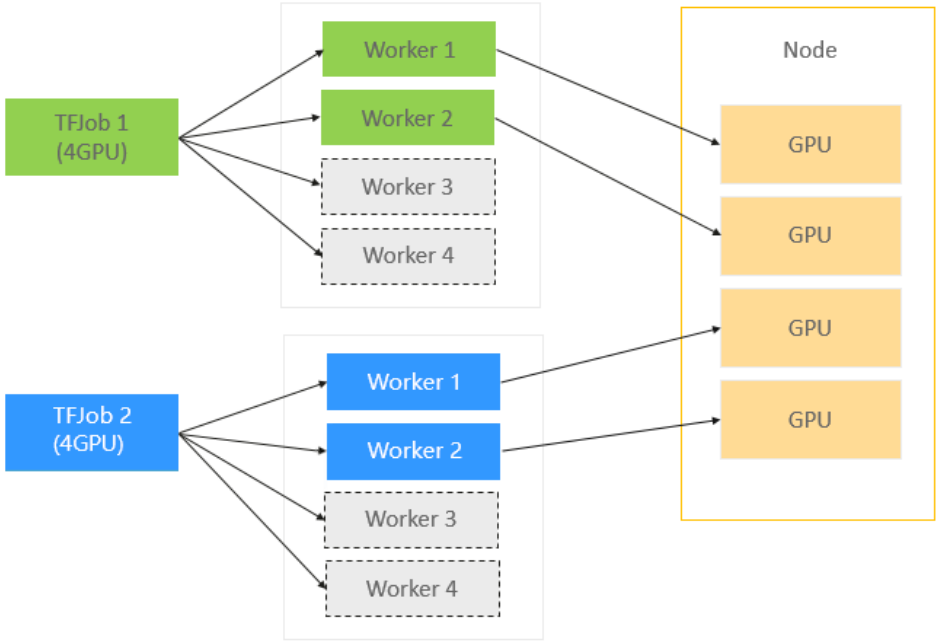
Kubernetes has become the de facto standard for cloud native application orchestration and management. An increasing number of applications are migrated to Kubernetes. AI and machine learning inherently involve a large number of computing-intensive tasks. Kubernetes is a preferential tool for developers building AI platforms because of its excellent capabilities in resource management, application orchestration, and O&M monitoring.

Kubernetes Pain Points

Kubeflow uses the default scheduler of Kubernetes, which was initially designed for long-term running services. Its scheduling capability is inadequate for tasks that involve batch computing and elastic scheduling in AI and big data scenarios. The main constraints are as follows:

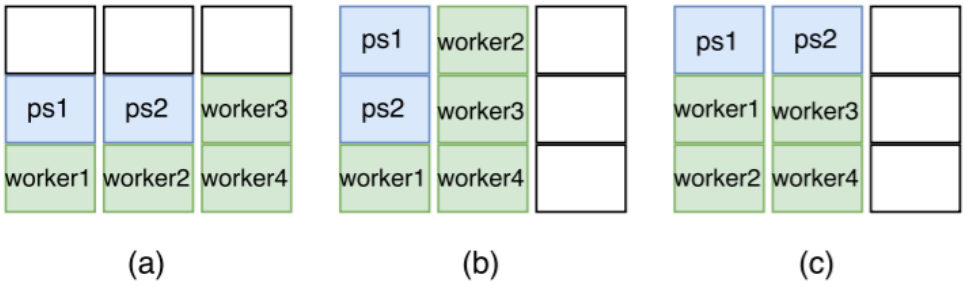
Resource preemption

A TensorFlow job involves two roles: parameter server (ps) and worker. Only when pods of these two roles run properly at the same time can a TensorFlow job be executed normally. However, the default scheduler is insensitive to the roles of pods in a TensorFlow job. Pods are treated identically and scheduled one by one. This causes problems when there are multiple jobs to schedule and cluster resources are scarce. Each job could end up being allocated with only part of the resources it needs to finish the execution. That is, resources are used up while no job can be successfully executed. To better illustrate this dilemma, assume that you want to run two TensorFlow jobs, namely, TFJob1 and TFJob2. Each of these jobs has four workers, which means each job requires four GPUs to run. However, your cluster only has four available GPUs in total. In this case, with the default scheduler, TFJob1 and TFJob2 could end up being allocated two GPUs each. They are waiting each other to finish and release the resources. However, this will not happen until you manually intervene. The deadlock created in this situation cause resource wastes and low efficiency in job execution.



Lack of affinity-based scheduling

In distributed training, data is frequently exchanged between parameter servers and workers. To ensure higher efficiency, parameter servers and workers of the same job should be scheduled to the same node for faster transmission using local networks. However, the default scheduler is insensitive to the affinity between parameter servers and workers of the same job. Pods are randomly scheduled instead. As shown in the following figure, assume that you want to run two TensorFlow jobs with each having one ps and two workers. With the default scheduler, the scheduling results could be any of the following three situations. However, only result (c) can deliver the highest efficiency. In (c), the ps and the workers can use the local network to communicate more efficiently and shorten the training time.



Volcano, a Perfect Batch Scheduling System for Accelerating AI Computing

Volcano is an enhanced batch scheduling system for high-performance computing workloads running on Kubernetes. It complements Kubernetes in machine learning, deep learning, HPC, and big data computing scenarios, providing capabilities such as gang scheduling, computing task queue management, task-topology, and GPU affinity scheduling. In addition, Volcano enhances batch task

creation and lifecycle management, fair-share, binpack, and other Kubernetes-native capabilities. It fully addresses the constraints of Kubeflow in distributed training mentioned above.

For more information about Volcano, visit **https://github.com/volcano-sh/volcano**.

Using Volcano in Huawei Cloud

The convergence of Kubeflow and Volcano, two open-source projects, greatly simplifies and accelerates AI computing workloads running on Kubernetes. The two projects have been recognized by an increasing number of players in the field and applied in production environments. Volcano is used in Huawei Cloud CCE, CCI, and Kubernetes-Native Batch Computing Solution. Volcano will continue to iterate with optimized algorithms, enhanced capabilities such as intelligent scheduling, and new inference features such as GPU Share, to further improve the efficiency of Kubeflow batch training and inference.

Implementing Typical Distributed AI Training Jobs

This section describes how to perform distributed training of a digital image classification model using the MNIST dataset based on Kubeflow and Volcano.

Step 1 Log in to the CCE console and click the cluster name to access the cluster console.

Step 2 Deploy volcano on the cluster.

In the navigation pane, choose **Add-ons**. Click **Install** under the **volcano** add-on. In the window that slides out from the right, configure the specifications and click **Install**.

Step 3 Deploy the MNIST dataset.

1. Download **kubeflow/examples** to the local host and select an operation guide based on the environment.
   ```
   yum install git
   git clone https://github.com/kubeflow/examples.git
   ```
2. Install python3.
   ```
   wget https://www.python.org/ftp/python/3.6.8/Python-3.6.8.tgz
   tar -zxvf Python-3.6.8.tgz
   ```



```
cd Python-3.6.8 ./configure
make make install
```

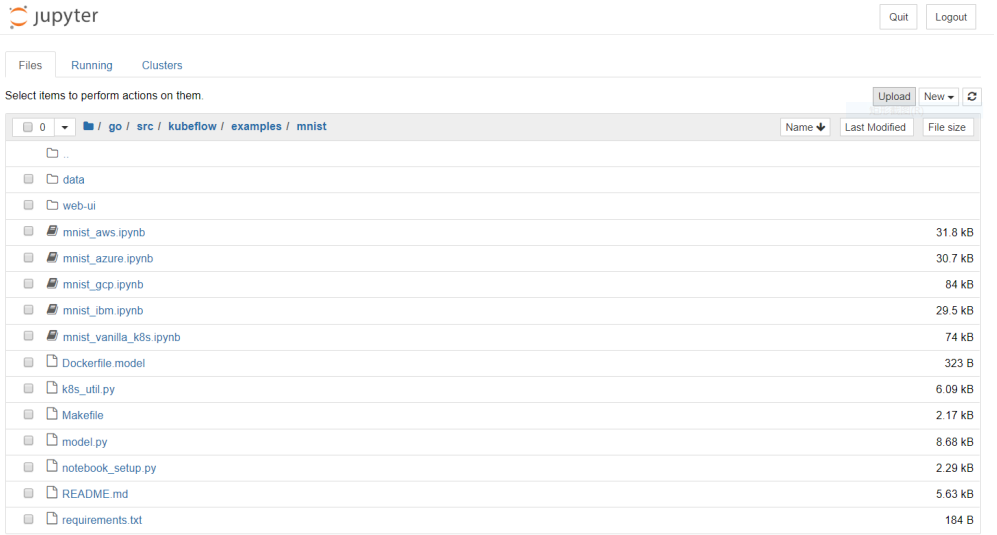
After the installation, run the following commands to check whether the installation is successful:

```
python3 -V
pip3 -V
```

3. Install and start Jupyter Notebook.

```
pip3 install jupyter notebook
jupyter notebook --allow-root
```

4. Configure an SSH tunnel on PuTTY and remotely connect to the notebook.
5. After the connection is successful, enter **localhost:8000** in the address box of a browser to log in to the notebook.



6. Create a distributed training job as prompted by Jupyter. Set the value of **schedulerName** to **volcano** to enable volcano.

```
kind: TFJob
metadata:
  name: {train_name}
spec:
  schedulerName: volcano
  tfReplicaSpecs:
    Ps:
      replicas: {num_ps}
      template:
        metadata:
          annotations:
            sidecar.istio.io/inject: "false"
        spec:
          serviceAccount: default-editor
          containers:
          - name: tensorflow
            command:
              ...
            env:
              ...
            image: {image}
            workingDir: /opt
          restartPolicy: OnFailure
    Worker:
      replicas: 1
      template:
        metadata:
          annotations:
            sidecar.istio.io/inject: "false"
```



```
    spec:
      serviceAccount: default-editor
      containers:
      - name: tensorflow
        command:
          ...
        env:
          ...
        image: {image}
        workingDir: /opt
      restartPolicy: OnFailure
```

Step 4 Submit the job and start the training.

```
kubectl apply -f mnist.yaml
```

```
root@ecs-1953:~/tmp# kubectl get po
NAME                          READY   STATUS    RESTARTS   AGE
tensorflow-mnist-ps-0         1/1     Running   0          5s
tensorflow-mnist-worker-0     1/1     Running   0          5s
```

After the training job is complete, you can query the training results on the Kubeflow UI. This is how you run a simple distributed training job using Kubeflow and Volcano. Kubeflow simplifies TensorFlow job configuration. Volcano, with simply one more line of configuration, saves you significant time and effort in large-scale distributed training by providing capabilities such as gang scheduling and task topology to eliminate deadlocks and achieve affinity scheduling.

----End

15.2 Deploying and Using Caffe in a CCE Cluster

15.2.1 Prerequisites

This section provides an example for running Caffe on CCE to classify an image. For more information, see **https://github.com/BVLC/caffe/blob/master/examples/00-classification.ipynb**.

Pre-configuring OBS Storage Data

Create an OBS bucket and ensure that the following folders have been created and required files have been uploaded to the specified paths using the OBS Browser.

The folder name can be in the format of *File path in the bucket/File name*. You can search for the file download addresses in the specified paths of the specified project in GitHub, as shown in **1** and **2**.

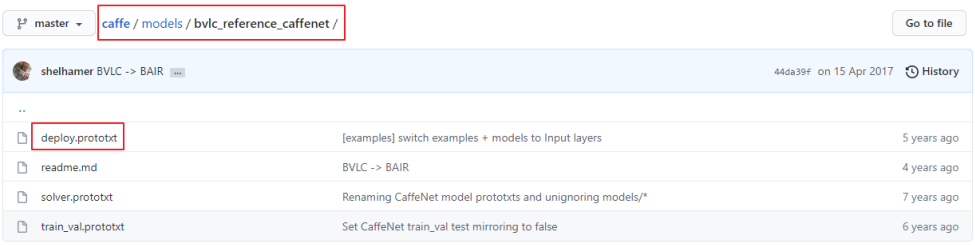
1. models/bvlc_reference_caffenet/bvlc_reference_caffenet.caffemodel

   https://github.com/BVLC/caffe/tree/master/models/bvlc_reference_caffenet

name	caffemodel	caffemodel_url	license
BAIR/BVLC CaffeNet Model	bvlc_reference_caffenet.caffemodel	http://dl.caffe.berkeleyvision.org/bvlc_reference_caffenet.caffemodel	unrestricted

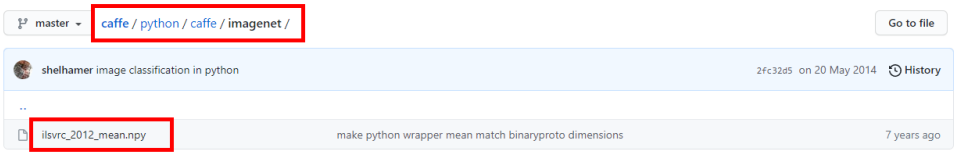
2. models/bvlc_reference_caffenet/deploy.prototxt

   https://github.com/BVLC/caffe/tree/master/models/bvlc_reference_caffenet



3. python/caffe/imagenet/ilsvrc_2012_mean.npy

   https://github.com/BVLC/caffe/tree/master/python/caffe/imagenet



4. outputimg/

   An empty folder **outputimg** is created to store output files.

5. examples/images/cat.jpg

   https://github.com/BVLC/caffe/blob/master/examples/00-classification.ipynb

   Save the picture of the cat in the link.

6. data/ilsvrc12/*

   https://github.com/BVLC/caffe/tree/master/data/ilsvrc12

   Obtain and execute the **get_ilsvrc_aux.sh** script. The script downloads a compressed package and decompresses it. After the script is executed, upload all decompressed files to the directory.

7. caffeEx00.py

```
# set up Python environment: numpy for numerical routines, and matplotlib for plotting
import numpy as np
import matplotlib as mpl
mpl.use('Agg')
import matplotlib.pyplot as plt
# display plots in this notebook
#%matplotlib inline

# set display defaults
plt.rcParams['figure.figsize'] = (10, 10)        # large images
plt.rcParams['image.interpolation'] = 'nearest'  # don't interpolate: show square pixels
plt.rcParams['image.cmap'] = 'gray'  # use grayscale output rather than a (potentially misleading)
color heatmap

# The caffe module needs to be on the Python path;
#  we'll add it here explicitly.
import sys
caffe_root = '/home/'  # this file should be run from {caffe_root}/examples (otherwise change this
line)
sys.path.insert(0, caffe_root + 'python')

import caffe
# If you get "No module named _caffe", either you have not built pycaffe or you have the wrong path.

import os
```



```
#if os.path.isfile(caffe_root + 'models/bvlc_reference_caffenet/bvlc_reference_caffenet.caffemodel'):
#    print 'CaffeNet found.'
#else:
#    print 'Downloading pre-trained CaffeNet model...'
#    !../scripts/download_model_binary.py ../models/bvlc_reference_caffenet

caffe.set_mode_cpu()

model_def = caffe_root + 'models/bvlc_reference_caffenet/deploy.prototxt'
model_weights = caffe_root + 'models/bvlc_reference_caffenet/bvlc_reference_caffenet.caffemodel'

net = caffe.Net(model_def,      # defines the structure of the model
                model_weights,  # contains the trained weights
                caffe.TEST)     # use test mode (e.g., don't perform dropout)

# load the mean ImageNet image (as distributed with Caffe) for subtraction
mu = np.load(caffe_root + 'python/caffe/imagenet/ilsvrc_2012_mean.npy')
mu = mu.mean(1).mean(1)  # average over pixels to obtain the mean (BGR) pixel values
print 'mean-subtracted values:', zip('BGR', mu)

# create transformer for the input called 'data'
transformer = caffe.io.Transformer({'data': net.blobs['data'].data.shape})

transformer.set_transpose('data', (2,0,1))  # move image channels to outermost dimension
transformer.set_mean('data', mu)            # subtract the dataset-mean value in each channel
transformer.set_raw_scale('data', 255)      # rescale from [0, 1] to [0, 255]
transformer.set_channel_swap('data', (2,1,0))  # swap channels from RGB to BGR

# set the size of the input (we can skip this if we're happy
#  with the default; we can also change it later, e.g., for different batch sizes)
net.blobs['data'].reshape(50,        # batch size
                          3,         # 3-channel (BGR) images
                          227, 227)  # image size is 227x227

image = caffe.io.load_image(caffe_root + 'examples/images/cat.jpg')
transformed_image = transformer.preprocess('data', image)
plt.imshow(image)
plt.savefig(caffe_root + 'outputimg/img1.png')

# copy the image data into the memory allocated for the net
net.blobs['data'].data[...] = transformed_image

### perform classification
output = net.forward()

output_prob = output['prob'][0]  # the output probability vector for the first image in the batch

print 'predicted class is:', output_prob.argmax()

# load ImageNet labels
labels_file = caffe_root + 'data/ilsvrc12/synset_words.txt'
#if not os.path.exists(labels_file):
#    !../data/ilsvrc12/get_ilsvrc_aux.sh

labels = np.loadtxt(labels_file, str, delimiter='\t')

print 'output label:', labels[output_prob.argmax()]

# sort top five predictions from softmax output
top_inds = output_prob.argsort()[::-1][:5]  # reverse sort and take five largest items

print 'probabilities and labels:'
zip(output_prob[top_inds], labels[top_inds])
```


15.2.2 Preparing Resources

Adding a GPU Node to a Cluster

Step 1 Log in to the CCE console and click the name of the target cluster to access the cluster console.

Step 2 Install the GPU add-on.

1. In the navigation pane, choose **Add-ons**. Locate **gpu-beta** (or **gpu-device-plugin**) and click **Install**.
2. In the window that slides out from the right, configure the key parameters.
   - **NVIDIA Driver**: Enter the download link of the NVIDIA driver. Select a driver based on the graphics card model of the GPU node.

   Retain the default values for other parameters. For details, see **gpu-beta**.
3. Click **Install**.

Step 3 Create a GPU node.

1. In the navigation pane, choose **Nodes**. Click **Create Node** in the upper right corner and configure the parameters.
2. Select **GPU-accelerated** for node specifications and configure other parameters as required. For details, see **Creating a Node**.
3. After the configuration, click **Next: Confirm**. On the page displayed, confirm the configuration and click **Submit**.

Step 4 View its status in the node list.

----End

Importing an OBS Volume

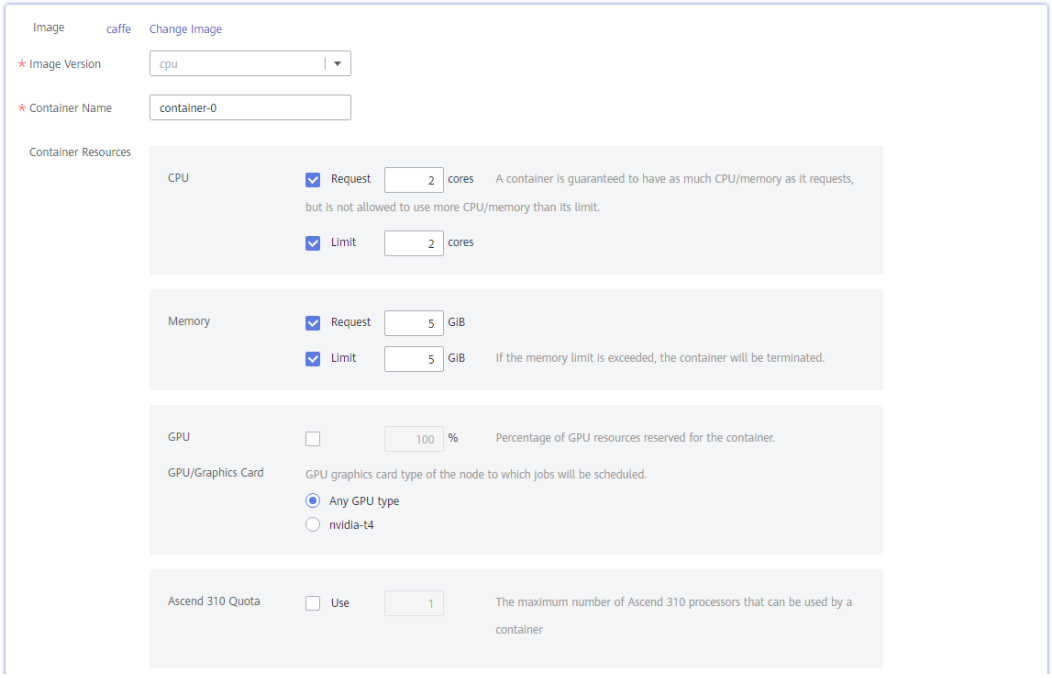
Go to the storage management page and import the OBS volume created in **Pre-configuring OBS Storage Data**.

15.2.3 Caffe Classification Example

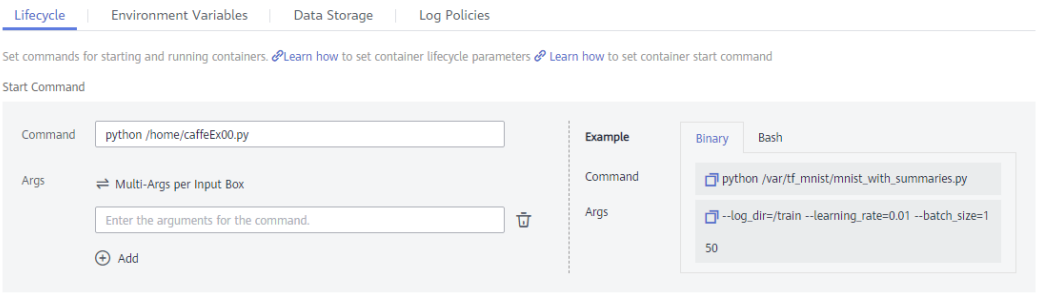
This section uses the official Caffe classification example at **https://github.com/BVLC/caffe/blob/master/examples/00-classification.ipynb** to illustrate how to run Caffe jobs on CCE.

Using CPUs

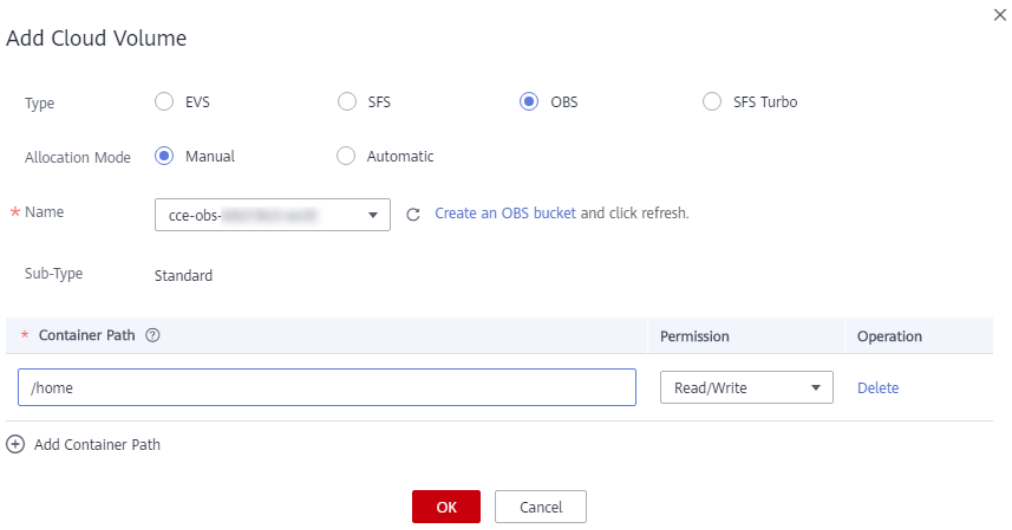
Create a job using the third-party **image bvlc/caffe:cpu**. Set the container specifications.



Add the startup command **python /home/caffeEx00.py**.

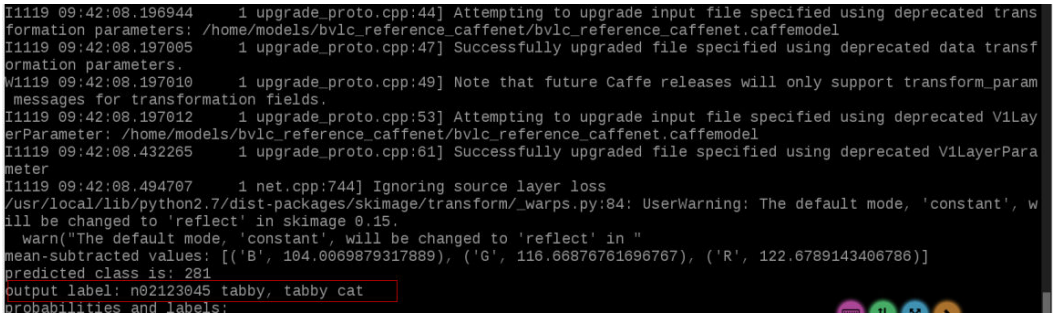


Mount the imported OBS volume.



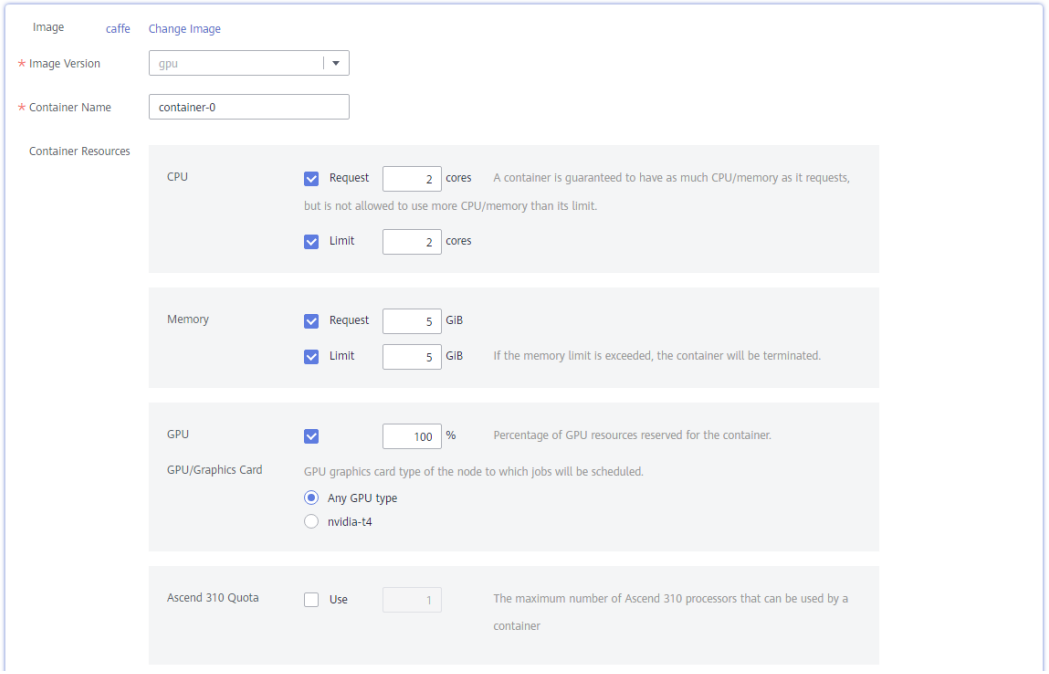
Click **Create**. After the job execution is complete, go to the **outputimg** directory of the OBS volume to view the image used for inference.

Log in to the node added in **Adding a GPU Node to a Cluster** and run the **docker logs {*Container ID*}** command to view the classification result. The result is displayed as **tabby cat**.

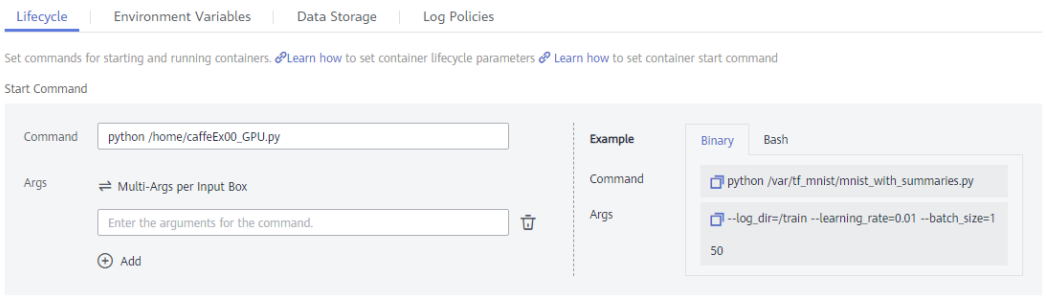


Using GPUs

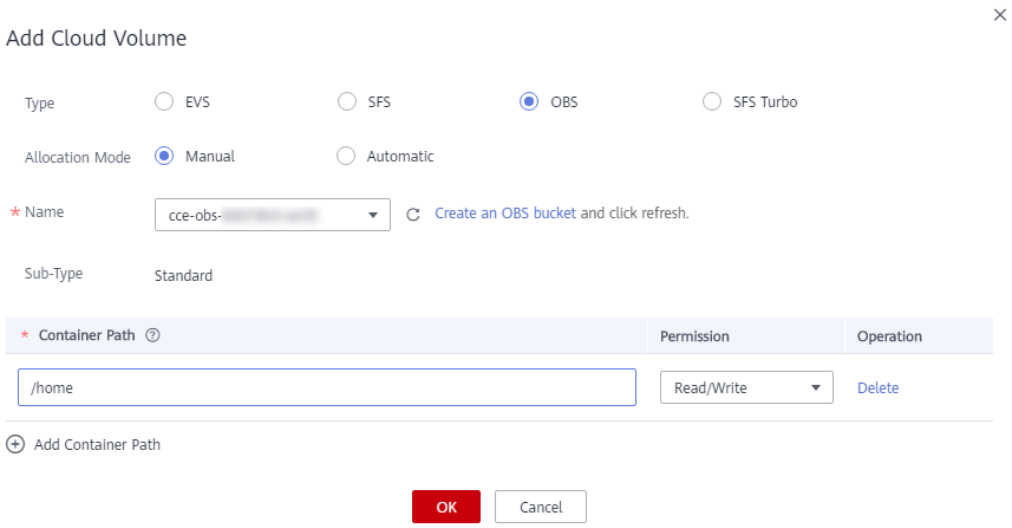
Create a job using the third-party **bvlc/caffe:gpu**. Set the container specifications.



Add the startup command **python /home/caffeEx00_GPU.py**.

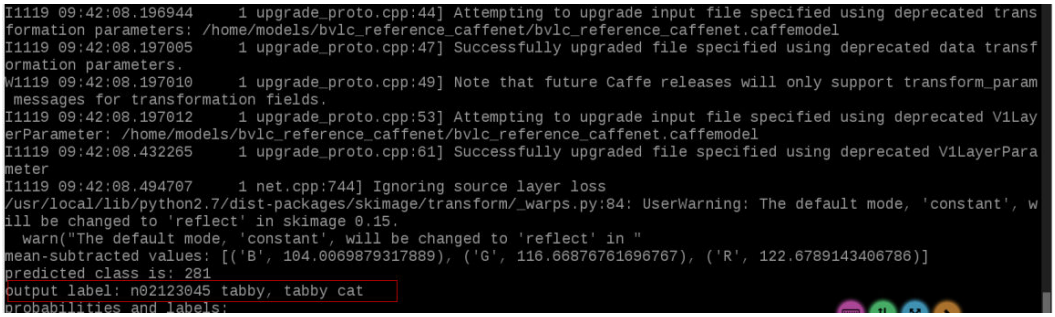


Mount the imported OBS volume.



Click **Create**. After the job execution is complete, go to the **outputimg** directory of the OBS volume to view the image used for inference.

Log in to the node added in **Adding a GPU Node to a Cluster** and run the **docker logs {***Container ID***}** command to view the classification result. The result is displayed as **tabby cat**.



15.3 Deploying and Using TensorFlow in a CCE Cluster

Preparing Resources

- Create a CCE cluster and GPU nodes, and use the gpu-beta add-on to install the graphics card driver.
- Add an object storage volume to the cluster.

Pre-configuring Data

Download data from **https://github.com/zalandoresearch/fashion-mnist**.

Get the Data

Many ML libraries already include Fashion-MNIST data/API, give it a try!

You can use direct links to download the dataset. The data is stored in the **same** format as the original MNIST data.

Name	Content	Examples	Size	Link	MD5 Checksum
`train-images-idx3-ubyte.gz`	training set images	60,000	26 MBytes	Download	`8d4fb7e6c68d591d4c3dfef9ec88bf0d`
`train-labels-idx1-ubyte.gz`	training set labels	60,000	29 KBytes	Download	`25c81989df183df01b3e8a0aad5dffbe`
`t10k-images-idx3-ubyte.gz`	test set images	10,000	4.3 MBytes	Download	`bef4ecab320f06d8554ea6380940ec79`
`t10k-labels-idx1-ubyte.gz`	test set labels	10,000	5.1 KBytes	Download	`bb300cfdad3c16e7a12a480ee83cd310`

Obtain the TensorFlow machine learning (ML) example and modify it based on your requirements.

basicClass.py

```
# TensorFlow and tf.keras
import tensorflow as tf
from tensorflow import keras

# Helper libraries
import numpy as np
import gzip
from tensorflow.python.keras.utils import get_file
import matplotlib as mpl
mpl.use('Agg')
import matplotlib.pyplot as plt

print(tf.__version__)

#fashion_mnist = keras.datasets.fashion_mnist
#(train_images, train_labels), (test_images, test_labels) = fashion_mnist.load_data()

def load_data():
    base = "file:////home/data/"
    files = [
        'train-labels-idx1-ubyte.gz', 'train-images-idx3-ubyte.gz',
        't10k-labels-idx1-ubyte.gz', 't10k-images-idx3-ubyte.gz'
    ]

    paths = []
    for fname in files:
        paths.append(get_file(fname, origin=base + fname))

    with gzip.open(paths[0], 'rb') as lbpath:
        y_train = np.frombuffer(lbpath.read(), np.uint8, offset=8)

    with gzip.open(paths[1], 'rb') as imgpath:
        x_train = np.frombuffer(
            imgpath.read(), np.uint8, offset=16).reshape(len(y_train), 28, 28)

    with gzip.open(paths[2], 'rb') as lbpath:
        y_test = np.frombuffer(lbpath.read(), np.uint8, offset=8)

    with gzip.open(paths[3], 'rb') as imgpath:
        x_test = np.frombuffer(
            imgpath.read(), np.uint8, offset=16).reshape(len(y_test), 28, 28)

    return (x_train, y_train), (x_test, y_test)

(train_images, train_labels), (test_images, test_labels) = load_data()
```

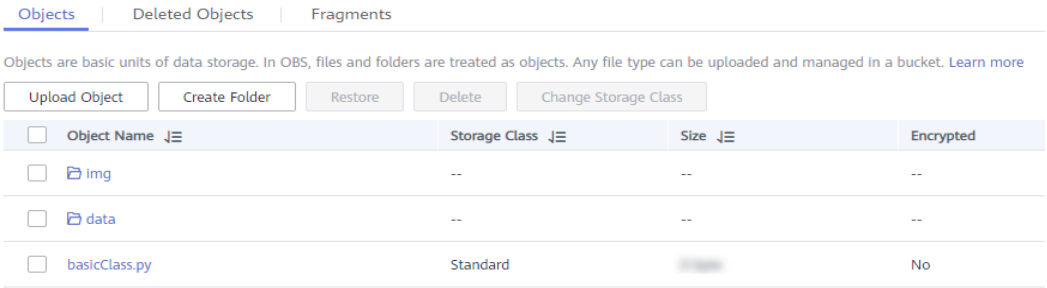


```
class_names = ['T-shirt/top', 'Trouser', 'Pullover', 'Dress', 'Coat',
               'Sandal', 'Shirt', 'Sneaker', 'Bag', 'Ankle boot']

plt.figure()
plt.imshow(train_images[0])
plt.colorbar()
plt.grid(False)
plt.savefig('/home/img/basicimg1.png')

train_images = train_images / 255.0

test_images = test_images / 255.0

plt.figure(figsize=(10,10))
for i in range(25):
    plt.subplot(5,5,i+1)
    plt.xticks([])
    plt.yticks([])
    plt.grid(False)
    plt.imshow(train_images[i], cmap=plt.cm.binary)
    plt.xlabel(class_names[train_labels[i]])
plt.savefig('/home/img/basicimg2.png')

model = keras.Sequential([
    keras.layers.Flatten(input_shape=(28, 28)),
    keras.layers.Dense(128, activation=tf.nn.relu),
    keras.layers.Dense(10, activation=tf.nn.softmax)
])

model.compile(optimizer=tf.train.AdamOptimizer(),
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])

model.fit(train_images, train_labels, epochs=5)

test_loss, test_acc = model.evaluate(test_images, test_labels)

print('Test accuracy:', test_acc)

predictions = model.predict(test_images)

def plot_image(i, predictions_array, true_label, img):
  predictions_array, true_label, img = predictions_array[i], true_label[i], img[i]
  plt.grid(False)
  plt.xticks([])
  plt.yticks([])

  plt.imshow(img, cmap=plt.cm.binary)

  predicted_label = np.argmax(predictions_array)
  if predicted_label == true_label:
    color = 'blue'
  else:
    color = 'red'

  plt.xlabel("{} {:2.0f}% ({})".format(class_names[predicted_label],
                                100*np.max(predictions_array),
                                class_names[true_label]),
                                color=color)

def plot_value_array(i, predictions_array, true_label):
  predictions_array, true_label = predictions_array[i], true_label[i]
  plt.grid(False)
  plt.xticks([])
  plt.yticks([])
  thisplot = plt.bar(range(10), predictions_array, color="#777777")
  plt.ylim([0, 1])
  predicted_label = np.argmax(predictions_array)
```



```
  thisplot[predicted_label].set_color('red')
  thisplot[true_label].set_color('blue')

i = 0
plt.figure(figsize=(6,3))
plt.subplot(1,2,1)
plot_image(i, predictions, test_labels, test_images)
plt.subplot(1,2,2)
plot_value_array(i, predictions,  test_labels)
plt.savefig('/home/img/basicimg3.png')

i = 12
plt.figure(figsize=(6,3))
plt.subplot(1,2,1)
plot_image(i, predictions, test_labels, test_images)
plt.subplot(1,2,2)
plot_value_array(i, predictions,  test_labels)
plt.savefig('/home/img/basicimg4.png')

# Plot the first X test images, their predicted label, and the true label
# Color correct predictions in blue, incorrect predictions in red
num_rows = 5
num_cols = 3
num_images = num_rows*num_cols
plt.figure(figsize=(2*2*num_cols, 2*num_rows))
for i in range(num_images):
  plt.subplot(num_rows, 2*num_cols, 2*i+1)
  plot_image(i, predictions, test_labels, test_images)
  plt.subplot(num_rows, 2*num_cols, 2*i+2)
  plot_value_array(i, predictions, test_labels)
plt.savefig('/home/img/basicimg5.png')
```

Go to the OBS bucket page, create the **data** and **img** folders, and upload **basicClass.py**.

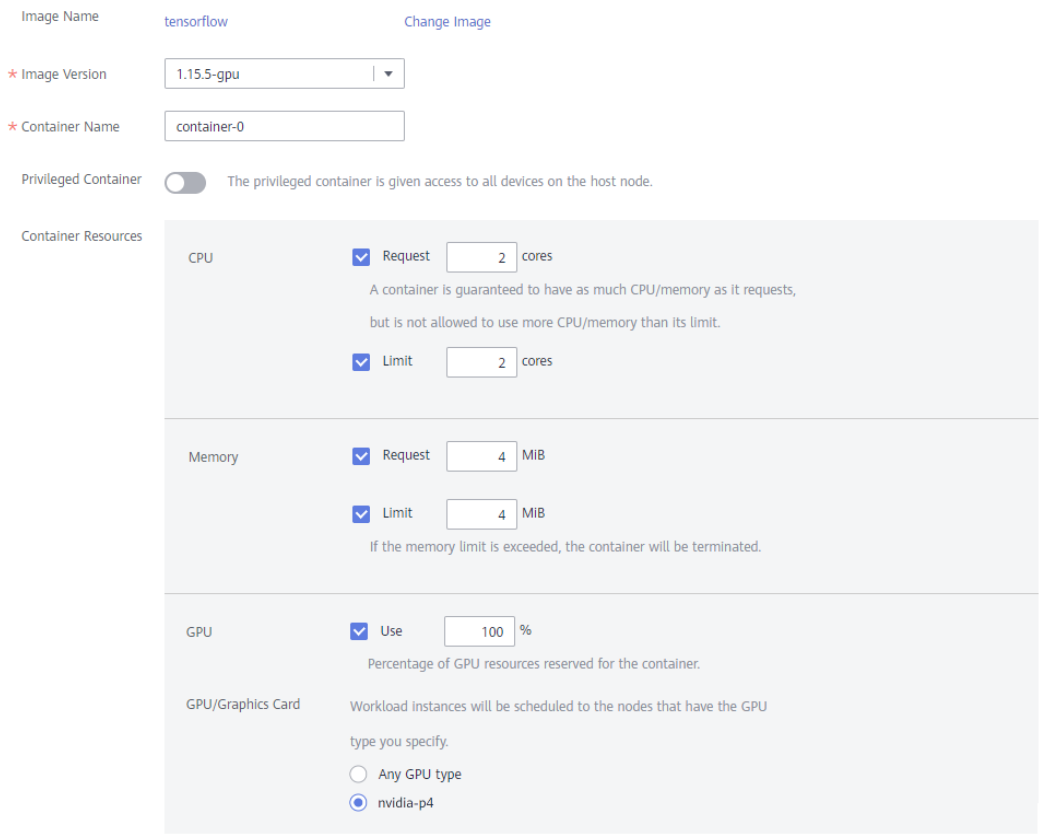


Go to the **data** folder and upload the four .gz files downloaded from GitHub.

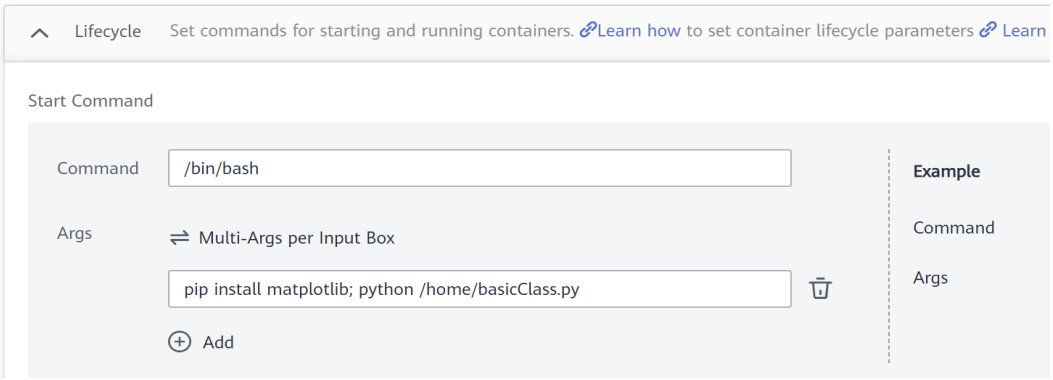
ML Example

In this section, the ML example from the TensorFlow official website is used. For details, see **https://www.tensorflow.org/tutorials/keras/classification?hl=en-us**.

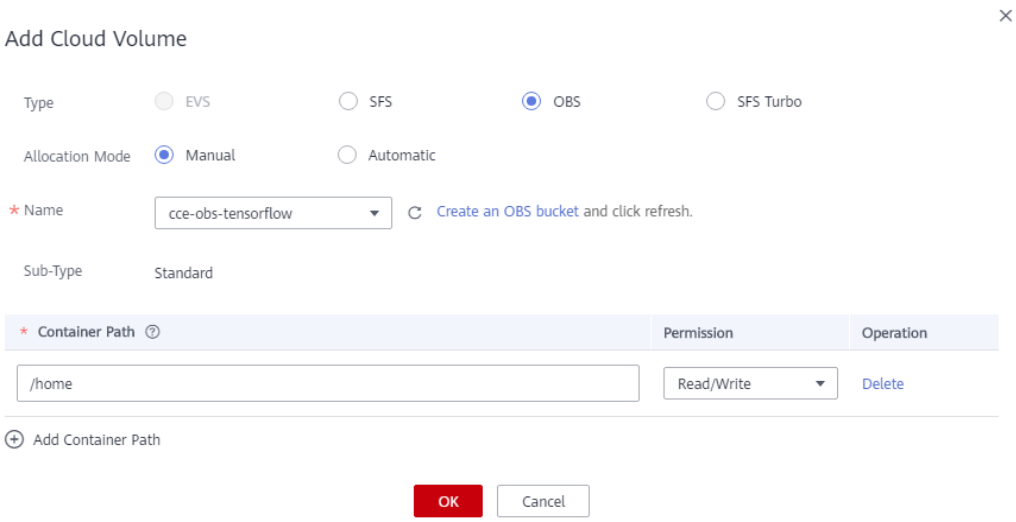
Create a job using the third-party **tensorflow/tensorflow:1.15.5-gpu**. Set the container specifications.



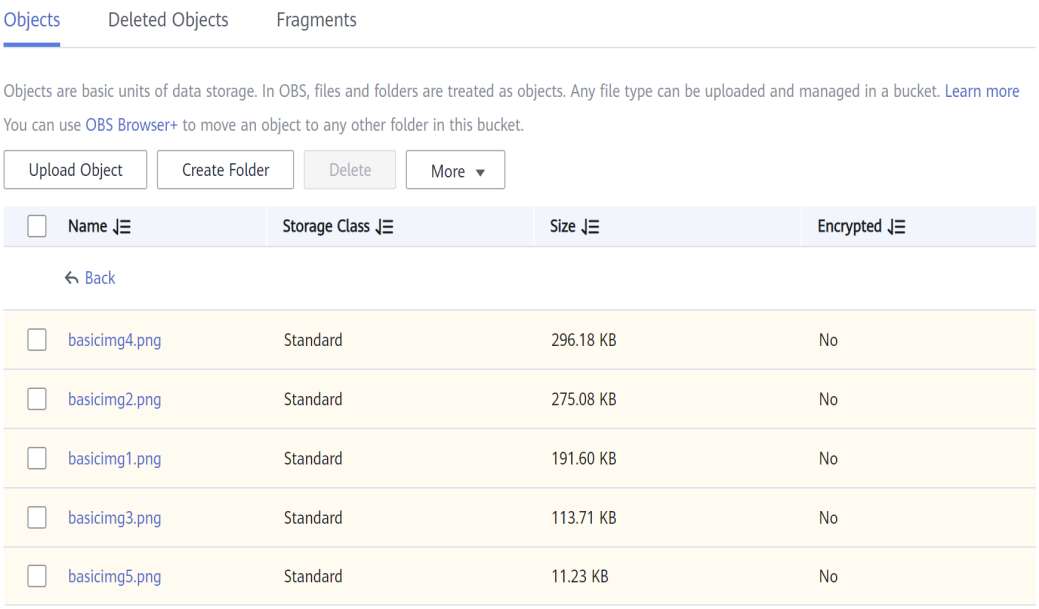
Add **pip install matplotlib;python /home/basicClass.py** in the **Start Command** area.



Mount the created OBS volume.



Click **Create**. Wait until the job execution is complete. On the OBS page, you can view the execution results that are shown as images.



If you want to use kubectl, you can use the following example YAML:

```
kind: Job
apiVersion: batch/v1
metadata:
  name: testjob
  namespace: default
spec:
  parallelism: 1
  completions: 1
  backoffLimit: 6
  template:
    metadata:
      name: testjob
    spec:
      volumes:
        - name: cce-obs-tensorflow
          persistentVolumeClaim:
```



```
      claimName: cce-obs-tensorflow
  containers:
    - name: container-0
      image: 'tensorflow/tensorflow:1.15.5-gpu'
      restartPolicy: OnFailure
      command:
        - /bin/bash
      args:
        - '-c'
        - pip install matplotlib;python /home/basicClass.py
      resources:
        limits:
          cpu: '2'
          memory: 4Gi
          nvidia.com/gpu: '1'
        requests:
          cpu: '2'
          memory: 4Gi
          nvidia.com/gpu: '1'
      volumeMounts:
        - name: cce-obs-tensorflow
          mountPath: /home
      imagePullPolicy: IfNotPresent
  imagePullSecrets:
    - name: default-secret
```

15.4 Deploying and Using Flink in a CCE Cluster

Apache Flink is a framework and distributed processing engine for stateful computations over unbounded (streams) and bounded (batches) data streams. It can process data streams in real time with low latency and high throughput and process complex events. Deploying Flink in CCE clusters enables you to build a high-performance, reliable, and flexible data processing system for a wide range of applications in big data environments while ensuring optimal resource usage. This section describes how to deploy Flink in a CCE cluster and how to run a Flink WordCount job in the CCE cluster. In this example, the Flink cluster is deployed standalone. For details about the deployment process, see the **Kubernetes | Apache Flink**.

Prerequisites

- There is a cluster with certain nodes available for use. For details, see **Buying a CCE Standard/Turbo Cluster**.
- An EIP has been assigned to nodes in the cluster, and the kubectl has been configured. For details, see **Binding an EIP to an Instance** and **Connecting to a Cluster Using kubectl**.

Step 1: Deploy a Flink Cluster

Three key components are required for deploying a Flink cluster. The Flink official website provides a resource definition file for each component. For details, see **Table 15-1**. In addition, you need to use the **flink-configuration-configmap.yaml** configuration file on the Flink official website to configure the Flink cluster.

Table 15-1 Key components of the Flink cluster

Key Component	Resource Definition File	Description
Deployment for running JobManager	jobmanager-session-deployment-non-ha.yaml	JobManager serves as the central coordinator in a Flink cluster. It coordinates Flink jobs, including task distribution, job scheduling, resource allocation, and fault tolerance.
Deployment for running TaskManager	taskmanager-session-deployment.yaml	TaskManager is a worker node in a Flink cluster and is responsible for executing data processing tasks. Each TaskManager runs one or more task slots, which are isolated units of execution.
Service exposing the JobManager's REST and UI ports	jobmanager-service.yaml	The REST and Web UI ports of Flink JobManager are exposed so that users can access the REST API and Web UI of JobManager through the Service.

Step 1 Configure basic information about the Flink cluster.

1. Create a YAML file named **flink-configuration-configmap.yaml**.

   ```
   vim flink-configuration-configmap.yaml
   ```

   Check that the file contains comments and the content is as follows:

   ```
   apiVersion: v1
   kind: ConfigMap
   metadata:
     name: flink-config
     labels:
       app: flink
   # data defines the data stored in ConfigMap. In the example, data contains two configuration files: config.yaml and log4j-console.properties.
   data:
     config.yaml: |+
   # RPC address of Flink JobManager. It is usually the JobManager name. In this example, the RPC address is flink-jobmanager.
       jobmanager.rpc.address: flink-jobmanager
   # Number of task slots in each TaskManager. Set the value to 2, indicating that each TaskManager can process two tasks concurrently.
       taskmanager.numberOfTaskSlots: 2
   # Port of the Flink BLOB service. It is used to transfer large objects, such as job code or large files.
       blob.server.port: 6124
       jobmanager.rpc.port: 6123              # RPC port of JobManager
       taskmanager.rpc.port: 6122             # RPC port of TaskManager
       jobmanager.memory.process.size: 1600m  # Total memory of JobManager
       taskmanager.memory.process.size: 1728m # Total memory of TaskManager
       parallelism.default: 2                 # The default degree of parallelism is 2 for Flink jobs.
     log4j-console.properties: |+
       # The following configuration affects the logging for user code and Flink logs.
       rootLogger.level = INFO                # Log messages of level INFO and above.
       rootLogger.appenderRef.console.ref = ConsoleAppender       # Send the logs to the console.
       rootLogger.appenderRef.rolling.ref = RollingFileAppender  # Export the logs to a rolling file.
       # If you only want to change the logging in Flink, delete the comments in the following lines:
       #logger.flink.name = org.apache.flink
   ```



```
#logger.flink.level = INFO

# The following eight lines keep the log level of the public libraries or connectors at INFO.
# The configuration of the root logger does not overwrite the configuration here.
# You need to manually change the log level.
logger.pekko.name = org.apache.pekko
logger.pekko.level = INFO
logger.kafka.name= org.apache.kafka
logger.kafka.level = INFO
logger.hadoop.name = org.apache.hadoop
logger.hadoop.level = INFO
logger.zookeeper.name = org.apache.zookeeper
logger.zookeeper.level = INFO

# Send all logs of the INFO level to the console.
appender.console.name = ConsoleAppender
appender.console.type = CONSOLE
appender.console.layout.type = PatternLayout
appender.console.layout.pattern = %d{yyyy-MM-dd HH:mm:ss,SSS} %-5p %-60c %x - %m%n

# Export all logs of the INFO level to a specified scrolling file.
appender.rolling.name = RollingFileAppender
appender.rolling.type = RollingFile
appender.rolling.append = false
appender.rolling.fileName = ${sys:log.file}
appender.rolling.filePattern = ${sys:log.file}.%i
appender.rolling.layout.type = PatternLayout
appender.rolling.layout.pattern = %d{yyyy-MM-dd HH:mm:ss,SSS} %-5p %-60c %x - %m%n
appender.rolling.policies.type = Policies
appender.rolling.policies.size.type = SizeBasedTriggeringPolicy
appender.rolling.policies.size.size=100MB
appender.rolling.strategy.type = DefaultRolloverStrategy
appender.rolling.strategy.max = 10

# Disable false alarms in the Netty channel handler.
logger.netty.name = org.jboss.netty.channel.DefaultChannelPipeline
logger.netty.level = OFF
```

2. Use **flink-configuration-configmap.yaml** to configure basic information about the Flink cluster.

   ```
   kubectl create -f flink-configuration-configmap.yaml
   ```

3. Check whether the ConfigMap named **flink-config** is successfully created.

   ```
   kubectl get configmap
   ```

   If the following information is displayed, the ConfigMap was created successfully.

   ```
   NAME              DATA   AGE
   flink-config      2      59s
   kube-root-ca.crt  1      16d
   ```

Step 2 Create a Service that exposes the REST and UI ports of JobManager.

1. Create a YAML file named **jobmanager-service.yaml**.

   ```
   vim jobmanager-service.yaml
   ```

   Check that the file contains comments and the content is as follows:

   ```
   apiVersion: v1
   kind: Service
   metadata:
     name: flink-jobmanager
   spec:
     type: ClusterIP   # The Service is used for internal communication within the cluster.
     ports:            # Define the list of ports to be exposed by Service.
     - name: rpc
       port: 6123
     - name: blob-server
       port: 6124
     - name: webui
       port: 8081
   ```



```
  selector:        # Define the Service's label selector, which is used to determine the pods to which the Service routes traffic.
    app: flink
    component: jobmanager
```

2. Use **jobmanager-service.yaml** to create a Service named **flink-jobmanager**.

```
kubectl create -f jobmanager-service.yaml
```

3. Check whether the Service is created successfully.

```
kubectl get service flink-jobmanager
```

If the following information is displayed, the Service was successfully created.

```
NAME              TYPE        CLUSTER-IP       EXTERNAL-IP   PORT(S)                      AGE
flink-jobmanager  ClusterIP   10.247.199.212   <none>        6123/TCP,6124/TCP,8081/TCP   115s
```

Step 3 Create a Deployment for running JobManager.

1. Create a YAML file named **jobmanager-session-deployment-non-ha.yaml**.

```
vim jobmanager-session-deployment-non-ha.yaml
```

Check that the file contains comments and the content is as follows:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: flink-jobmanager
spec:
  replicas: 1                # Set the number of JobManager replicas to 1.
  selector:
    matchLabels:             # Define labels.
      app: flink
      component: jobmanager
  template:
    metadata:
      labels:
        app: flink
        component: jobmanager
    spec:
      containers:
      - name: jobmanager       # Set the container name to jobmanager.
        image: apache/flink:1.20.0-scala_2.12    # Use the Flink image of v1.20.0 and the Scala of v2.12.
        args: ["jobmanager"]   # Designate the container to run as JobManager.
        ports:                 # Expose ports in the container.
        - containerPort: 6123  # Used for communication between TaskManager and JobManager.
          name: rpc
        - containerPort: 6124  # Used to transfer binary objects.
          name: blob-server
        - containerPort: 8081  # Used to access the Flink web management page.
          name: webui
        livenessProbe:
          tcpSocket:
            port: 6123         # Use TCP to check the health status of RPC port 6123.
          initialDelaySeconds: 30
          periodSeconds: 60
        volumeMounts:          # Mount a storage volume.
        - name: flink-config-volume
          mountPath: /opt/flink/conf
        securityContext:
          runAsUser: 9999      # For details, see the _flink_User in the official Flink image. You can change the username if necessary.
      volumes:                 # Define storage volumes to store configuration files.
      - name: flink-config-volume
        configMap:
          name: flink-config
          items:
          - key: config.yaml   # Mount the config.yaml file in the ConfigMap to the specified path of the container.
            path: config.yaml  # The path in the container is /opt/flink/conf/config.yaml.
          - key: log4j-console.properties    # Mount the log4j-console.properties file in the ConfigMap to the specified path of the container.
            path: log4j-console.properties   # The path in the container is /opt/flink/conf/log4j-console.properties.
```


2. Use **jobmanager-session-deployment-non-ha.yaml** to create a Deployment named **flink-jobmanager**.
```
kubectl create -f jobmanager-session-deployment-non-ha.yaml
```
3. Check whether the Deployment **flink-jobmanager** is successfully created.
```
kubectl get pod
```
The Deployment was successfully created if the following information is displayed:
```
NAME                                READY   STATUS    RESTARTS   AGE
flink-jobmanager-789c8777-vhqbv     1/1     Running   0          97s
```

Step 4 Create a Deployment for running TaskManager.

1. Create a YAML file named **taskmanager-session-deployment.yaml**.
```
vim taskmanager-session-deployment.yaml
```
Check that the file contains comments and the content is as follows:
```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: flink-taskmanager
spec:
  replicas: 2                  # Set the number of TaskManager replicas to 2.
  selector:
    matchLabels:               # Define labels.
      app: flink
      component: taskmanager
  template:
    metadata:
      labels:
        app: flink
        component: taskmanager
    spec:
      containers:
      - name: taskmanager        # Set the container name to taskmanager.
        image: apache/flink:1.20.0-scala_2.12    # Use the Flink image of v1.20.0 and the Scala of v2.12.
        args: ["taskmanager"]    # Designate the container to run as TaskManager.
        ports:                   # Expose ports in the container.
        - containerPort: 6122    # Used for communication between TaskManager and JobManager.
          name: rpc
        livenessProbe:
          tcpSocket:
            port: 6122           # Use TCP to check the health status of RPC port 6122.
          initialDelaySeconds: 30
          periodSeconds: 60
        volumeMounts:            # Mount a storage volume.
        - name: flink-config-volume
          mountPath: /opt/flink/conf/
        securityContext:
          runAsUser: 9999       # For details, see the _flink_User in the official Flink image. You can change the username if necessary.
      volumes:                   # Define storage volumes to store configuration files.
      - name: flink-config-volume
        configMap:
          name: flink-config
          items:
          - key: config.yaml
            path: config.yaml
          - key: log4j-console.properties
            path: log4j-console.properties
```
2. Use **taskmanager-session-deployment.yaml** to create a Deployment named **flink-taskmanager**.
```
kubectl create -f taskmanager-session-deployment.yaml
```
3. Check whether the Deployment **flink-taskmanager** is successfully created.
```
kubectl get pod
```


The Deployment was successfully created if the following information is displayed:

```
NAME                                READY   STATUS    RESTARTS   AGE
flink-jobmanager-789c8777-vhqbv     1/1     Running   0          13m
flink-taskmanager-579f47cf9f-prrff  1/1     Running   0          23s
flink-taskmanager-579f47cf9f-wgt66  1/1     Running   0          23s
```

----End

Step 2: Publish the Service

Create a NodePort Service for **flink-jobmanager** to allow external networks to access **flink-jobmanager** through the public IP address and automatically allocated external port number. The Service will forward external requests to the corresponding container.

Step 1 Log in to the CCE console. Choose **Workloads** > **Deployments**, click **flink-jobmanager**, the **Access Mode** tab, and then **Create Service**.

Step 2 On the **Create Service** page, set **Service Type** to **NodePort**. In the **Ports** area, set both **Container Port** and **Service Port** to **8081**, and click **OK**. The Service automatically generates a port for accessing the node. The port is displayed in **Figure 15-3**. In this example, the port is **30327**. You can access the workload using the EIP and the port of any node in the cluster.

Figure 15-2 Creating a NodePort Service

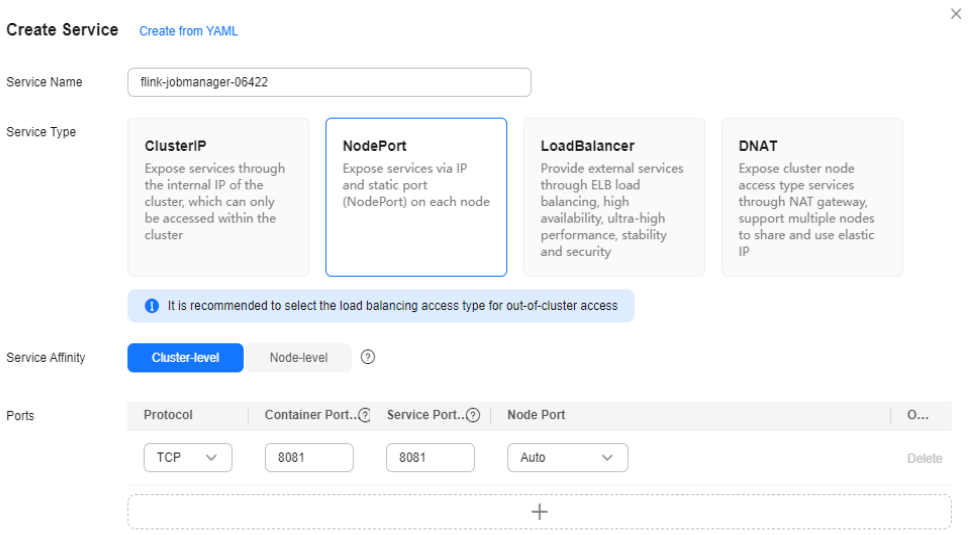
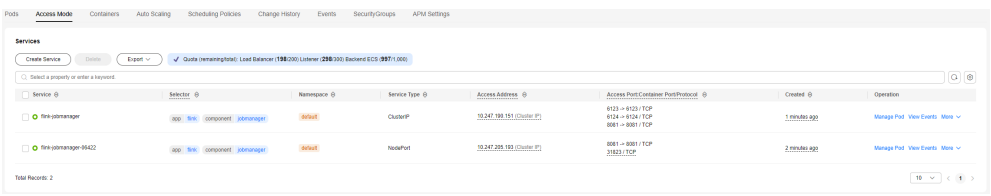


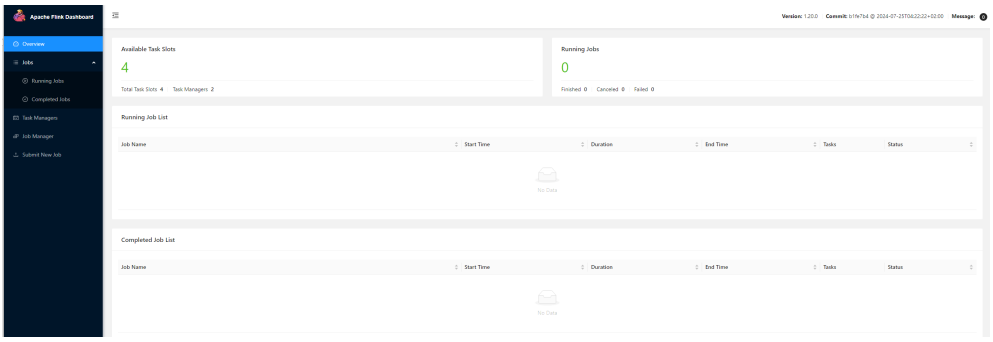
Figure 15-3 NodePort



Step 3 Check whether the Service can be accessed. Choose **Nodes**, click the **Nodes** tab, select a node, and copy its EIP.

In the address box of a browser, enter ***EIP of the node*:*Port for accessing the node***. If the Flink dashboard page is displayed, the access is successful. If the access failed, check whether the source IP address for the node port is set to **0.0.0.0/0** or **All** in the inbound rule of the cluster security group. For details, see **Configuring Security Group Rules**.

Figure 15-4 Flink Dashboard



----End

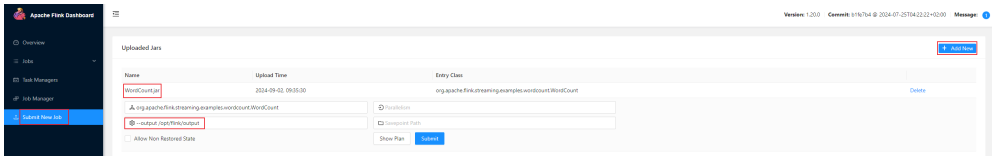
Step 3: Run the Flink Job

Use the official **WordCount.jar** file to demonstrate how to execute Flink jobs in a CCE cluster. The WordCount task is to calculate the number of occurrences of each word in the text.

Step 1 Download and decompress the **flink-1.20.0-bin-scala_2.12.tgz** file. The file can be obtained at **https://archive.apache.org/dist/flink/flink-1.20.0/flink-1.20.0-bin-scala_2.12.tgz**. Check whether the **WordCount.jar** package exists in the **flink-1.20.0-bin-scala_2.12\flink-1.20.0\examples\streamin** directory.

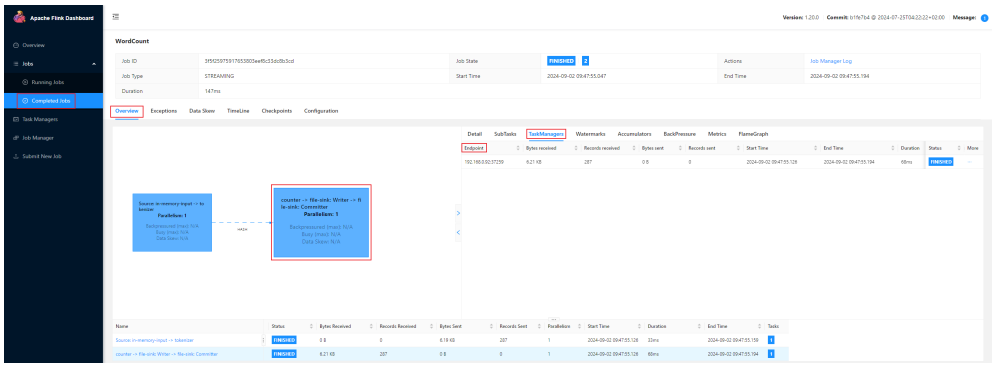
Step 2 Add a **.jar** package on the **Dashboard** page. Open the **Apache Flink Dashboard** page, choose **Submit New Job** from the navigation tree, click **Add New** in the upper right corner, and select **WordCount.jar** in the **flink-1.20.0-bin-scala_2.12\flink-1.20.0\examples\streamin** directory. Click the **WordCount.jar** file and specify the output file path, for example, **--output /opt/flink/output** in the **Program Arguments** text box.

Figure 15-5 Uploading a WordCount job



Step 3 Click the blue box on the lower right of **Overview** and click **Taskmanager** to check the endpoint of the job.

Figure 15-6 Checking an endpoint



Step 4 Use the endpoint to obtain the TaskManager pod. Run the following command to query the IP address of the Flink pod:

```
kubectl get pod -o wide | grep flink
```

flink-taskmanager-579f47cf9f-prrff is the TaskManager pod if the following information is displayed:

```
flink-jobmanager-789c8777-vhqbv         1/1     Running             1 (28m ago)   40h     192.168.0.139
192.168.0.53    <none>           <none>
flink-taskmanager-579f47cf9f-prrff      1/1     Running             1 (28m ago)   40h     192.168.0.92
192.168.0.53    <none>           <none>
flink-taskmanager-579f47cf9f-wgt66      1/1     Running             1 (28m ago)   40h     192.168.0.194
192.168.0.212   <none>           <none>
```

Step 5 After the job is complete, go to **flink-taskmanager-579f47cf9f-prrff** to check whether the number of occurrences of each word is correctly displayed.

```
kubectl exec -it flink-taskmanager-579f47cf9f-prrff bash
```

Run the **ls** command to query the output path.

```
ls /opt/flink/output/
```

Information similar to the following is displayed:

```
2024-09-02--01
```

Check the content of the **2024-09-02--01** folder.

```
ls /opt/flink/output/2024-09-02--01
```

Information similar to the following is displayed:

```
part-bd89ad8b-a0dd-4b4d-b771-4c88eaed61e4-0
```

Check the number of occurrences of each word.

```
cat /opt/flink/output/2024-09-02--01/part-bd89ad8b-a0dd-4b4d-b771-4c88eaed61e4-0
```

Information similar to the following is displayed:

```
(to,1)
(be,1)
(or,1)
(not,1)
(to,2)
(be,2)
(that,1)
...
```

----End

Step 4: Clear the Cluster

Step 1 Delete the Deployment that runs the JobManager.

```
kubectl delete -f jobmanager-session-deployment-non-ha.yaml
```

Information similar to the following is displayed:

```
deployment.apps "flink-jobmanager" deleted
```

Step 2 Delete the Deployment that runs the TaskManager.

```
kubectl delete -f taskmanager-session-deployment.yaml
```

Information similar to the following is displayed:

```
deployment.apps "flink-taskmanager" deleted
```

Step 3 Delete the ConfigMap.

```
kubectl delete -f flink-configuration-configmap.yaml
```

Information similar to the following is displayed:

```
configmap "flink-config" deleted
```

Step 4 Delete the Service.

```
kubectl delete -f jobmanager-service.yaml
```

Information similar to the following is displayed:

```
service "flink-jobmanager" delete
```

----End

15.5 Deploying and Using ClickHouse in a CCE Cluster

ClickHouse is a columnar database management system for online analytical processing (OLAP). It is suitable for real-time query and analysis of large-scale datasets. There are four ways to deploy ClickHouse on containers. For details, see **Table 15-2**. ClickHouse Operator is a tool for deploying and managing ClickHouse in Kubernetes clusters. It can replicate clusters and manage users, configuration files, and persistent volumes. These functions simplify application configuration, management, and monitoring.

Table 15-2 ClickHouse deployment on containers

Deployment Method	Difficulty in Deployment	Difficulty in Management
Native Kubectl	Difficult	Difficult
Kubectl and Operator	Medium	Medium
Helm	Easy	Difficult
Helm and Operator	Easy	Easy

The following describes how to deploy ClickHouse in a CCE cluster using Kubectl and Operator. For details, see **https://github.com/Altinity/clickhouse-operator**.

Prerequisites

- There is a cluster with certain nodes available for use. For details, see **Buying a CCE Standard/Turbo Cluster**.
- An EIP has been assigned to nodes in the cluster, and the kubectl has been configured. For details, see **Binding an EIP to an Instance** and **Connecting to a Cluster Using kubectl**.

Procedure for Deploying ClickHouse

The following describes how to deploy ClickHouse in a CCE Turbo cluster of v1.29. For details about the cluster parameters, see **Table 15-3**.

Table 15-3 Cluster parameters

Parameter	Value
Type	CCE Turbo Cluster
Cluster Version	1.29
Region	AP-Singapore
Container Engine	Containerd
Network Model	Cloud Native Network 2.0
Request Forwarding	iptables

Step 1 Create a ClickHouse Operator.

1. Download the YAML file **clickhouse-operator-install-bundle.yaml** from **https://github.com/Altinity/clickhouse-operator/blob/master/deploy/operator/clickhouse-operator-install-bundle.yaml**.

   NOTE

   clickhouse-operator-install-bundle.yaml is used to deploy the ClickHouse Operator in the **kube-system** namespace to monitor the resources in all Kubernetes namespaces. If the ClickHouse Operator is deployed in another namespace, only resources in that namespace are monitored.

   ```
   kubectl apply -f clickhouse-operator-install-bundle.yaml
   ```

   Information similar to the following is displayed:

   ```
   customresourcedefinition.apiextensions.k8s.io/clickhouseinstallations.clickhouse.altinity.comcreated
   customresourcedefinition.apiextensions.k8s.io/clickhouseinstallationtemplates.clickhouse.altinity.com created
   customresourcedefinition.apiextensions.k8s.io/clickhouseoperatorconfigurations.clickhouse.altinity.com created
   ...
   ```

2. Check whether the ClickHouse Operator is successfully created.

   ```
   kubectl get pod -n kube-system | grep clickhouse
   ```

   If the pod status is **Running**, the ClickHouse Operator was successfully created.

   ```
   clickhouse-operator-656d67bd4d-k64gm          2/2     Running   4 (15m ago)   3d23h
   ```


3. Check all CRD resources related to ClickHouse in the cluster.

```
kubectl get crd | grep clickhouse
```

Information similar to the following is displayed:

```
clickhouseinstallations.clickhouse.altinity.com                2024-08-20T09:30:30Z
clickhouseinstallationtemplates.clickhouse.altinity.com        2024-08-20T09:30:30Z
clickhousekeeperinstallations.clickhouse-keeper.altinity.com   2024-08-20T09:30:30Z
clickhouseoperatorconfigurations.clickhouse.altinity.com       2024-08-20T09:30:30Z
```

Step 2 Create namespace **test-clickhouse-operator**. To facilitate the verification, the subsequent operations are all performed in **test-clickhouse-operator**.

```
kubectl create namespace test-clickhouse-operator
```

Step 3 Create a ClickHouse cluster.

1. Create a YAML file named **simple-01.yaml**. You can obtain **simple-01.yaml** from **https://raw.githubusercontent.com/Altinity/clickhouse-operator/master/docs/chi-examples/01-simple-layout-01-1shard-1repl.yaml**.

```
vim simple-01.yaml
```

NOTE

ClickHouseInstallation is a custom resource object (CR) defined when a ClickHouse Operator is used in a Kubernetes cluster. After **ClickHouseInstallation** resources are created or updated, the ClickHouse Operator automatically creates and manages Kubernetes resources, such as StatefulSets, Services, and PersistentVolumeClaims, to ensure that the ClickHouse cluster runs as expected.

The file content is as follows:

```
apiVersion: "clickhouse.altinity.com/v1"
kind: "ClickHouseInstallation"
metadata:
  name: "simple-01"
spec:
 configuration:
   users:
     # printf 'test_password' | sha256sum
     test_user/password_sha256_hex:
10a6e6cc8311a3e2bcc09bf6c199adecd5dd59408c343e926b129c4914f3cb01
     test_user/password: test_password
     # to allow access outside from kubernetes
     test_user/networks/ip:
     - 0.0.0.0/0
   clusters:
   - name: "simple"
```

Use the preceding file to create a ClickHouse cluster.

```
kubectl apply -n test-clickhouse-operator -f simple-01.yaml
```

Step 4 Check whether ClickHouse resources are successfully created.

1. Check the pods of the **test-clickhouse-operator** namespace. If all pods are in the **Running** state, the pods were successfully created.

```
kubectl get pod -n test-clickhouse-operator
```

Information similar to the following is displayed:

```
NAME                          READY   STATUS    RESTARTS      AGE
chi-simple-01-simple-0-0-0    2/2     Running   0             3d7h
```

2. Check the other service resources.

```
kubectl get service -n test-clickhouse-operator
```

Information similar to the following is displayed:

```
NAME                       TYPE        CLUSTER-IP   EXTERNAL-IP   PORT(S)                      AGE
chi-simple-01-simple-0-0   ClusterIP   None         <none>        9000/TCP,8123/TCP,9009/TCP   3d7h
clickhouse-simple-01       ClusterIP   None         <none>        9000/TCP,8123/TCP            3d8h
```


Step 5 Connect to the ClickHouse database.

```
kubectl -n test-clickhouse-operator exec -ti chi-simple-01-simple-0-0-0 -- clickhouse-client
```

If the following information is displayed, the connection is successful: Enter **exit** and press **Enter** to exit the ClickHouse database.

```
ClickHouse client version 24.8.2.3 (official build).
Connecting to localhost:9000 as user default.
Connected to ClickHouse server version 24.8.2.

Warnings:
 * Linux transparent hugepages are set to "always". Check /sys/kernel/mm/transparent_hugepage/enabled

chi-simple-01-simple-0-0-0.chi-simple-01-simple-0-0.test-clickhouse-operator.svc.cluster.local :)
```

Step 6 Clear ClickHouse cluster resources.

Run the following command to delete the ClickHouse cluster:

```
kubectl delete -f simple-01.yaml -n test-clickhouse-operator
```

Information similar to the following is displayed:

```
clickhouseinstallation.clickhouse.altinity.com "simple-01" deleted
```

----End

Example 1: Creating a ClickHouse Cluster with a PV Provisioned Dynamically

The following example describes how to create a ClickHouse cluster with a PV dynamically provisioned. The EVS is used as an example to describe how to dynamically provision a PV for a ClickHouse cluster.

NOTICE

The VolumeClaimTemplate can only be used to provision EVS disks and local PVs to StatefulSets.

Step 1 Create a StorageClass.

1. Create a YAML file named **csi-disk-ssd.yaml**.

   ```
   vim csi-disk-ssd.yaml
   ```

   By default, CCE supports SAS disks. If you want to use another type of disk, you need to create the corresponding StorageClass. For details about StorageClass parameters, see **Table 15-4**.

   ```
   allowVolumeExpansion: true
   apiVersion: storage.k8s.io/v1
   kind: StorageClass
   metadata:
     name: csi-disk-ssd
   provisioner: everest-csi-provisioner
   parameters:
     csi.storage.k8s.io/csi-driver-name: disk.csi.everest.io
     csi.storage.k8s.io/fstype: ext4
     everest.io/disk-volume-type: SSD
     everest.io/passthrough: "true"
   reclaimPolicy: Delete
   volumeBindingMode: Immediate
   ```


Table 15-4 StorageClass parameters

Parameter	Description
provisioner	Specifies the storage resource provider, which is the Everest add-on for CCE. Set this parameter to **everest-csi-provisioner**.
parameters	Specifies the storage parameters, which vary with storage types. **NOTICE** **everest.io/disk-volume-type** indicates the cloud disk type, which can be any of the following: – **SAS**: high I/O – **SSD**: ultra-high I/O – **GPSSD**: general purpose SSD – **ESSD**: extreme SSD – **GPSSD2**: general purpose SSD v2, which is supported when the Everest version is 2.4.4 or later and the **everest.io/disk-iops** and **everest.io/disk-throughput** annotations are configured. – **ESSD2**: extreme SSD v2, which is supported when the Everest version is 2.4.4 or later and the **everest.io/disk-iops** annotation is configured. Default: **SAS**
reclaimPolicy	Specifies the value of **persistentVolumeReclaimPolicy** for creating a PV. The value can be **Delete** or **Retain**. If **reclaimPolicy** is not specified when a StorageClass object is created, the value defaults to **Delete**. – **Delete**: indicates that a dynamically provisioned PV will be automatically deleted when the PVC is deleted. – **Retain**: indicates that a dynamically provisioned PV will be retained when the PVC is deleted.
volumeBindingMode	Specifies when a PV is dynamically provisioned. The value can be **Immediate** or **WaitForFirstConsumer**. – **Immediate**: The PV is dynamically provisioned when a PVC is created. – **WaitForFirstConsumer**: The PV is dynamically provisioned when the PVC is used by the workload.

2. Use **csi-disk-ssd.yaml** to create a StorageClass named **csi-disk-ssd**.
```
kubectl create -f csi-disk-ssd.yaml
```

Step 2 Create a ClickHouse cluster with a PV dynamically provisioned.

1. Create a YAML file named **pv-simple.yaml**.
```
vim pv-simple.yaml
```
For details about the file content, see **https://github.com/Altinity/clickhouse-operator/blob/master/docs/chi-examples/03-persistent-volume-01-default-volume.yaml**.

NOTICE

EVS disks can be mounted as read-write by a single node, so **accessModes** must be set to **ReadWriteOnce**.

```
apiVersion: "clickhouse.altinity.com/v1"
kind: "ClickHouseInstallation"
metadata:
  name: "pv-simple"
  namespace: test-clickhouse-operator
spec:
  defaults:
    templates:
      dataVolumeClaimTemplate: data-volume-template
      logVolumeClaimTemplate: log-volume-template
  configuration:
    clusters:
      - name: "simple"
        layout:
          shardsCount: 1
          replicasCount: 1
  templates:
    volumeClaimTemplates:                # Dynamic provisioning
      - name: data-volume-template          # Template for defining a data storage volume
        spec:
          accessModes:
            - ReadWriteOnce              # EVS disks can be mounted as read-write by a single node, so accessModes must be set to ReadWriteOnce.
          resources:
            requests:
              storage: 10Gi
          storageClassName: csi-disk-ssd    # Specify the newly created csi-disk-ssd as the StorageClass.
      - name: log-volume-template           # Template for defining the log storage volume
        spec:
          accessModes:
            - ReadWriteOnce              # EVS disks can be mounted as read-write by a single node, so accessModes must be set to ReadWriteOnce.
          resources:
            requests:
              storage: 10Gi
          storageClassName: csi-disk-ssd    # Specify the newly created csi-disk-ssd as the StorageClass.
```

2. Use **pv-simple.yaml** to create a ClickHouse cluster.

```
kubectl -n test-clickhouse-operator create -f pv-simple.yaml
```

Step 3 Check whether the ClickHouse cluster is successfully created and whether the PV is successfully provisioned.

1. Check the pods of the **test-clickhouse-operator** namespace. If all pods are in the **Running** state, the pods were successfully created.

```
kubectl get pod -n test-clickhouse-operator
```

If the following information is displayed, the pods are successfully created.

```
NAME                          READY   STATUS    RESTARTS   AGE
chi-pv-simple-simple-0-0-0    2/2     Running   0          5m2s
chi-simple-01-simple-0-0-0    1/1     Running   0          3d7h
```

2. Check whether the PVCs named **data-volume-template** and **log-volume-template** are successfully created.

```
kubectl get pvc -n test-clickhouse-operator
```

If **STATUS** is **Bound**, the PVC is bound successfully.

```
NAME                                     STATUS   VOLUME                                     CAPACITY   ACCESS
MODES   STORAGECLASS   VOLUMEATTRIBUTESCLASS   AGE
data-volume-template-chi-pv-simple-simple-0-0-0   Bound    pvc-981b1d73-a13e-41d5-aade-
ea8c6b1199d7   10Gi       RWO            csi-disk-ssd   <unset>                 28s
```



```
log-volume-template-chi-pv-simple-simple-0-0-0    Bound    pvc-fcf70a2e-131d-4da1-a9c2-
eddd89887b45   10Gi       RWO            csi-disk-ssd   <unset>                 28s
```

3. Check whether the PV is mounted to the cluster.

   Go to the CLI of the **chi-pv-simple-simple-0-0-0** container.

   ```
   kubectl -n test-clickhouse-operator exec -ti chi-pv-simple-simple-0-0-0 -c clickhouse bash
   ```

   Check whether the PV is mounted to the container:

   ```
   df -h
   ```

   The command output shows that the PV has been mounted to the container. You can press **Ctrl+D** to exit the CLI.

   ```
   Filesystem                Size    Used   Avail  Use% Mounted on
   overlay                   99G    5.1G     89G    6% /
   tmpfs                     64M       0     64M    0% /dev
   tmpfs                     3.9G      0    3.9G    0% /sys/fs/cgroup
   /dev/mapper/vgpaas-share       99G     5.1G      89G    6% /etc/hosts
   shm                       64M       0     64M    0% /dev/shm
   /dev/sdb                   9.8G    66M    9.8G    1% /var/lib/clickhouse
   /dev/sda                   9.8G    37M    9.8G    1% /var/log/clickhouse-server
   tmpfs                     6.3G     12K    6.3G    1% /run/secrets/kubernetes.io/serviceaccount
   tmpfs                     3.9G       0    3.9G    0% /proc/acpi
   tmpfs                     3.9G       0    3.9G    0% /proc/scsi
   tmpfs                     3.9G       0    3.9G    0% /sys/firmware
   ```

Step 4 Connect to the ClickHouse database.

```
kubectl -n test-clickhouse-operator exec -ti chi-pv-simple-simple-0-0-0 -- clickhouse-client
```

If the following information is displayed, you have successfully connected to the ClickHouse database: Enter **exit** and press **Enter** to exit the ClickHouse database.

```
Defaulted container "clickhouse" out of: clickhouse, clickhouse-log
ClickHouse client version 24.8.2.3 (official build).
Connecting to localhost:9000 as user default.
Connected to ClickHouse server version 24.8.2.

Warnings:
 * Linux transparent hugepages are set to "always". Check /sys/kernel/mm/transparent_hugepage/enabled

chi-pv-simple-simple-0-0-0.chi-pv-simple-simple-0-0.test-clickhouse-operator.svc.cluster.local :)
```

Step 5 Clear ClickHouse cluster resources.

Run the following command to delete the ClickHouse cluster with a PV provisioned dynamically:

```
kubectl delete -f pv-simple.yaml -n test-clickhouse-operator
```

Information similar to the following is displayed:

```
clickhouseinstallation.clickhouse.altinity.com "pv-simple" deleted
```

----End

Example 2: Creating a ClickHouse Cluster with a LoadBalancer Service

The following example describes how to create a ClickHouse cluster with a LoadBalancer Service. The LoadBalancer Service allows you to access the ClickHouse cluster from the Internet.

Step 1 Create a ClickHouse cluster with a LoadBalancer Service so that you can access the ClickHouse cluster from the Internet.

1. Create a YAML file named **elb.yaml**.

   ```
   vim elb.yaml
   ```


For details about parameters in **kubernetes.io/elb.autocreate**, see **Table 15-5**.

```
apiVersion: "clickhouse.altinity.com/v1"
kind: "ClickHouseInstallation"
metadata:
  name: "ck-elb"
  namespace: test-clickhouse-operator
spec:
  defaults:
    templates:
      dataVolumeClaimTemplate: data-volume-nas
      serviceTemplate: chi-service-elb
  configuration:
    clusters:
      - name: "ck-elb"
        templates:
          podTemplate: pod-template-with-nas
        layout:
          shardsCount: 1
          replicasCount: 1
  templates:
    podTemplates:
      - name: pod-template-with-nas
        spec:
          containers:
            - name: clickhouse
              image: clickhouse/clickhouse-server:23.8
              volumeMounts:
                - name: data-volume-nas
                  mountPath: /var/lib/clickhouse
    volumeClaimTemplates:              # Specify the storage access mode, requested storage size, and StorageClass.
      - name: data-volume-nas
        spec:
          accessModes:
            - ReadWriteOnce
          resources:
            requests:
              storage: 20Gi
          storageClassName: csi-disk-ssd
    serviceTemplates:                  # Service template
      - name: chi-service-elb
        metadata:
          annotations:
            # Load balancer type. union (default value) indicates shared load balancers, and performance indicates dedicated load balancers.
            kubernetes.io/elb.class: union
            # Automatically create a load balancer associated with the ingress and define load balancer parameters.
            kubernetes.io/elb.autocreate: >-
              {"type":"public","bandwidth_name":"cce-bandwidth-ck","bandwidth_chargemode":"bandwidth","bandwidth_size":5,"bandwidth_sharetype":"PER","eip_type":"5_bgp"}
        spec:
          ports:
            - name: http
              port: 8123
            - name: client
              port: 9000
          type: LoadBalancer           # Set the Service type to LoadBalancer.
```


Table 15-5 Parameters in the **kubernetes.io/elb.autocreate** file

Parameter	Mandatory	Type	Description
type	No	String	Network type of the load balancer. – **public**: public network load balancer – **inner**: private network load balancer Default: **inner**
bandwidth_name	**Yes** for public network load balancers	String	Bandwidth name. The default value is **cce-bandwidth-******. The value can contain 1 to 64 characters. Only letters, digits, underscores (_), hyphens (-), and periods (.) are allowed.
bandwidth_chargemode	No	String	Bandwidth billing mode. – **bandwidth**: billed by bandwidth – **traffic**: billed by traffic Default: **bandwidth**
bandwidth_size	**Yes** for public network load balancers	Integer	Bandwidth size. The default value is 1 to 2000 Mbit/s. Configure this parameter based on the bandwidth range allowed in your region. The minimum increment for bandwidth adjustment varies depending on the bandwidth range. – If the allowed bandwidth does not exceed 300 Mbit/s, the minimum increment is 1 Mbit/s. – If the allowed bandwidth is greater than 300 Mbit/s but less than or equal to 1000 Mbit/s, the minimum increment is 50 Mbit/s. – If the allowed bandwidth exceeds 1000 Mbit/s, the minimum increment is 500 Mbit/s.
bandwidth_sharetype	**Yes** for public network load balancers	String	Specifies the bandwidth sharing mode. **PER** indicates that the bandwidth is dedicated.

Parameter	Mandatory	Type	Description
eip_type	**Yes** for public network load balancers	String	EIP type. – **5_bgp**: Dynamic BGP – **5_sbgp**: Static BGP The types vary by region. For details, see the EIP console.

2. Use **elb.yaml** to create a ClickHouse cluster.
   ```
   kubectl create -f elb.yaml -n test-clickhouse-operator
   ```

Step 2 Check whether the ClickHouse cluster is successfully created and associated with a LoadBalancer Service.

1. Check the pods of the **test-clickhouse-operator** namespace. If all pods are in the **Running** state, the pods were successfully created.
   ```
   kubectl get pod -n test-clickhouse-operator
   ```
   If the following information is displayed, the ClickHouse cluster is successfully created:
   ```
   NAME                          READY   STATUS    RESTARTS   AGE
   chi-ck-elb-ck-elb-0-0-0       1/1     Running   0          3m4s
   chi-pv-simple-simple-0-0-0    2/2     Running   0          33m
   chi-simple-01-simple-0-0-0    1/1     Running   0          3d7h
   ```
2. Check whether the LoadBalancer Service is successfully created:
   ```
   kubectl get svc -n test-clickhouse-operator
   ```
   If the following information is displayed, the LoadBalancer Service is successfully created:
   ```
   NAME                        TYPE          CLUSTER-IP     EXTERNAL-IP   PORT(S)                       AGE
   chi-ck-elb-ck-elb-0-0       ClusterIP     None           <none>        9000/TCP,8123/TCP,9009/TCP    2s
   chi-pv-simple-simple-0-0    ClusterIP     None           <none>        9000/TCP,8123/TCP,9009/TCP    35m
   chi-simple-01-simple-0-0    ClusterIP     None           <none>        9000/TCP,8123/TCP,9009/TCP    38m
   clickhouse-pv-simple        ClusterIP     None           <none>        8123/TCP,9000/TCP             35m
   clickhouse-simple-01        ClusterIP     None           <none>        8123/TCP,9000/TCP             3d7h
   ```

Step 3 Connect to the ClickHouse database.

```
kubectl -n test-clickhouse-operator exec -ti chi-ck-elb-ck-elb-0-0-0 -- clickhouse-client
```

If the following information is displayed, you have successfully connected to the ClickHouse database: Enter **exit** and press **Enter** to exit the ClickHouse database.

```
ClickHouse client version 23.8.16.16 (official build).
Connecting to localhost:9000 as user default.
Connected to ClickHouse server version 23.8.16 revision 54465.

Warnings:
 * Linux transparent hugepages are set to "always". Check /sys/kernel/mm/transparent_hugepage/enabled

chi-ck-elb-ck-elb-0-0-0.chi-ck-elb-ck-elb-0-0.test-clickhouse-operator.svc.cluster.local :)
```

Step 4 Clear ClickHouse cluster resources.

Delete the ClickHouse cluster (the one that is associated with the LoadBalancer Service).

```
kubectl delete -f elb.yaml  -n test-clickhouse-operator
```


Information similar to the following is displayed:

```
clickhouseinstallation.clickhouse.altinity.com "ck-elb1" deleted
```

----End

Follow-up Procedure: Clearing Other ClickHouse Resources

1. Delete the **test-clickhouse-operator** namespace.
   ```
   kubectl delete namespace test-clickhouse-operator
   ```
   Information similar to the following is displayed:
   ```
   namespace "test-clickhouse-operator" deleted
   ```
2. Delete the ClickHouse Operator:
   ```
   kubectl delete -f clickhouse-operator-install-bundle.yaml
   ```
   Information similar to the following is displayed:
   ```
   customresourcedefinition.apiextensions.k8s.io "clickhouseinstallations.clickhouse.altinity.com" deleted
   customresourcedefinition.apiextensions.k8s.io "clickhouseinstallationtemplates.clickhouse.altinity.com" deleted
   customresourcedefinition.apiextensions.k8s.io "clickhouseoperatorconfigurations.clickhouse.altinity.com" deleted
   customresourcedefinition.apiextensions.k8s.io "clickhousekeeperinstallations.clickhouse-keeper.altinity.com" deleted
   ...
   ```

15.6 Deploying and Using Spark in a CCE Cluster

15.6.1 Installing Spark

Prerequisites

A Linux server that can access the public network is available. The recommended node specifications are 4 vCPUs and 8 GiB memory or higher.

Configuring the JDK

This section uses CentOS as an example to describe how to install JDK 1.8.

Step 1 Obtain the available version.

```
yum -y list java*
```

Step 2 Install JDK 1.8.

```
yum install -y java-1.8.0-openjdk java-1.8.0-openjdk-devel
```

Step 3 Check the version after the installation.

```
# java -version
openjdk version "1.8.0_382"
OpenJDK Runtime Environment (build 1.8.0_382-b05)
OpenJDK 64-Bit Server VM (build 25.382-b05, mixed mode)
```

Step 4 Add environment variables.

1. Linux environment variables are configured in the **/etc/profile** file.
   ```
   vim /etc/profile
   ```
2. In the editing mode, add the following content to the end of the file:
   ```
   JAVA_HOME=/usr/lib/jvm/java-1.8.0-openjdk-1.8.0.382.b05-1.el7_9.x86_64
   PATH=$PATH:$JAVA_HOME/bin
   ```



```
CLASSPATH=.:$JAVA_HOME/lib/dt.jar:$JAVA_HOME/lib/tools.jar
export JAVA_HOME  PATH  CLASSPATH
```

3. Save and close the **profile** file. Run the following command for the modification to take effect:

```
source /etc/profile
```

4. Check the JDK environment variables.

```
echo $JAVA_HOME
echo $PATH
echo $CLASSPATH
```

----End

Obtaining the Spark Package

OBS matches Hadoop 2.8.3 and 3.1.1. Hadoop 3.1.1 is used in this example.

Step 1 Download Spark v3.1.1. If Git is not installed, run **yum install git** to install it.

```
git clone -b v3.1.1 https://github.com/apache/spark.git
```

Step 2 Modify the **/dev/make-distribution.sh** file and specify the Spark version so that the check can be skipped during compilation.

1. Search for the line where **VERSION** resides and check the number of the line where the version number is located.

```
cat ./spark/dev/make-distribution.sh |grep -n '^VERSION=' -A18
```

2. Comment out the content displayed from lines 129 to 147 and specify the version.

```
sed -i '129,147s/^/#/g' ./spark/dev/make-distribution.sh
sed -i '148a
VERSION=3.1.3\nSCALA_VERSION=2.12\nSPARK_HADOOP_VERSION=3.1.1\nSPARK_HIVE=1' ./
spark/dev/make-distribution.sh
```

Step 3 Download the dependency.

```
wget https://archive.apache.org/dist//maven/maven-3/3.6.3/binaries/apache-maven-3.6.3-bin.tar.gz
tar -zxvf apache-maven-3.6.3-bin.tar.gz && mv apache-maven-3.6.3 ./spark/build
```

Step 4 Run the following command to perform compilation:

```
./spark/dev/make-distribution.sh --name hadoop3.1 --tgz -Pkubernetes -Pyarn -Dhadoop.version=3.1.1
```

Step 5 Wait for the compilation to complete. After the compilation, the software package is named **spark-3.1.3-bin-hadoop3.1**.tgz.

----End

Configuring the Runtime Environment for Spark

To simplify the operation, use the **root** user to place the compiled package **spark-3.1.3-bin-hadoop3.1.tgz** in the **/root** directory on the operation node.

Step 1 Move the software package to the **/root** directory.

```
mv ./spark/spark-3.1.3-bin-hadoop3.1.tgz /root
```

Step 2 Run the following command to install Spark:

```
tar -zxvf spark-3.1.3-bin-hadoop3.1.tgz
mv spark-3.1.3-bin-hadoop3.1 spark-obs
cat >> ~/.bashrc <<EOF
PATH=/root/spark-obs/bin:\$PATH
PATH=/root/spark-obs/sbin:\$PATH
export SPARK_HOME=/root/spark-obs
EOF
```



```
source ~/.bashrc
```

Step 3 Run the following command where binary **spark-submit** is used to check the Spark version:

```
spark-submit --version
```

----End

Interconnecting Spark with OBS

Step 1 Obtain Huawei Cloud OBS JAR. The **hadoop-huaweicloud-3.1.1-hw-45.jar** package is used, which can be obtained from **https://github.com/huaweicloud/obsa-hdfs/tree/master/release**.

```
wget https://github.com/huaweicloud/obsa-hdfs/releases/download/v45/hadoop-huaweicloud-3.1.1-hw-45.jar
```

Step 2 Copy the package to the corresponding directory.

```
cp hadoop-huaweicloud-3.1.1-hw-45.jar /root/spark-obs/jars/
```

Step 3 Modify Spark configuration items. To interconnect Spark with OBS, add ConfigMaps for Spark as follows:

1. Obtain the AK/SK. For details, see **Access Keys**.
2. Change the values of **AK_OF_YOUR_ACCOUNT**, **SK_OF_YOUR_ACCOUNT**, and **OBS_ENDPOINT** to the actual values.
   - **AK_OF_YOUR_ACCOUNT**: indicates the AK obtained in the previous step.
   - **SK_OF_YOUR_ACCOUNT**: indicates the SK obtained in the previous step.
   - **OBS_ENDPOINT**: indicates the OBS endpoint. It can be obtained in **Regions and Endpoints**.

```
cp ~/spark-obs/conf/spark-defaults.conf.template ~/spark-obs/conf/spark-defaults.conf

cat >> ~/spark-obs/conf/spark-defaults.conf <<EOF
spark.hadoop.fs.obs.readahead.inputstream.enabled=true
spark.hadoop.fs.obs.buffer.max.range=6291456
spark.hadoop.fs.obs.buffer.part.size=2097152
spark.hadoop.fs.obs.threads.read.core=500
spark.hadoop.fs.obs.threads.read.max=1000
spark.hadoop.fs.obs.write.buffer.size=8192
spark.hadoop.fs.obs.read.buffer.size=8192
spark.hadoop.fs.obs.connection.maximum=1000
spark.hadoop.fs.obs.access.key=AK_OF_YOUR_ACCOUNT
spark.hadoop.fs.obs.secret.key=SK_OF_YOUR_ACCOUNT
spark.hadoop.fs.obs.endpoint=OBS_ENDPOINT
spark.hadoop.fs.obs.buffer.dir=/root/hadoop-obs/obs-cache
spark.hadoop.fs.obs.impl=org.apache.hadoop.fs.obs.OBSFileSystem
spark.hadoop.fs.obs.connection.ssl.enabled=false
spark.hadoop.fs.obs.fast.upload=true
spark.hadoop.fs.obs.socket.send.buffer=65536
spark.hadoop.fs.obs.socket.recv.buffer=65536
spark.hadoop.fs.obs.max.total.tasks=20
spark.hadoop.fs.obs.threads.max=20
spark.kubernetes.container.image.pullSecrets=default-secret
EOF
```

----End

Pushing an Image to SWR

To run Spark tasks in Kubernetes, build a Spark container image of the same version and upload it to SWR. A **Dockerfile** file has been generated during compilation. Use this file to create an image and push it to SWR.

Step 1 Create an image.

```
cd ~/spark-obs
docker build -t spark:3.1.3-obs --build-arg spark_uid=0 -f kubernetes/dockerfiles/spark/Dockerfile .
```

Step 2 Upload the image.

1. (Optional) Log in to the SWR console, choose **Organizations** in the navigation pane, and click **Create Organization** in the upper right corner of the page.

   Skip this step if you already have an organization.

2. Choose **My Images** in the navigation pane and click **Upload Through Client**. On the page displayed, click **Generate a temporary login command** and click  to copy the command.

3. Run the login command copied in the previous step on the node. If the login is successful, the message "Login Succeeded" will display.

4. Log in to the node where the image is created and run the login command.

   ```
   Docker tag [{ Image name }:{Version name }] swr. ap-southeast-1.myhuaweicloud.com/{ Organization name }/{Image name }:{version name }
   docker push swr.ap-southeast-1.myhuaweicloud.com/{Organization name }/{Image name }:{Version name }
   ```

   Record the image access address for later use.

   For example, record the IP address as **swr.ap-southeast-1.myhuaweicloud.com/dev-container/spark:3.1.3-obs**.

----End

Configuring Spark History Server

Step 1 Modify the **~/spark-obs/conf/spark-defaults.conf** file, enable Spark event logging, and configure the OBS bucket name and directory.

```
cat >> ~/spark-obs/conf/spark-defaults.conf <<EOF
spark.eventLog.enabled=true
spark.eventLog.dir=obs://{bucket-name}/{log-dir}/
EOF
```

- **spark.eventLog.enabled**: indicates that Spark event logging is enabled if it is set to **true**.
- **spark.eventLog.dir**: indicates the OBS bucket name and path. The bucket is named in the format of **obs://***{bucket-name}***/***{log-dir}***/**, for example, **obs://spark-sh1/history-obs/**. Ensure that the OBS bucket name and directory are correct.

Step 2 Modify the **~/spark-obs/conf/spark-env.sh** file. If the file does not exist, run the command to copy the template as a file:

```
cp ~/spark-obs/conf/spark-env.sh.template ~/spark-obs/conf/spark-env.sh

cat >> ~/spark-obs/conf/spark-env.sh <<EOF
SPARK_HISTORY_OPTS="-Dspark.history.fs.logDirectory=obs://{bucket-name}/{log-dir}/"
EOF
```


The OBS address must be the same as that in **spark-default.conf** in the previous step.

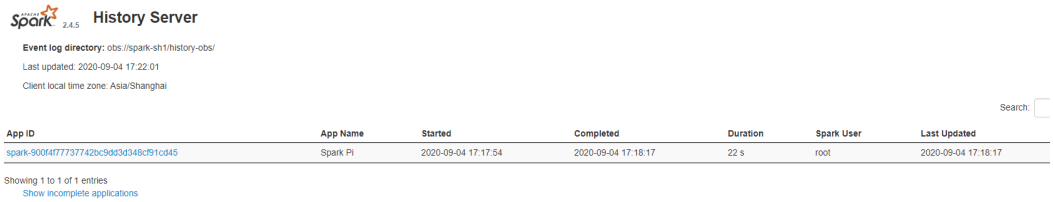
Step 3 Start Spark History Server.

```
start-history-server.sh
```

Information similar to the following is displayed:

```
starting org.apache.spark.deploy.history.HistoryServer, logging to /root/spark-obs/logs/spark-root-org.apache.spark.deploy.history.HistoryServer-1-spark-sh1.out
```

Step 4 Access the server through port 18080 on the node.



To stop the server, run the following command:

```
stop-history-server.sh
```

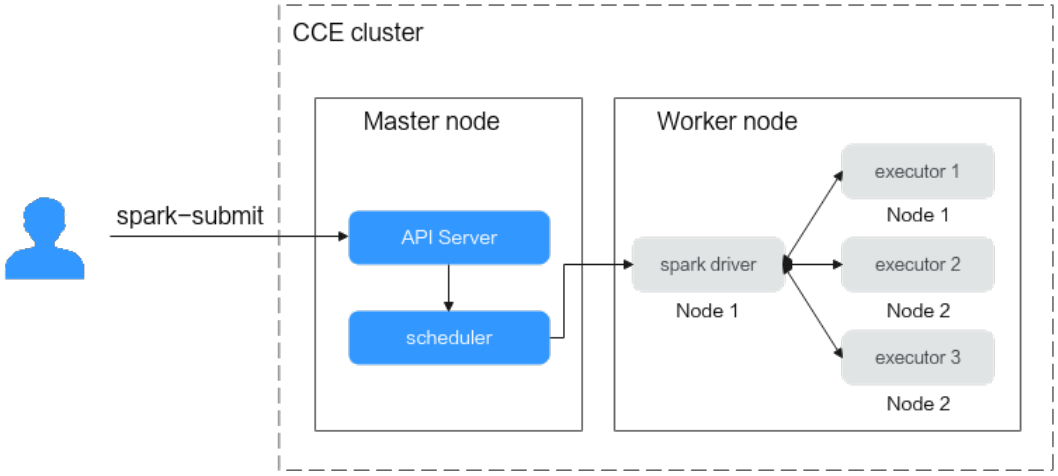
----End

15.6.2 Using Spark

You can use Spark's Kubernetes scheduler spark-submit to submit Spark applications to Kubernetes clusters. For details, see **Running Spark on Kubernetes**. The submission mechanism works as follows:

- Create a pod to run the Spark driver.
- The driver creates pods for executing the programs and establishes a connection with these pods.
- After the application is complete, the pods that execute the programs are terminated and cleaned up, but the driver pod exists and remains in the completed state until the garbage is collected or it is manually cleaned up. In the completed state, the driver pod does not use any computing or memory resources.

Figure 15-7 Submission mechanism



Running SparkPi on CCE

Step 1 Install kubectl on the node where Spark is running. For details, see **Connecting to a Cluster Using kubectl**.

Step 2 Run the following command to grant the cluster-level permissions:

```
# Create a service account.
kubectl create serviceaccount spark
# Bind the ClusterRole spark-role to the service account created in the previous step, specify the default namespace, and grant the ClusterRole permission to edit resources.
kubectl create clusterrolebinding spark-role --clusterrole=edit --serviceaccount=default:spark --namespace=default
```

Step 3 Submit a SparkPi job to CCE. The following shows an example:

```
spark-submit \
  --master k8s://https://**.**.**.**:5443 \
  --deploy-mode cluster \
  --name spark-pi \
  --class org.apache.spark.examples.SparkPi \
  --conf spark.executor.instances=2 \
  --conf spark.kubernetes.authenticate.driver.serviceAccountName=spark \
  --conf spark.kubernetes.container.image=swr.ap-southeast-1.myhuaweicloud.com/dev-container/spark:3.1.3-obs \
  local:///root/spark-obs/examples/jars/spark-examples_2.12-3.1.1.jar
```

Parameters:

- **--master**: indicates the API Server of the cluster. **https://**.*.*.**:5443** is the address of the master node used in **~/.kube/config**. It can be obtained from **kubectl cluster-info**.
- **--deploy-mode**:
  - **cluster**: a mode in which the driver is deployed on the worker nodes.
  - **client**: (default value) a mode in which the driver is deployed locally as an external client.
- **--name**: indicates the name of a job. It is used to name the pods in the cluster.
- **--class**: indicates the applications, for example, **org.apache.spark.examples.SparkPi**.
- **--conf**: indicates the Spark's configuration parameters. It is in the key-value pair format. All parameters that can be specified using **--conf** are read from the **~/spark-obs/conf/spark-defaults.conf** file by default. Therefore, the general configuration can be written to be the default settings, the same way as **Interconnecting Spark with OBS**.
  - **spark.executor.instances**: indicates the number of pods for executing programs.
  - **spark.kubernetes.authenticate.driver.serviceAccountName**: indicates the driver's cluster-level permissions. Select the service account created in **Step 2**.
  - **spark.kubernetes.container.image**: indicates the image path of the image pushed to SWR in **Pushing an Image to SWR**.
- **local**: indicates the path to the JAR packages stored in the local files. In this example, a local file is used to store the JAR packages. The value of this parameter can be **file**, **http**, or **local**. For details, see the **Official Documentation**.

----End

Accessing OBS

Use **spark-submit** to deliver an HDFS job. Change the value of **obs://bucket-name/filename** at the end of the script to the actual file name of the tenant.

```
spark-submit \
  --master k8s://https://**.**.**.**:5443 \
  --deploy-mode cluster \
  --name spark-hdfs-test \
  --class org.apache.spark.examples.HdfsTest \
  --conf spark.kubernetes.authenticate.driver.serviceAccountName=spark \
  --conf spark.kubernetes.container.image=swr.ap-southeast-1.myhuaweicloud.com/dev-container/
spark:3.1.3-obs \
  local:///root/spark-obs/examples/jars/spark-examples_2.12-3.1.1.jar obs://bucket-name/filename
```

Support for Spark Shell Commands to Interact with Spark-Scala

```
spark-shell \
  --conf spark.kubernetes.authenticate.driver.serviceAccountName=spark \
  --conf spark.kubernetes.container.image=swr.ap-southeast-1.myhuaweicloud.com/dev-container/
spark:3.1.3-obs \
  --master k8s://https://**.**.**.**:5443
```

Run the following commands to define the algorithms of Spark computing jobs linecount and wordcount:

```
def linecount(input:org.apache.spark.sql.Dataset[String]):Long=input.filter(line => line.length()>0).count()
def wordcount(input:org.apache.spark.sql.Dataset[String]):Long=input.flatMap(value => value.split("\\s
+")).groupByKey(value => value).count().count()
```

Run the following commands to define data sources:

```
var alluxio = spark.read.textFile("alluxio://alluxio-master:19998/sample-1g")
var obs = spark.read.textFile("obs://gene-container-gtest/sample-1g")
var hdfs = spark.read.textFile("hdfs://192.168.1.184:9000/user/hadoop/books/sample-1g")
```

Run the following command to start computing jobs:

```
spark.time(wordcount(obs))
spark.time(linecount(obs))
```

